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Radio-frequency module and communication device

Abstract

In a radio-frequency module, a conductive layer covers a major surface opposite to the mounting board side of a resin layer and a major surface opposite to the mounting board side of an electronic component. The electronic component includes an electronic component body and a plurality of outer electrodes. The electronic component body includes an electrical insulating portion and a conductive portion provided inside the electrical insulating portion, forming at least a portion of a circuit element of the electronic component. The electronic component body has a third major surface and a fourth major surface opposite to each other, and an outer side surface. The third major surface forms the major surface of the electronic component, and the third major surface is in contact with the conductive layer. The plurality of outer electrodes are provided on the fourth major surface, but are not extended over the third major surface.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATION (1) This is a continuation of International Application No. PCT/JP2021/039035 filed on Oct. 22, 2021 which claims priority from Japanese Patent Application No. 2020-181865 filed on Oct. 29, 2020. The contents of these applications are incorporated herein by reference in their entireties.

BACKGROUND OF THE DISCLOSURE
Field of the Disclosure
(1) The present disclosure generally relates to radio-frequency modules and communication devices, and more particularly, to a radio-frequency module including an electronic component, and a communication device including the radio-frequency module.
Description of the Related Art
(2) Patent Document 1 discloses a module (a radio-frequency module) including a module substrate (a mounting board), a chip coil (an electronic component), a resin layer, and a metal film (a conductive layer).
(3) In the module disclosed in Patent Document 1, the chip coil is mounted at electrodes provided on a mounting surface of the module substrate. Patent Document 1: International Publication No. 2014/013831
BRIEF SUMMARY OF THE DISCLOSURE
(4) In radio-frequency modules such as the module disclosed in Patent Document 1, for the purpose of preventing two outer electrodes of an electronic component, for example the chip coil, and the metal film from being short-circuited, it is necessary to interpose a portion of the resin layer between the electronic component and the metal film in the thickness direction of the module substrate. For this reason, in the radio-frequency module disclosed in Patent Document 1, it is difficult to increase an element value (for example, inductance or capacitance) of a circuit element (for example, an inductor or capacitor) included in the electronic component.
(5) A possible benefit of the present disclosure is to provide a radio-frequency module and a communication device in which the element value of a circuit element included in an electronic component can be increased.
(6) A radio-frequency module according to an aspect of the present disclosure includes a mounting

board, an electronic component, a resin layer, and a conductive layer. The mounting board has a first major surface and a second major surface opposite to each other. The electronic component is mounted on the first major surface of the mounting board. The resin layer is provided on the first major surface of the mounting board. The resin layer covers at least a portion of an outer side surface of the electronic component. The conductive layer covers at least a portion of a major surface opposite to a mounting board side of the resin layer and at least a portion of a major surface opposite to a mounting board side of the electronic component. The electronic component includes an electronic component body and a plurality of outer electrodes. The electronic component body includes an electrical insulating portion and a conductive portion that is provided inside the electrical insulating portion and that forms at least a portion of a circuit element of the electronic component. The electronic component body has a third major surface and a fourth major surface, which are opposite to each other, and an outer side surface. In the electronic component, the third major surface of the electronic component body forms the major surface of the electronic component, and the third major surface of the electronic component body is in contact with the conductive layer. The plurality of outer electrodes are provided on the fourth major surface of the electronic component body, and the plurality of outer electrodes are not extended over the third major surface.
(7) A communication device according to an aspect of the present disclosure includes the radio-frequency module described above and a signal processing circuit. The signal processing circuit is coupled to the radio-frequency module.
(8) In the radio-frequency module and communication device according to the aspects of the present disclosure described above, the element value of a circuit element included in the electronic component can be increased.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS
(1) FIG. **1** is a plan view of a radio-frequency module according to a first embodiment.
(2) FIG. **2** illustrates the radio-frequency module; FIG. **2** is a sectional view taken along line X-X in FIG. **1**.
(3) FIG. **3** illustrates the radio-frequency module; FIG. **3** is a sectional view taken along line Y-Y in FIG. **1**.
(4) FIG. **4** is a partially enlarged sectional view of the radio-frequency module.
(5) FIG. **5** is a circuit configuration diagram of a communication device including the radio-frequency module.
(6) FIG. **6** is a sectional view of a radio-frequency module according to a first modification of the first embodiment.
(7) FIG. **7** is a partially enlarged sectional view of a radio-frequency module according to a second modification of the first embodiment.
(8) FIG. **8** is a circuit diagram of a radio-frequency module according to a third modification of the first embodiment.
(9) FIG. **9** is a partially cutaway plan view of the radio-frequency module.
(10) FIG. **10** illustrates the radio-frequency module; FIG. **10** is a sectional view taken along line X-X in FIG. **9**.
(11) FIG. **11** illustrates the radio-frequency module; FIG. **11** is a sectional view taken along line Y-Y in FIG. **9**.
(12) FIG. **12** is a sectional view of a radio-frequency module according to a second embodiment.
(13) FIG. **13** is a partially enlarged sectional view of the radio-frequency module.
(14) FIG. **14** is a perspective view of an LC filter as another example of a first electronic

component when viewed from below.

DETAILED DESCRIPTION OF THE DISCLOSURE

(15) FIGS. **1** to **4**, **6**, **7**, and **9** to **14**, which will be referred to in the following embodiments and other examples, are all schematic drawings, and the proportion of size and thickness of each constituent element in the drawings is not necessarily identical to the corresponding proportion in actual measurements.

First Embodiment

(16) A radio-frequency module **100** according to the first embodiment includes, for example, as illustrated in FIGS. **1** and **2**, a mounting board **9**, an electronic component **1**, a resin layer **5** (see FIG. **2**), and a conductive layer **6** (see FIG. **2**). As illustrated in FIG. **2**, the mounting board **9** has a first major surface **91** and a second major surface **92** that are opposite to each other. The electronic component **1** is mounted on the first major surface **91** of the mounting board **9**. The resin layer **5** is provided on the first major surface **91** of the mounting board **9**. The resin layer **5** covers an outer side surface **13** of the electronic component **1**. The conductive layer **6** covers a major surface **51** of the resin layer **5**, opposite to the mounting board **9** side, and a major surface **11** of the electronic component **1**, opposite to the mounting board **9** side. The electronic component **1** includes, as illustrated in FIG. **3**, an electronic component body **2** and a plurality of outer electrodes **3**. The electronic component **1** is a surface mount device (SMD).

(17) The radio-frequency module **100** according to the first embodiment further includes, as illustrated in FIGS. **1** and **2**, as well as the electronic component **1** (hereinafter also referred to as the first electronic component **1**), a second electronic component **4** mounted on the first major surface **91** of the mounting board **9**. As illustrated in FIG. **2**, the resin layer **5** covers an outer side surface **43** of the second electronic component **4**. The conductive layer **6** covers a major surface **41** of the second electronic component **4**, opposite to the mounting board **9** side.

(18) The radio-frequency module **100** further includes, as illustrated in FIGS. **1** and **2**, a third electronic component **7**. The third electronic component **7** is mounted on the first major surface **91** of the mounting board **9**. As illustrated in FIG. **2**, the third electronic component **7** is lower in height than the first electronic component **1** and the second electronic component **4**. The resin layer **5** covers the outer side surface **73** of the third electronic component **7**. The resin layer **5** also covers a major surface **71** of the third electronic component **7**, opposite to the mounting board **9** side.

(19) The radio-frequency module **100** further includes, as illustrated in FIGS. **1** and **2**, a fourth electronic component **10**. The fourth electronic component **10** is mounted on the first major surface **91** of the mounting board **9**. As illustrated in FIG. **2**, the resin layer **5** covers an outer side surface **103** of the fourth electronic component **10**. The conductive layer **6** covers a major surface **101** of the fourth electronic component **10**, opposite to the mounting board **9** side.

(20) Hereinafter, the radio-frequency module **100** and a communication device **300** according to the first embodiment will be more specifically described with reference to FIGS. **1** to **5**.

(1) Radio-Frequency Module and Communication Device

(21) (1.1) Circuit Configuration of Radio-Frequency Module and Communication Device

(22) The following describes a circuit configuration of the radio-frequency module **100** and the communication device **300** according to the first embodiment with reference to FIG. **5**.

(23) The radio-frequency module **100** is used in, for example, the communication device **300**. The communication device **300** may be, for example, a mobile phone (for example, a smartphone). The communication device **300** is not limited to this example and may be, for example, a wearable device (for example, a smartwatch). The radio-frequency module **100** can support technology standards such as the fourth generation (4G) and fifth generation (5G) technology standards for cellular networks. Examples of the 4G standards include the 3rd Generation Partnership Project (3GPP) Long-Term Evolution (LTE) standard. Examples of the 5G standards include 5G New Radio (NR). The radio-frequency module **100** enables, for example, carrier aggregation and dual connectivity.

(24) The radio-frequency module **100** is configured to, for example, amplify a transmit signal inputted from a signal processing circuit **301** and output the transmit signal to an antenna **310**. The radio-frequency module **100** is also configured to amplify a receive signal inputted from the antenna **310** and output the receive signal to the signal processing circuit **301**. The signal processing circuit **301** is not a constituent element of the radio-frequency module **100**; the signal processing circuit **301** is a constituent element of the communication device **300** including the radio-frequency module **100**. The radio-frequency module **100** according to the first embodiment is controlled by, for example, the signal processing circuit **301** included in the communication device **300**. The communication device **300** includes the radio-frequency module **100** and the signal processing circuit **301**. The communication device **300** further includes the antenna **310**. The communication device **300** further includes a circuit board having the radio-frequency module **100**. The circuit board is, for example, a printed-circuit board. The circuit board has a ground electrode to which a ground potential is supplied.
(25) The signal processing circuit **301** includes, for example, a radio-frequency (RF) signal processing circuit **302** and a baseband signal processing circuit **303**. The RF signal processing circuit **302**, which is, for example, a radio frequency integrated circuit (RFIC), processes a radio-frequency signal. The RF signal processing circuit **302** processes by, for example, up-converting a radio-frequency signal (transmit signal) outputted by the baseband signal processing circuit **303** and outputs the processed radio-frequency signal. The RF signal processing circuit **302** also processes by, for example, down-converting a radio-frequency signal (receive signal) outputted by the radio-frequency module **100** and outputs the processed radio-frequency signal to the baseband signal processing circuit **303**. The baseband signal processing circuit **303** is, for example, a baseband integrated circuit (BBIC). The baseband signal processing circuit **303** generates an in-phase signal and a quadrature signal from a baseband signal. The baseband signal is, for example, a sound signal or image signal inputted from outside. The baseband signal processing circuit **303** performs IQ modulation by adding an in-phase signal and a quadrature signal together and outputs a transmit signal. At this time, the transmit signal is a modulated signal (IQ signal) generated by amplitude modulating a carrier wave signal of a given frequency by a period longer than the period of the carrier wave signal. The receive signal processed by the baseband signal processing circuit **303** is used as, for example, an image signal for displaying an image, or a sound signal for talk by a user of the communication device **300**. The radio-frequency module **100** transfers radio-frequency signals (receive and transmit signals) between the antenna **310** and the RF signal processing circuit **302** of the signal processing circuit **301**.
(26) The radio-frequency module **100** includes a plurality of (for example, three) transmit filters **131**, **132**, and **133**. The radio-frequency module **100** includes a power amplifier **111** and an output matching network **113**. The radio-frequency module **100** also includes a plurality of (for example, three) receive filters **171**, **172**, and **173**. The radio-frequency module **100** also includes a low-noise amplifier **121** and an input matching network **123**. The input matching network **123** includes, for example, one inductor. The radio-frequency module **100** further includes a controller **115**. The radio-frequency module **100** also includes a first switch **104**, a second switch **105**, and a third switch **106**. In the radio-frequency module **100**, the inductor included in the input matching network **123** is implemented as the first electronic component **1**. In the radio-frequency module **100**, the transmit filter **131** is implemented as the second electronic component **4** described above. In the radio-frequency module **100**, the power amplifier **111** is implemented as the third electronic component **7** described above. In the radio-frequency module **100**, the receive filter **171** is implemented as the fourth electronic component **10** described above.
(27) The radio-frequency module **100** also includes a plurality of external connection terminals **8**. The external connection terminals **8** include an antenna terminal **81**, a signal input terminal **82**, a signal output terminal **83**, a control terminal **84**, and a plurality of ground terminals **85** (see FIG. **2**). The ground terminals **85** are electrically coupled to the ground electrode of the circuit board

included in the communication device **300** so that the ground potential is supplied to the external ground terminals **85**.

(28) The following more specifically describes the circuit configuration of the radio-frequency module **100** with reference to FIG. **5**.

(29) The transmit filters **131**, **132**, and **133** are transmit filters of different frequency ranges as pass bands. In the following, when the three transmit filters **131**, **132**, and **133** are distinctively described, the three transmit filters **131**, **132**, and **133** are also respectively referred to as the first transmit filter **131**, the second transmit filter **132**, and the third transmit filter **133**.

(30) The first transmit filter **131** is, for example, a filter configured such that the pass band is a transmit band of a first communication band. The second transmit filter **132** is, for example, a filter configured such that the pass band is a transmit band of a second communication band. The third transmit filter **133** is, for example, a filter configured such that the pass band is a transmit band of a third communication band. The first communication band corresponds to transmit signals passed by the first transmit filter **131**. The second communication band corresponds to transmit signals passed by the second transmit filter **132**. The third communication band corresponds to transmit signals passed by the third transmit filter **133**. The first to third communication bands are communication bands of, for example, the 3GPP LTE standard or the 5G NR standard.

(31) The power amplifier **111** has an input terminal and an output terminal. The power amplifier **111** amplifies a transmit signal inputted to the input terminal and outputs the transmit signal from the output terminal. The input terminal of the power amplifier **111** is coupled to the signal input terminal **82**. The input terminal of the power amplifier **111** is coupled to the signal processing circuit **301** via the signal input terminal **82**. The signal input terminal **82** is a terminal for inputting a radio-frequency signal (a transmit signal) from an external circuit (for example, the signal processing circuit **301**) to the radio-frequency module **100**. In the radio-frequency module **100**, the output terminal of the power amplifier **111** is couplable to the first to third transmit filters **131** to **133** via the output matching network **113** and the second switch **105**. The second switch **105** has a common terminal **150** and a plurality of (for example, three) selection terminals **151** to **153**. In the radio-frequency module **100**, the output terminal of the power amplifier **111** is coupled to the common terminal **150** of the second switch **105** via the output matching network **113**, and the three selection terminals **151**, **152**, and **153** of the second switch **105** are coupled to the three transmit filters **131**, **132**, and **133** in one-to-one correspondence. The controller **115** controls the power amplifier **111**.

(32) The power amplifier **111** is, for example, a multistage amplifier including a driver stage amplifier and a final stage amplifier. In the power amplifier **111**, an input terminal of the driver stage amplifier is coupled to the signal input terminal **82**, an output terminal of the driver stage amplifier is coupled to an input terminal of the final stage amplifier, and an output terminal of the final stage amplifier is coupled to the output matching network **113**. The power amplifier **111** is not necessarily a multistage amplifier; the power amplifier **111** may be, for example, an in-phase combining amplifier, differential combining amplifier, or Doherty amplifier.

(33) The controller **115** controls the power amplifier **111** based on, for example, a control signal from the signal processing circuit **301**. The controller **115** is coupled to, for example, the driver stage amplifier and the output-stage amplifier of the power amplifier **111**. The controller **115** is coupled to the signal processing circuit **301** via a plurality of (for example, four) control terminals **84**. The control terminals **84** are terminals for inputting a control signal from an external circuit (for example, the signal processing circuit **301**) to the controller **115**. Based on the control signal obtained via the control terminals **84**, the controller **115** controls the power amplifier **111**. The control signal obtained by the controller **115** via the control terminals **84** is a digital signal. The number of the control terminals **84** is, for example, four, but FIG. **5** illustrates only one control terminal **84**. Based on the control signal from the signal processing circuit **301**, the controller **115** supplies, for example, a first bias current to the driver stage amplifier and a second bias current to

the output-stage amplifier.
(34) The output matching network **113** is provided in a signal path between the output terminal of the power amplifier **111** and the common terminal **150** of the second switch **105**. The output matching network **113** is a circuit for providing the impedance matching between the power amplifier **111** and the three transmit filters **131**, **132**, and **133**. The output matching network **113** includes, for example, a first inductor L**1** (see FIG. **1**) coupled between the output terminal of the power amplifier **111** and the common terminal **150** of the second switch **105**. The output matching network **113** may include, for example, a plurality of inductors and a plurality of capacitors.
(35) The receive filters **171**, **172**, and **173** are receive filters of different frequency ranges as pass bands. In the following, when the three receive filters **171**, **172**, and **173** are distinctively described, the three receive filters **171**, **172**, and **173** are also respectively referred to as the first receive filter **171**, the second receive filter **172**, and the third receive filter **173**.
(36) The first receive filter **171** is, for example, a filter configured such that the pass band is a receive band of the first communication band. The second receive filter **172** is, for example, a filter configured such that the pass band is a receive band of the second communication band. The third receive filter **173** is, for example, a filter configured such that the pass band is a receive band of the third communication band. The first communication band corresponds to receive signals passed by the first receive filter **171**. The second communication band corresponds to receive signals passed by the second receive filter **172**. The third communication band corresponds to receive signals passed by the third receive filter **173**. The first to third communication bands are communication bands of, for example, the 3GPP LTE standard or the 5G NR standard. In the radio-frequency module **100**, the first transmit filter **131** and the first receive filter **171** form a first duplexer. In the radio-frequency module **100**, the second transmit filter **132** and the second receive filter **172** form a second duplexer. In the radio-frequency module **100**, the third transmit filter **133** and the receive filter **173** form a third duplexer.
(37) The low-noise amplifier **121** has an input terminal and an output terminal. The low-noise amplifier **121** amplifies a receive signal inputted to the input terminal and outputs the receive signal from the output terminal. The input terminal of the low-noise amplifier **121** is coupled to a common terminal **160** of the third switch **106** via the input matching network **123**. The output terminal of the low-noise amplifier **121** is coupled to the signal output terminal **83**. The output terminal of the low-noise amplifier **121** is coupled to, for example, the signal processing circuit **301** via the signal output terminal **83**. The signal output terminal **83** is a terminal for outputting a radio-frequency signal (a receive signal) from the low-noise amplifier **121** to an external circuit (for example, the signal processing circuit **301**). In the radio-frequency module **100**, the input terminal of the low-noise amplifier **121** is couplable to the first to third receive filters **171** to **173** via the input matching network **123** and the third switch **106**. The third switch **106** has the common terminal **160** and a plurality of (for example, three) selection terminals **161** to **163**. In the radio-frequency module **100**, the input terminal of the low-noise amplifier **121** is coupled to the common terminal **160** of the third switch **106** via the input matching network **123**, and the three selection terminals **161**, **162**, and **163** of the third switch **106** are coupled to the three receive filters **171**, **172**, and **173** in one-to-one correspondence.
(38) The input matching network **123** is a circuit for providing the impedance matching between the low-noise amplifier **121** and the three receive filters **171**, **172**, and **173**. The input matching network **123** includes, for example, a second inductor L**2** (see FIG. **1**) coupled between the input terminal of the low-noise amplifier **121** and the common terminal **160** of the third switch **106**. The input matching network **123** may include, for example, a plurality of inductors and a plurality of capacitors. The radio-frequency module **100** may include a plurality of (three) input matching networks **123**; in this case, the three input matching networks **123** may be provided between the low-noise amplifier **121** and the three respective receive filters **171**, **172**, and **173**.
(39) The first switch **104** has a common terminal **140** and a plurality of (for example, three)

selection terminals **141** to **143**. Of the first switch **104**, the common terminal **140** is coupled to the antenna terminal **81**. The radio-frequency module **100** is not necessarily configured such that the common terminal **140** is coupled to the antenna terminal **81** via no circuit element; the common terminal **140** may be coupled to the antenna terminal **81** via, for example, a low pass filter and a coupler. The selection terminal **141** is coupled to a node between an output terminal of the first transmit filter **131** and the input terminal of the first receive filter **171**. The selection terminal **142** is coupled to a node between an output terminal of the second transmit filter **132** and an input terminal of the second receive filter **172**. The selection terminal **143** is coupled to a node between an output terminal of the third transmit filter **133** and an input terminal of the third receive filter **173**. The first switch **104** is, for example, a switch configured to establish the connection between the common terminal **140** and at least one or more of the three selection terminals **141** to **143**. The first switch **104** is, for example, a switch configured to establish the connection between one terminal and another one terminal and between one terminal and a plurality of terminals.

(40) The first switch **104** is controlled by, for example, the signal processing circuit **301**. Based on a control signal from the RF signal processing circuit **302** of the signal processing circuit **301**, the first switch **104** switches the connections between the common terminal **140** and the three selection terminals **141** to **143**. The first switch **104** is, for example, a switch integrated circuit (IC).

(41) The second switch **105** has the common terminal **150** and the plurality of (for example, three) selection terminals **151**, **152**, and **153**. Of the second switch **105**, the common terminal **150** is coupled to the output terminal of the power amplifier **111** via the output matching network **113**. The selection terminal **151** is coupled to an input terminal of the first transmit filter **131**. The selection terminal **152** is coupled to an input terminal of the second transmit filter **132**. The selection terminal **153** is coupled to an input terminal of the third transmit filter **133**. The second switch **105** is, for example, a switch configured to establish the connection between the common terminal **150** and at least one or more of the three selection terminals **151** to **153**. The second switch **105** is, for example, a switch configured to establish the connection between one terminal and another one terminal and between one terminal and a plurality of terminals.

(42) The second switch **105** is controlled by, for example, the signal processing circuit **301**. Based on a control signal from the RF signal processing circuit **302** of the signal processing circuit **301**, the second switch **105** switches the connections between the common terminal **150** and the three selection terminals **151** to **153**. The second switch **105** is, for example, a switch IC.

(43) The third switch **106** has the common terminal **160** and the plurality of (for example, three) selection terminals **161**, **162**, and **163**. Of the third switch **106**, the common terminal **160** is coupled to the input terminal of the low-noise amplifier **121** via the input matching network **123**. The selection terminal **161** is coupled to an output terminal of the first receive filter **171**. The selection terminal **162** is coupled to an output terminal of the second receive filter **172**. The selection terminal **163** is coupled to an output terminal of the third receive filter **173**. The third switch **106** is, for example, a switch configured to establish the connection between the common terminal **160** and at least one or more of the three selection terminals **161** to **163**. The third switch **106** is, for example, a switch configured to establish the connection between one terminal and another one terminal and between one terminal and a plurality of terminals.

(44) The third switch **106** is controlled by, for example, the signal processing circuit **301**. Based on a control signal from the RF signal processing circuit **302** of the signal processing circuit **301**, the third switch **106** switches the connections between the common terminal **160** and the three selection terminals **161** to **163**. The third switch **106** is, for example, a switch IC.

(45) (1.2) Structure of Radio-Frequency Module

(46) The radio-frequency module **100** includes, as illustrated in FIG. **1**, the mounting board **9** and the three transmit filters **131**, **132**, and **133**. The radio-frequency module **100** also includes the power amplifier **111**, the output matching network **113** (see FIG. **5**), and the controller **115** (see FIG. **2**). The radio-frequency module **100** also includes the three receive filters **171**, **172**, and **173**,

the low-noise amplifier **121**, the input matching network **123** (see FIG. **5**), the first switch **104** (see FIG. **5**), the second switch **105** (see FIG. **5**), and the third switch **106** (see FIG. **5**). The radio-frequency module **100** also includes the external connection terminals **8** (see FIG. **2**).

(47) As illustrated in FIG. **2**, the mounting board **9** has the first major surface **91** and the second major surface **92** that are opposite to each other in a thickness direction D**1** of the mounting board **9**. The mounting board **9** is, for example, a multilayer substrate including a plurality of dielectric layers and a plurality of conductive layers. The dielectric layers and the conductive layers are stacked in the thickness direction D**1** of the mounting board **9**. The conductive layers are shaped in particular patterns designed for the respective conductive layers. The conductive layers each include one or a plurality of conductive portions in one plane perpendicular to the thickness direction D**1** of the mounting board **9**. The conductive layers are made of, for example, copper. The conductive pattern layers include a ground layer. In the radio-frequency module **100**, the ground terminals **85** are electrically coupled to the ground layer by, for example, via-conductors provided in the mounting board **9**. The mounting board **9** is, for example, a low temperature co-fired ceramics (LTCC) substrate. The mounting board **9** is not limited to an LTCC substrate, and may be, for example, a printed-circuit board, high temperature co-fired ceramics (HTCC) substrate, or resin multilayer substrate.

(48) The mounting board **9** is not limited to an LTCC substrate, and may be, for example, a wiring structure. The wiring structure is, for example, a multilayer structure. The multilayer structure includes at least one insulating layer and at least one conductive layer. The insulating layer is shaped in a particular pattern. When a plurality of insulating layers are included, the insulating layers are shaped in particular patterns designed for the respective insulating layers. The conductive layer is shaped in a particular pattern different from the particular pattern of the insulating layer. When a plurality of conductive layers are included, the conductive layers are shaped in particular patterns designed for the respective conductive layers. The conductive layer may include one or a plurality of redistribution portions. In the wiring structure, of two surfaces that are opposite to each other in the thickness direction of the multilayer structure, a first surface is the first major surface **91** of the mounting board **9**, and a second surface is the second major surface **92** of the mounting board **9**. The wiring structure may be, for example, an interposer. The interposer may be an interposer made of a silicon substrate or a substrate composed of multiple layers.

(49) The first major surface **91** and the second major surface **92** of the mounting board **9** are away from each other in the thickness direction D**1** of the mounting board **9**. The first major surface **91** and the second major surface **92** of the mounting board **9** cross the thickness direction D**1** of the mounting board **9**. The first major surface **91** of the mounting board **9** is, for example, perpendicular to the thickness direction D**1** of the mounting board **9**. However, the first major surface **91** may include, for example, a side surface of a conductive portion as a surface not perpendicular to the thickness direction D**1**. The second major surface **92** of the mounting board **9** is, for example, perpendicular to the thickness direction D**1** of the mounting board **9**. However, the second major surface **92** may include, for example, a side surface of a conductive portion as a surface not perpendicular to the thickness direction D**1**. On the first major surface **91** and the second major surface **92** of the mounting board **9**, fine irregularities, or a depressed or raised portion may be formed. For example, when a depressed portion is formed on the first major surface **91** of the mounting board **9**, the inner surface of the depressed portion is included in the first major surface **91**.

(50) In the radio-frequency module **100** according to the first embodiment, circuit components of a first group are mounted on the first major surface **91** of the mounting board **9**. The circuit components of the first group include, as illustrated in FIG. **1**, the three transmit filters **131**, **132**, and **133**, the power amplifier **111**, the first inductor L**1** of the output matching network **113**, the three receive filters **171**, **172**, and **173**, and the second inductor L**2** of the input matching network **123**. The expression “circuit components are mounted on the first major surface **91** of the mounting

board **9**" includes both the state in which circuit components are disposed on (mechanically coupled to) the first major surface **91** of the mounting board **9** and the state in which circuit components are electrically coupled to (appropriate conductive portions of) the mounting board **9**. In the radio-frequency module **100**, of the plurality of circuit components, circuit components of a second group are mounted on the second major surface **92** of the mounting board **9**. The circuit components of the second group include the controller **115**, the low-noise amplifier **121**, the first switch **104**, the second switch **105**, and the third switch **106**. The expression "circuit components are mounted on the second major surface **92** of the mounting board **9**" includes both the state in which circuit components are disposed on (mechanically coupled to) the second major surface **92** of the mounting board **9** and the state in which circuit components are electrically coupled to (appropriate conductive portions of) the mounting board **9**. In the radio-frequency module **100** according to the first embodiment, as described above, the second inductor L**2**, the transmit filter **131**, the power amplifier **111**, and the receive filter **171** are respectively implemented as the first electronic component **1**, the second electronic component **4**, the third electronic component **7**, and the fourth electronic component **10**.
(51) The three transmit filters **131**, **132**, and **133** are, for example, ladder filters and each include a plurality of (for example, four) series arm resonators and a plurality of (for example, three) parallel arm resonators. The three transmit filters **131**, **132**, and **133** are, for example, acoustic wave filters. In the acoustic wave filter, a plurality of series arm resonators and a plurality of parallel arm resonators are individually formed by acoustic wave resonators. The acoustic wave filter is, for example, a surface acoustic wave filter using surface acoustic waves. In the surface acoustic wave filter, the plurality of series arm resonators and the plurality of parallel arm resonators are, for example, surface acoustic wave (SAW) resonators.
(52) The three transmit filters **131**, **132**, and **133** are, as illustrated in FIG. **1**, mounted on the first major surface **91** of the mounting board **9**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the three transmit filters **131**, **132**, and **133** is rectangular. The transmit filter **131**, which is implemented as the second electronic component **4**, includes, for example, a substrate **401** and a circuit portion **414** as illustrated in FIG. **4**. The substrate **401** has a first major surface **411** and a second major surface **412** that are opposite to each other in the thickness direction of the substrate **401**. The circuit portion **414** includes a plurality of interdigital transducer (IDT) electrodes **415** that are formed on the first major surface **411** of the substrate **401**. The transmit filter **131** includes, as elements forming the package structure, a spacer layer **417**, a cover member **418**, and a plurality of outer electrodes **45**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the transmit filter **131** is rectangular; but this is not to be interpreted as limiting, and the transmit filter **131** may be, for example, square. Of the transmit filter **131**, the substrate **401** is a piezoelectric substrate; the substrate **401** is, for example, a lithium tantalate or a lithium niobate substrate.
(53) The spacer layer **417** is disposed on the first major surface **411** side of the substrate **401**. When viewed in plan view in the thickness direction of the substrate **401**, the spacer layer **417** is provided around the IDT electrodes **415**. When viewed in plan view in the thickness direction of the substrate **401**, the spacer layer **417** is rectangular. The spacer layer **417** is electrically non-conductive. The material of the spacer layer **417** is, for example, epoxy resin or polyimide. The cover member **418** is shaped as a plate. The cover member **418** is disposed on the spacer layer **417** such that the cover member **418** faces the substrate **401** in the thickness direction of the substrate **401**. In the thickness direction of the substrate **401**, the cover member **418** overlaps the IDT electrodes **415**, but the cover member **418** is spaced apart from the IDT electrodes **415** in the thickness direction of the substrate **401**. The cover member **418** is electrically non-conductive. The material of the cover member **418** is, for example, epoxy resin or polyimide.
(54) The transmit filter **131** has a space S**1** enclosed by the substrate **401**, the spacer layer **417**, and the cover member **418**. The space S**1** is filled with gas. The gas is, for example, air or an inert gas

(for example, nitrogen gas). The outer electrodes **45** are exposed from the cover member **418**.
(55) The structure of the second transmit filter **132** and the third transmit filter **133** is the same as the structure of the first transmit filter **131**.
(56) The power amplifier **111** is an IC chip for power amplification. The power amplifier **111** is mounted on the first major surface **91** of the mounting board **9** as illustrated in FIGS. **1** and **2**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the power amplifier **111** is rectangular. The power amplifier **111** is an IC chip including a substrate and a circuit portion; the substrate has a first major surface and a second major surface that are opposite to each other; the circuit portion is formed on the first major surface side of the substrate. The substrate is, for example, a gallium arsenide substrate. The circuit portion includes the driver stage amplifier coupled to the input terminal of the power amplifier **111** and the final stage amplifier coupled to the output end of the driver stage amplifier. The driver stage amplifier and the final stage amplifier each include a transistor for amplification. The transistor for amplification is, for example, a heterojunction bipolar transistor (HBT). The power amplifier **111** may include, for example, a direct-current blocking capacitor. The power amplifier **111** is flip-chip mounted on the first major surface **91** of the mounting board **9** such that, out of the first major surface and the second major surface of the substrate, the first major surface faces the first major surface **91** side of the mounting board **9**. Thus, of the third electronic component **7**, which is implemented by the power amplifier **111**, the major surface **71** opposite to the mounting board **9** side of the third electronic component **7** is the second major surface of the substrate (a gallium arsenide substrate) included in the power amplifier **111**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the IC chip including the power amplifier **111** is rectangular. The substrate of the power amplifier **111** is not limited to a gallium arsenide substrate; the substrate of the power amplifier **111** may be, for example, a silicon substrate, silicon germanium substrate, or gallium nitride substrate. The transistor for amplification is not limited to an HBT; the transistor for amplification may be, for example, a bipolar transistor or field effect transistor (FET). The FET may be, for example, a metal-oxide-semiconductor field effect transistor (MOSFET).
(57) The first inductor L**1** included in the output matching network **113** is mounted on the first major surface **91** of the mounting board **9**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the first inductor L**1** is rectangular. The first inductor L**1** is a chip inductor. The output matching network **113** does not necessarily include only the first inductor L**1**; the output matching network **113** may include an inductor and a capacitor. When the power amplifier **111** is a differential combining amplifier, the output matching network **113** may include a transformer.
(58) The controller **115** is mounted on the second major surface **92** of the mounting board **9** as illustrated in FIG. **2**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the controller **115** is rectangular. The controller **115** is, for example, an IC chip including a substrate and a circuit portion; the substrate has a first major surface and a second major surface that are opposite to each other; the circuit portion is formed on the first major surface side of the substrate. The substrate is, for example, a silicon substrate. The circuit portion includes a control circuit for controlling the power amplifier **111** based on a control signal from the signal processing circuit **301**.
(59) The three receive filters **171**, **172**, and **173** are, for example, ladder filters and each include a plurality of (for example, four) series arm resonators and a plurality of (for example, three) parallel arm resonators. The three receive filters **171**, **172**, and **173** are, for example, acoustic wave filters. In the acoustic wave filter, a plurality of series arm resonators and a plurality of parallel arm resonators are individually formed by acoustic wave resonators. The acoustic wave filter is, for example, a surface acoustic wave filter using surface acoustic waves. In the surface acoustic wave filter, the plurality of series arm resonators and the plurality of parallel arm resonators are, for example, SAW resonators.

(60) The three receive filters **171**, **172**, and **173** are, as illustrated in FIG. **1**, mounted on the first major surface **91** of the mounting board **9**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the three receive filters **171**, **172**, and **173** is rectangular. The receive filter **171**, which is implemented as the fourth electronic component **10**, includes, for example, a substrate **1001** and a circuit portion **1014** as illustrated in FIG. **4**. The substrate **1001** has a first major surface **1011** and a second major surface **1012** that are opposite to each other in the thickness direction of the substrate **1001**. The circuit portion **1014** includes a plurality of IDT electrodes **1015** formed on the first major surface **1011** of the substrate **1001**. The receive filter **171** includes, as elements forming the package structure, a spacer layer **1017**, a cover member **1018**, and a plurality of outer electrodes **1045**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the receive filter **171** is rectangular; but this is not to be interpreted as limiting, and the receive filter **171** may be, for example, square. Of the receive filter **171**, the substrate **1001** is a piezoelectric substrate; the substrate **1001** is, for example, a lithium tantalate or a lithium niobate substrate.
(61) The spacer layer **1017** is disposed on the first major surface **1011** side of the substrate **1001**. When viewed in plan view in the thickness direction of the substrate **1001**, the spacer layer **1017** is provided around the IDT electrodes **1015**. When viewed in plan view in the thickness direction of the substrate **1001**, the spacer layer **1017** is rectangular. The spacer layer **1017** is electrically non-conductive. The material of the spacer layer **1017** is, for example, epoxy resin or polyimide. The cover member **1018** is shaped as a plate. The cover member **1018** is disposed on the spacer layer **1017** such that the cover member **1018** faces the substrate **1001** in the thickness direction of the substrate **1001**. In the thickness direction of the substrate **1001**, the cover member **1018** overlaps the IDT electrodes **1015**, but the cover member **1018** is spaced apart from the IDT electrodes **1015** in the thickness direction of the substrate **1001**. The cover member **1018** is electrically non-conductive. The material of the cover member **1018** is, for example, epoxy resin or polyimide. The receive filter **171** has a space S**2** enclosed by the substrate **1001**, the spacer layer **1017**, and the cover member **1018**. The space S**2** is filled with gas. The gas is, for example, air or an inert gas (for example, nitrogen gas). The outer electrodes **1045** are exposed from the cover member **1018**.
(62) The structure of the second receive filter **172** and the third receive filter **173** is the same as the structure of the first receive filter **171**.
(63) The low-noise amplifier **121** is mounted on the second major surface **92** of the mounting board **9** as illustrated in FIG. **2**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the low-noise amplifier **121** is rectangular. The low-noise amplifier **121** is, for example, an IC chip including a substrate and a circuit portion; the substrate has a first major surface and a second major surface that are opposite to each other; the circuit portion is formed on the first major surface side of the substrate. The substrate is, for example, a silicon substrate. The circuit portion includes a FET as a transistor for amplification configured to amplify a receive signal inputted to the input terminal of the low-noise amplifier **121**. The transistor for amplification is not limited to a FET; the transistor for amplification may be, for example, a bipolar transistor. The low-noise amplifier **121** is flip-chip mounted on the second major surface **92** of the mounting board **9** such that, out of the first major surface and the second major surface of the substrate, the first major surface faces the second major surface **92** side of the mounting board **9**.
(64) The second inductor L**2** included in the input matching network **123** (see FIG. **5**) is mounted on the first major surface **91** of the mounting board **9** as illustrated in FIGS. **1** and **2**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the contour of the second inductor L**2** is rectangular. The second inductor L**2** is a chip inductor. The input matching network **123** does not necessarily include only the second inductor L**2**; the input matching network **123** may include an inductor and a capacitor.
(65) The first switch **104**, the second switch **105**, and the third switch **106**, which are illustrated in FIG. **5**, are mounted on the second major surface **92** of the mounting board **9**. When viewed in plan

view in the thickness direction D**1** of the mounting board **9**, the contour of the first switch **104**, the second switch **105**, and the third switch **106** is rectangular. Each of the first switch **104**, the second switch **105**, and the third switch **106** is, for example, an IC chip including a substrate and a circuit portion; the substrate has a first major surface and a second major surface that are opposite to each other; the circuit portion is formed on the first major surface side of the substrate. The substrate is, for example, a silicon substrate. The circuit portion includes a plurality of FETs as a plurality of switching elements. The switching elements are not limited to FETs; the switching elements may be, for example, bipolar transistors. The first switch **104**, the second switch **105**, and the third switch **106** are flip-chip mounted on the second major surface **92** of the mounting board **9** such that, out of the first major surface and the second major surface of the substrate, the first major surface faces the second major surface **92** side of the mounting board **9**. In the radio-frequency module **100**, two or three of the first switch **104**, the second switch **105**, and the third switch **106** may be included in one IC chip.
(66) The external connection terminals **8** are arranged on the second major surface **92** of the mounting board **9** as illustrated in FIG. **2**. The expression "the external connection terminals **8** are arranged on the second major surface **92** of the mounting board **9**" includes both the state in which the external connection terminals **8** are mechanically coupled to the second major surface **92** of the mounting board **9** and the state in which the external connection terminals **8** are electrically coupled to (appropriate conductive portions of) the mounting board **9**. The material of the external connection terminals **8** is, for example, metal (for example, copper or a copper alloy). The external connection terminals **8** are columnar electrodes. The columnar electrodes may be, for example, cylindrical electrodes. The external connection terminals **8** are joined to conductive portions in the mounting board **9** by, for example, solder; but this is not to be interpreted as limiting, and the external connection terminals **8** may be joined, for example, by conductive adhesive (for example, conductive paste) or directly to the conductor portions in the mounting board **9**.
(67) The external connection terminals **8** include, as illustrated in FIGS. **2** and **5**, the antenna terminal **81**, the signal input terminal **82**, the signal output terminal **83**, a plurality of control terminals **84** (only one control terminal **84** is illustrated in FIG. **5**), and the ground terminals **85**. The ground terminals **85** are electrically coupled to the ground layer of the mounting board **9**. The ground layer serves as the circuit ground of the radio-frequency module **100**. The circuit components of the radio-frequency module **100** include circuit components electrically coupled to the ground layer.
(68) The resin layer **5** (hereinafter also referred to as the first resin layer **5**) is disposed on the first major surface **91** of the mounting board **9** as illustrated in FIG. **2**. The first resin layer **5** covers the outer side surfaces of the circuit components of the first group, which are mounted on the first major surface **91** of the mounting board **9**, out of the plurality of circuit components. The first resin layer **5** covers the outer side surface **13** of the first electronic component **1** (the second inductor L**2**), the outer side surface **43** of the second electronic component **4** (the transmit filter **131**), the outer side surface **73** of the third electronic component **7** (the power amplifier **111**), and the outer side surface **103** of the fourth electronic component **10** (the receive filter **171**). The first resin layer **5** contains a resin (for example, an epoxy resin). The first resin layer **5** may contain a filler as well as a resin.
(69) The radio-frequency module **100** further includes a second resin layer **19** disposed on the second major surface **92** of the mounting board **9**. The second resin layer **19** covers the outer side surfaces of the circuit components of the second group, which are mounted on the second major surface **92** of the mounting board **9**, and the outer side surfaces of the external connection terminals **8**. The second resin layer **19** contains a resin (for example, an epoxy resin). The second resin layer **19** may contain a filler as well as a resin. The material of the second resin layer **19** may be the same as or different from the material of the first resin layer **5**.
(70) The conductive layer **6** covers the first resin layer **5**. The conductive layer **6** is electrically

conductive. In the radio-frequency module **100**, the conductive layer **6** is provided for electromagnetic shielding between the inside and outside of the radio-frequency module **100**. The conductive layer **6** has a multilayer structure formed by stacking a plurality of metal layers; but this is not to be interpreted as limiting, and the conductive layer **6** may be formed by one metal layer. The metal layer contains one or more kinds of metals. The conductive layer **6** covers the major surface **51** of the first resin layer **5**, opposite to the mounting board **9** side of the first resin layer **5**, an outer side surface **53** of the first resin layer **5**, and an outer side surface **93** of the mounting board **9**. The conductive layer **6** also covers an outer side surface **193** of the second resin layer **19**. The conductive layer **6** is in contact with at least a portion of an outer side surface of the ground layer included in the mounting board **9**. As a result, the electric potential at the conductive layer **6** can be set at the same potential as the ground layer.

(71) The conductive layer **6** covers the major surface **11** on the mounting board **9** side of the first electronic component **1**, the major surface **41** on the mounting board **9** side of the second electronic component **4**, and the major surface **101** on the mounting board **9** side of the fourth electronic component **10**. The conductive layer **6** is in contact with the major surface **11** on the mounting board **9** side of the first electronic component **1**, the major surface **41** on the mounting board **9** side of the second electronic component **4**, and the major surface **101** on the mounting board **9** side of the fourth electronic component **10**.

(72) (1.3) Detailed Structure of Radio-Frequency Module

(73) The first electronic component **1** includes, as illustrated in FIG. **3**, the electronic component body **2** and the plurality of (for example, two) outer electrodes **3**. The electronic component body **2** has a third major surface **23** and a fourth major surface **24** that are opposite to each other in the thickness direction D**1** of the mounting board **9** (see FIG. **2**) and an outer side surface **25**. Of the electronic component body **2**, the third major surface **23**, the fourth major surface **24**, and the outer side surface **25** are electrically non-conductive. Of the first electronic component **1**, the third major surface **23** of the electronic component body **2** is the major surface **11** of the first electronic component **1**; the third major surface **23** is in contact with the conductive layer **6**. The outer electrodes **3** are arranged on the fourth major surface **24** of the electronic component body **2**, but the outer electrodes **3** are not extended over the third major surface **23**. The state in which the outer electrodes **3** are not extended over the third major surface **23** means that the outer electrodes **3** are not arranged on the third major surface **23** of the electronic component body **2**. As a result, of the first electronic component **1**, the outer electrodes **3** are not in contact with the conductive layer **6**. The outer electrodes **3** are provided over both the fourth major surface **24** of the electronic component body **2** and the outer side surface **25** of the electronic component body **2**. In other words, each outer electrode **3** includes a first portion provided on the fourth major surface **24** of the electronic component body **2**, and a second portion provided on the outer side surface **25** of the electronic component body **2** and connected to the first portion. Each outer electrode **3** is not extended to an edge between the third major surface **23** of the electronic component body **2** and the outer side surface **25**. The first electronic component **1** is an SMD. The outer electrodes **3** are joined to the mounting board **9** by joint portions **39** that are in one-to-one correspondence with the outer electrodes **3**, so that the first electronic component **1** is surface-mounted on the mounting board **9**. The material of the joint portions **39** is, for example, solder.

(74) The material of the electronic component body **2** includes a ceramic. The third major surface **23** of the electronic component body **2** is a portion of a part made of a ceramic of the electronic component body **2**. The inductor forming the first electronic component **1** (the second inductor L**2**) is a multilayer ceramic inductor. The electronic component body **2** includes a multilayer ceramic structure **20**. The second inductor L**2** includes a winding portion **26** coupled between the two outer electrodes **3**. The winding portion **26** is provided inside the multilayer ceramic structure **20**. The winding portion **26** includes a plurality of conductive layers **27** and via-conductors connecting two adjacent conductive layers **27** in the thickness direction D**1** of the mounting board **9**. The

conductive layers **27** have, for example, a C-shape when viewed in the thickness direction D**1** of the mounting board **9**. In the first electronic component **1**, the multilayer ceramic structure **20** forms an electrical insulating portion **21** of the electronic component body **2**; the winding portion **26** and the two outer electrodes **3** form a circuit element **15** included in the first electronic component **1**; the winding portion **26** forms a conductive portion **14** that is a portion of the circuit element **15**, provided inside the electrical insulating portion **21** in the electronic component body **2**. The winding axis of the second inductor L**2** is the winding axis of the winding portion **26**. The winding axis of the second inductor L**2** extends in the thickness direction D**1** of the mounting board **9** (see FIG. **2**). The winding axis of the second inductor L**2** is parallel to the thickness direction D**1** of the mounting board **9**; however, the winding axis of the second inductor L**2** is not necessarily exactly parallel to the thickness direction D**1** of the mounting board **9**, and it is sufficient that the winding axis of the second inductor L**2** be almost parallel to the thickness direction D**1** of the mounting board **9**. Almost parallel means that the angle between the winding axis and the thickness direction D**1** is 10 degrees or less. The winding axis of the second inductor L**2** is not necessarily parallel to the thickness direction D**1** of the mounting board **9**; the winding axis of the second inductor L**2** may be parallel to one direction perpendicular to the thickness direction D**1**. In the electronic component **1** of the radio-frequency module **100** according to the first embodiment, the "electronic component body **2**" is, of the electronic component **1**, a portion excluding the outer electrodes **3**; the "electronic component body **2**" is a structure that includes the electrical insulating portion **21**, which has the third major surface **23** forming the major surface **11** of the electronic component **1** and the outer side surface **25** forming a portion of the outer side surface **13** of the electronic component **1**, and that also includes the winding portion **26** provided inside the electrical insulating portion **21**. The size of the electronic component body **2** is almost the same as the size of the electronic component **1**. The electrical insulating portion **21** is shaped as, for example, a parallelepiped. The electrical insulating portion **21** is formed by a plurality of dielectric layers (ceramic layers) that are stacked.

(75) In the following, for ease of description, a reference plane RP**1** refers to a plane perpendicular to the thickness direction D**1** of the mounting board **9**, including at least a portion of the first major surface **91** of the mounting board **9**, as illustrated in FIG. **2**. In the radio-frequency module **100**, the first electronic component **1** is mounted on the first major surface **91** of the mounting board **9** such that the thickness direction of the first electronic component **1** coincides with the thickness direction D**1** of the mounting board **9**. The second electronic component **4** is mounted on the first major surface **91** of the mounting board **9** such that the thickness direction of the second electronic component **4** coincides with the thickness direction D**1** of the mounting board **9**. The major surface **11** of the first electronic component **1** and the major surface **41** of the second electronic component **4** are almost parallel to the reference plane RP**1**. In the radio-frequency module **100**, a first distance H**1** between the reference plane RP**1** and the major surface **11** of the first electronic component **1** in the thickness direction D**1** of the mounting board **9** is equal to a second distance H**2** between the reference plane RP**1** and the major surface **41** of the second electronic component **4** in the thickness direction D**1** of the mounting board **9**. The state in which the first distance H**1** is equal to the second distance H**2** is not limited to the state in which the first distance H**1** is exactly equal to the second distance H**2**; it is sufficient that the second distance H**2** be within the range of ±15% of the first distance H**1**; the second distance H**2** is preferably within the range of ±10% of the first distance H**1**, and more preferably ±5% of the first distance H**1**.

(76) In the radio-frequency module **100**, the major surface **11** of the first electronic component **1** and the major surface **41** of the second electronic component **4** are rough surfaces. In other words, in the radio-frequency module **100**, fine irregularities are formed in the major surface **11** of the first electronic component **1** and the major surface **41** of the second electronic component **4**. The major surface **11** of the first electronic component **1** may be rougher than the outer side surface **13** of the first electronic component **1**. The major surface **41** of the second electronic component **4** may be

rougher than the outer side surface **43** of the second electronic component **4**.
(77) In the radio-frequency module **100**, the first electronic component **1**, the second electronic component **4**, and the third electronic component **7** are mounted on the first major surface **91** of the mounting board **9**. The third electronic component **7** is lower in height than the first electronic component **1** and the second electronic component **4**. In other words, a third distance H**3** between the reference plane RP**1** and the major surface **71** of the third electronic component **7** in the thickness direction D**1** of the mounting board **9** is shorter than both the first distance H**1** and the second distance H**2**. The resin layer **5** covers the major surface **71** of the third electronic component **7**. In the radio-frequency module **100**, the maximum height roughness (Rz) of the major surface **11** of the first electronic component **1** and the maximum height roughness of the major surface **41** of the second electronic component **4** are greater than the maximum height roughness of the major surface **71** of the third electronic component **7**. The value of the maximum height roughness of the major surface **11** of the first electronic component **1**, the value of the maximum height roughness of the major surface **41** of the second electronic component **4**, and the value of the maximum height roughness of the major surface **71** of the third electronic component **7** are measured on STEM images obtained when the sections of the radio-frequency module **100** are observed with a scanning transmission electron microscope (STEM). The maximum height roughness is the total of the maximum peak height and the maximum valley depth of each of the major surface **11** of the electronic component **1**, the major surface **41** of the second electronic component **4**, and the major surface **71** of the third electronic component **7** in STEM images. In other words, the maximum height roughness is the peak-to-valley value of irregularities of each of the major surface **11** of the electronic component **1**, the major surface **41** of the second electronic component **4**, and the major surface **71** of the third electronic component **7**. The surface roughness of the major surface **11** of the electronic component **1** and the major surface **41** of the second electronic component is changeable, for example, in accordance with conditions for the process of making rough surfaces on the first electronic component **1** and the second electronic component **4** by processing such as grinding in the manufacturing processes for the radio-frequency module **100**. To discuss the relative differences in the maximum height roughness, the value of maximum height roughness is not necessarily obtained based on STEM images; the value of maximum height roughness may be obtained based on, for example, scanning electron microscope (SEM) images.
(78) In the radio-frequency module **100**, a fourth distance H**4** between the reference plane RP**1** and the major surface **101** of the fourth electronic component **10** in the thickness direction D**1** of the mounting board **9** is equal to the first distance H**1**. The state in which the fourth distance H**4** is equal to the first distance H**1** is not limited to the state in which the fourth distance H**4** is exactly equal to the first distance H**1**; it is sufficient that the fourth distance H**4** be within the range of ±15% of the first distance H**1**; the fourth distance H**4** is preferably within the range of ±10% of the first distance H**1**, and more preferably ±5% of the first distance H**1**.
(79) In the radio-frequency module **100**, a fifth distance H**5** between the reference plane RP**1** and the major surface **51** of the resin layer **5** in the thickness direction D**1** of the mounting board **9** is equal to the first distance H**1**. The state in which the fifth distance H**5** is equal to the first distance H**1** is not limited to the state in which the fifth distance H**5** is exactly equal to the first distance H**1**; it is sufficient that the fifth distance H**5** be within the range of ±15% of the first distance H**1**; the fifth distance H**5** is preferably within the range of ±10% of the first distance H**1**, and more preferably ±5% of the first distance H**1**.
(80) In the radio-frequency module **100**, the major surface **11** of the first electronic component **1**, the major surface **41** of the second electronic component **4**, the major surface **101** of the fourth electronic component **10**, and the major surface **51** of the resin layer **5** are flush with each other.
(81) In the radio-frequency module **100**, the first electronic component **1** is different from the second electronic component **4** with respect to the material of a portion in contact with the conductive layer **6**. The material of the portion in contact with the conductive layer **6** of the first

electronic component **1** is a ceramic. The material of the portion in contact with the conductive layer **6** of the second electronic component **4** is lithium tantalate or a lithium niobate. In the radio-frequency module **100** according to the first embodiment, the material of the portion in contact with the conductive layer **6** of the fourth electronic component **10** is the same as the material of the portion in contact with the conductive layer **6** of the second electronic component **4**, but the fourth electronic component **10** may be different from the second electronic component **4** with respect to the material.
(82) In the radio-frequency module **100** according to the first embodiment, for the purpose of improving the heat release performance, it is preferable that the conductive layer **6** be in contact with the entire major surfaces of the transmit filters **131**, **132**, and **133** on the side opposite to the mounting board **9** side.
(83) (1.4) Layout of Circuit Components in Radio-Frequency Module
(84) In the radio-frequency module **100**, when viewed in plan view in the thickness direction D**1** of the mounting board **9** (see FIG. **2**), the first transmit filter **131**, the second transmit filter **132**, and the third transmit filter **133** are arranged parallel to the direction in which the power amplifier **111** and the first inductor L**1** of the output matching network **113** (see FIG. **5**) are arranged, in the order of the first transmit filter **131**, the second transmit filter **132**, and the third transmit filter **133** in the direction from the power amplifier **111** to the first inductor L**1**, as illustrated in FIG. **1**.
(85) In the radio-frequency module **100**, when viewed in plan view in the thickness direction D**1** of the mounting board **9**, the first receive filter **171**, the second receive filter **172**, and the third receive filter **173** are arranged parallel to the direction in which the first transmit filter **131**, the second transmit filter **132**, and the third transmit filter **133** are arranged, in the order of the first receive filter **171**, the second receive filter **172**, and the third receive filter **173** in the direction from the first transmit filter **131** to the third transmit filter **133**, as illustrated in FIG. **1**.
(86) When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the second inductor L**2** of the input matching network **123** (see FIG. **5**) is adjacent to the receive filter **171** (see FIG. **1**). The expression "the second inductor L**42** is adjacent to the receive filter **171**" means that when viewed in plan view in the thickness direction D**1** of the mounting board **9**, the second inductor L**2** and the receive filter **171** are next to each other without any circuit component mounted on the first major surface **91** of the mounting board **9** between the second inductor L**2** and the receive filter **171**.
(87) In the radio-frequency module **100**, when viewed in plan view in the thickness direction D**1** of the mounting board **9**, the receive filter **171** overlaps the low-noise amplifier **121** (see FIG. **2**). When viewed in plan view in the thickness direction D**1** of the mounting board **9**, a portion of the receive filter **171** coincides with a portion of the low-noise amplifier **121**; this is not to be interpreted as limiting, and the entire portion of the receive filter **171** may coincide with the entire portion of the low-noise amplifier **121**. The entire portion of the receive filter **171** may coincide with a portion of the low-noise amplifier **121**, or the entire portion of the low-noise amplifier **121** may coincide with a portion of the receive filter **171**.
(88) In the radio-frequency module **100**, when viewed in plan view in the thickness direction D**1** of the mounting board **9**, the power amplifier **111** does not overlap the low-noise amplifier **121** (see FIG. **2**).
(89) (1.5) Method of Manufacturing Radio-Frequency Module
(90) As a method of manufacturing the radio-frequency module **100**, a manufacturing method including, for example, a first step, a second step, a third step, a fourth step, and a fifth step is usable. The first step is a step of mounting a plurality of circuit components on the mounting board **9** and disposing the external connection terminals **8**. The second step is a step of forming, on the first major surface **91** side with respect to the mounting board **9**, a first resin material layer that covers portions including the circuit components of the first group and that is later made into the first resin layer **5** and also forming, on the second major surface **92** side with respect to the

mounting board **9**, a second resin material layer that is later made into the second resin layer **19**. The third step is a step of grinding the first resin material layer from the major surface opposite to the mounting board **9** side of the first resin material layer and further grinding the first resin material layer, the first electronic component **1**, the second electronic component **4**, and the fourth electronic component **10** to form the first resin layer **5** and to make the first electronic component **1**, the second electronic component **4**, and the fourth electronic component **10** thinner. In the third step, by grinding the first electronic component **1**, the second electronic component **4**, and the fourth electronic component **10**, the major surface **11** of the first electronic component **1**, the major surface **41** of the second electronic component **4**, and the major surface **101** of the fourth electronic component **10** are made rough (roughening). The fourth step is a step of grinding the second resin material layer from the major surface opposite to the mounting board **9** side of the second resin material layer to expose the ends of the external connection terminals **8** and subsequently grinding the second resin material layer and the external connection terminals **8**, thereby forming the second resin layer **19**. The fifth step is a step of forming the conductive layer **6** in contact with the major surface **51** of the first resin layer **5** and the major surfaces **11**, **41**, and **101** opposite to the mounting board **9** side of the first electronic component **1**, the second electronic component **4**, and the fourth electronic component **10** by, for example, sputtering, vapor deposition, or printing.

(91) In the radio-frequency module **100** manufactured by the manufacturing method including the third step described above, the major surface **51** of the first resin layer **5** and the major surfaces **11**, **41**, and **101** opposite to the mounting board **9** side of the first electronic component **1**, the second electronic component **4**, and the fourth electronic component **10** are rough surfaces, and grinding marks can remain on the rough surfaces. In the method of manufacturing the radio-frequency module **100**, for the purpose of not grinding portions constructing the circuit element **15** of the first electronic component **1** in the third step, the multilayer ceramic structure **20** of the electronic component body **2** before grinding is made thick. The thickness direction of the multilayer ceramic structure **20** is parallel to the thickness direction D**1** of the mounting board **9**. In the first electronic component **1** before grinding, the portions constructing the circuit element **15** (the winding portion **26** and the outer electrodes **3**) are positioned on the mounting board **9** side in the thickness direction of the multilayer ceramic structure **20**. In other words, the shortest distance between the winding portion **26** and the surface opposite to the mounting board **9** side of the multilayer ceramic structure **20** in the thickness direction of the multilayer ceramic structure **20** is longer than the shortest distance between the winding portion **26** and the surface on the mounting board **9** side of the multilayer ceramic structure **20** in the thickness direction of the multilayer ceramic structure **20**. Similarly, the shortest distance between the outer electrodes **3** and the surface opposite to the mounting board **9** side of the multilayer ceramic structure **20** in the thickness direction of the multilayer ceramic structure **20** is longer than the shortest distance between the outer electrodes **3** and the surface on the mounting board **9** side of the multilayer ceramic structure **20** in the thickness direction of the multilayer ceramic structure **20**.

(2) Effects

(92) (2.1) Radio-Frequency Module

(93) The radio-frequency module **100** according to the first embodiment includes the mounting board **9**, the electronic component **1**, the resin layer **5**, and the conductive layer **6**. The mounting board **9** has the first major surface **91** and the second major surface **92** that are opposite to each other. The electronic component **1** is mounted on the first major surface **91** of the mounting board **9**. The resin layer **5** is provided on the first major surface **91** of the mounting board **9**. The resin layer **5** covers the outer side surface **13** of the electronic component **1**. The conductive layer **6** covers the major surface **51** of the resin layer **5**, opposite to the mounting board **9** side, and the major surface **11** of the electronic component **1**, opposite to the mounting board **9** side. The electronic component **1** includes the electronic component body **2** and the outer electrodes **3**. The electronic component body **2** includes the electrical insulating portion **21** and the conductive

portion **14** provided inside the electrical insulating portion **21**, forming at least a portion of the circuit element **15** of the electronic component **1**. The electronic component body **2** has the third major surface **23** and the fourth major surface **24**, which are opposite to each other, and the outer side surface **25**. The outer electrodes **3** are provided at the electronic component body **2**. Of the electronic component **1**, the third major surface **23** of the electronic component body **2** is the major surface **11** of the electronic component **1**; the third major surface **23** is in contact with the conductive layer **6**. The outer electrodes **3** are arranged on the fourth major surface **24** of the electronic component body **2**, but the outer electrodes **3** are not extended over the third major surface **23**.

(94) In the radio-frequency module **100** according to the first embodiment, the element value of the circuit element **15** included in the electronic component **1** can be increased. If a plurality of outer electrodes of an electronic component are extended to a third major surface of an electronic component body, the outer electrodes are in contact with a conductive layer; as a result, the outer electrodes in contact with the conductive layer are short-circuited with the conductive layer. Furthermore, when the above-described method of manufacturing a radio-frequency module is used, it is necessary to grind a portion of each outer electrode during the grinding in the third step, and as a result, the grinding becomes difficult. In the radio-frequency module **100** according to the first embodiment, the major surface **11** opposite to the mounting board **9** side of the electronic component **1** is in contact with the conductive layer **6**, but the outer electrodes **3** are not in contact with the conductive layer **6**. This structure reduces the height of the radio-frequency module **100** in the thickness direction D**1** of the mounting board **9** and also increases the element value of the circuit element **15** included in the electronic component **1**. In the radio-frequency module **100** according to the first embodiment, the element value of the circuit element **15** included in the electronic component **1** is inductance. In the radio-frequency module **100** according to the first embodiment, the third major surface **23** of the electronic component body **2** forms the major surface **11** of the electronic component **1**, and the third major surface **23** is in contact with the conductive layer **6**. This structure enables the electrical insulating portion **21** to be made thicker than the case where the electronic component **1** is not in contact with the conductive layer **6**. As a result, in the radio-frequency module **100** according to the first embodiment, it is possible to increase the turns of the winding portion **26**, which is the conductive portion **14** forming a portion of the circuit element **15** (it is possible to increase the number of conductive layers **27** and via-conductors included in the winding portion **26**), and consequently increase the inductance of the circuit element **15**.

(95) (2.2) Communication Device

(96) The communication device **300** according to the first embodiment includes the signal processing circuit **301** and the radio-frequency module **100**. The signal processing circuit **301** is coupled to the radio-frequency module **100**.

(97) Because the communication device **300** according to the first embodiment includes the radio-frequency module **100**, the element value of the circuit element **15** included in the electronic component **1** can be increased.

(98) A plurality of electronic components constituting the signal processing circuit **301** may be mounted on, for example, the circuit board described above, or a circuit board (a second circuit board) different from the circuit board having the radio-frequency module **100** (a first circuit board).

(3) Modifications of Radio-Frequency Module

(99) (3.1) First Modification

(100) A radio-frequency module **100***a* according to a first modification of the first embodiment will be described with reference to FIG. **6**. Regarding the radio-frequency module **100***a* according to the first modification, the same reference characters are assigned to the same constituent elements as the radio-frequency module **100** according to the first embodiment, and descriptions thereof are not

repeated.
(101) The radio-frequency module **100***a* according to the first modification differs from the radio-frequency module **100** according to the first embodiment in that the external connection terminals **8** are ball bumps. The radio-frequency module **100***a* according to the first modification differs from the radio-frequency module **100** according to the first embodiment also in that the second resin layer **19** (see FIG. **2**) of the radio-frequency module **100** according to the first embodiment is not included. The radio-frequency module **100***a* according to the first modification may include an underfill deposited in the gap between the circuit components of the second group (for example, the controller **115** and the low-noise amplifier **121**) mounted on the second major surface **92** of the mounting board **9** and the second major surface **92** of the mounting board **9**.
(102) The material of the ball bumps respectively forming the external connection terminals **8** is, for example, gold, copper, or solder.
(103) The external connection terminals **8** may include both the external connection terminals **8** formed by ball bumps and the external connection terminals **8** formed by columnar electrodes.
(104) (3.2) Second Modification
(105) A radio-frequency module **100***b* according to a second modification of the first embodiment will be described with reference to FIG. **7**. Regarding the radio-frequency module **100***b* according to the second modification, the same reference characters are assigned to the same constituent elements as the radio-frequency module **100** according to the first embodiment, and descriptions thereof are not repeated.
(106) The radio-frequency module **100***b* according to the second modification differs from the radio-frequency module **100** according to the first embodiment in that the controller **115** is mounted on the first major surface **91** of the mounting board **9**.
(107) In the radio-frequency module **100***b* according to the second modification, the controller **115** is implemented as the fourth electronic component **10**. The resin layer **5** covers the outer side surface **103** of the fourth electronic component **10**. The conductive layer **6** covers a major surface **101** of the fourth electronic component **10**, opposite to the mounting board **9** side. Regarding the fourth electronic component **10**, the major surface **101** of the fourth electronic component **10** is in contact with the conductive layer **6**.
(108) The controller **115** is an IC chip including a substrate **1150** and a circuit portion **1154**. The substrate **1150** has a first major surface **1151** and a second major surface **1152** that are opposite to each other. The circuit portion **1154** is formed on the first major surface **1151** side of the substrate **1150**. The substrate **1150** is, for example, a silicon substrate. The circuit portion **1154** includes a control circuit for controlling the power amplifier **111** based on a control signal from the signal processing circuit **301**.
(109) In the radio-frequency module **100***b* according to the second modification, the first electronic component **1** (see FIG. **2**), the second electronic component **4** (see FIG. **2**), and the fourth electronic component **10** are different from each other with respect to the material of a portion in contact with the conductive layer **6**. The material of the portion in contact with the conductive layer **6** of the first electronic component **1** is a ceramic. The material of the portion in contact with the conductive layer **6** of the second electronic component **4** is a piezoelectric material (lithium tantalate or lithium niobate). The material of the portion in contact with the conductive layer **6** of the fourth electronic component **10** is silicon.
(110) (3.3) Third Modification
(111) A radio-frequency module **100***c* according to a third modification of the first embodiment will be described with reference to FIGS. **8** to **11**. Regarding the radio-frequency module **100***c* according to the third modification, the same reference characters are assigned to the same constituent elements as the radio-frequency module **100** according to the first embodiment, and descriptions thereof are not repeated.
(112) The radio-frequency module **100***c* according to the third modification differs from the radio-

frequency module **100** according to the first embodiment in that a matching network **114** is coupled between the first switch **104** and a node between the output terminal of the transmit filter **131** and the input terminal of the receive filter **171**, as illustrated in FIG. **8**.
(113) The matching network **114** is a circuit for providing the impedance matching between the transmit filter **131** and the receive filter **171**, and the first switch **104**. The matching network **114** includes a capacitor C**3** and a third inductor L**3**, the capacitor C**3** being provided in a signal path r**1** between the first switch **104** and a node T**1** which connects the output terminal of the transmit filter **131** and the input terminal of the receive filter **171**, and the third inductor L**3** being coupled between the signal path r**1** and the ground.
(114) In the radio-frequency module **100***c* according to the third modification, as illustrated in FIGS. **9** and **10**, the first inductor L**1** of the output matching network **113** is mounted on the second major surface **92** of the mounting board **9**. In the radio-frequency module **100***c*, the second inductor L**2** of the input matching network **123** is mounted on the first major surface **91** of the mounting board **9**. In the radio-frequency module **100***c*, the capacitor C**3** of the matching network **114** is mounted on the first major surface **91** of the mounting board **9**. In the radio-frequency module **100***c*, the third inductor L**3** of the matching network **114** is mounted on the second major surface **92** of the mounting board **9**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the capacitor C**3** is positioned between the transmit filter **131** and the receive filter **171**. In the radio-frequency module **100***c* according to the third modification, major surfaces SL**1** and SL**3** opposite to the mounting board **9** side of the first inductor L**1** and the third inductor L**3** are exposed at a major surface **191** opposite to the mounting board **9** side of the second resin layer **19**.
(115) In the radio-frequency module **100***c* according to the third modification, the capacitor C**3** is implemented as the first electronic component **1**. The first electronic component **1** includes, as illustrated in FIG. **11**, the electronic component body **2** and the plurality of (for example, two) outer electrodes **3**. The electronic component body **2** has a third major surface **23** and a fourth major surface **24** that are opposite to each other in the thickness direction D**1** of the mounting board **9** and an outer side surface **25**. Of the electronic component body **2**, the third major surface **23**, the fourth major surface **24**, and the outer side surface **25** are electrically non-conductive. Of the first electronic component **1**, the third major surface **23** of the electronic component body **2** is the major surface **11** of the first electronic component **1**; the third major surface **23** is in contact with the conductive layer **6**. The outer electrodes **3** are arranged on the fourth major surface **24** of the electronic component body **2**, but the outer electrodes **3** are not extended over the third major surface **23**. As a result, of the first electronic component **1**, the outer electrodes **3** are not in contact with the conductive layer **6**. The outer electrodes **3** are provided over both the fourth major surface **24** of the electronic component body **2** and the outer side surface **25** of the electronic component body **2**. Each outer electrode **3** is not extended to an edge between the third major surface **23** of the electronic component body **2** and the outer side surface **25**.
(116) The material of the electronic component body **2** includes a ceramic. The third major surface **23** of the electronic component body **2** is a portion of a part made of a ceramic of the electronic component body **2**. The capacitor C**3** implemented as the first electronic component **1** is a multilayer ceramic capacitor. The electronic component body **2** includes the multilayer ceramic structure **20**, a plurality of first inner electrodes **28**, and a plurality of second inner electrodes **29**. In the capacitor C**3**, the first inner electrodes **28** are coupled to one outer electrode **3** of the two outer electrodes **3**, and the second inner electrodes **29** are coupled to the other outer electrode **3** of the two outer electrodes **3**. In the capacitor C**3**, the first inner electrodes **28** and the second inner electrodes **29** are arranged one by one in an alternating manner in the thickness direction D**1** of the mounting board **9**. In the first electronic component **1**, the multilayer ceramic structure **20** forms the electrical insulating portion **21** of the electronic component body **2**; the first inner electrodes **28** and the second inner electrodes **29**, and the two outer electrodes **3** form the circuit element **15** included in the first electronic component **1**. The element value of the circuit element **15** is

capacitance. In the first electronic component **1**, the multilayer ceramic structure **20** forms the electrical insulating portion **21** of the electronic component body **2**; the first inner electrodes **28** and the second inner electrodes **29**, and the two outer electrodes **3** form the circuit element **15** included in the first electronic component **1**; the first inner electrodes **28** and the second inner electrodes **29** form the conductive portion **14** that is a portion of the circuit element **15**, provided inside the electrical insulating portion **21** in the electronic component body **2**. In the electronic component **1** of the radio-frequency module **100***c* according to the third modification, the "electronic component body **2**" is, of the electronic component **1**, a portion excluding the outer electrodes **3**; the "electronic component body **2**" is a structure that includes the electrical insulating portion **21**, which has the third major surface **23** forming the major surface **11** of the electronic component **1** and the outer side surface **25** forming a portion of the outer side surface **13** of the electronic component **1**, and that also includes the first inner electrodes **28** and the second inner electrodes **29** provided inside the electrical insulating portion **21**. The size of the electronic component body **2** is almost the same as the size of the electronic component **1**. The electrical insulating portion **21** is shaped as, for example, a parallelepiped. The electrical insulating portion **21** is formed by a plurality of dielectric layers (ceramic layers) that are stacked.

(117) The radio-frequency module **100***c* according to the third modification also includes an IC chip **108** (see FIGS. **9** and **10**) including the low-noise amplifier **121** and the first switch **104**. The IC chip **108** is mounted on the second major surface **92** of the mounting board **9** as illustrated in FIG. **10**. Although not illustrated in the drawings, a capacitor functioning as a bypass capacitor provided in a path for supplying power to elements including the low-noise amplifier **121** is mounted on the second major surface **92** of the mounting board **9**. In the structure of the third modification illustrated in FIG. **10**, the major surfaces opposite to the mounting board **9** side of elements including the first inductor L**1**, the third inductor L**3**, and the bypass capacitor mounted on the second major surface **92** of the mounting board **9**, in other words, SMDs mounted on the second major surface **92** of the mounting board **9** are flush with the major surface **191** opposite to the mounting board **9** side of the second resin layer **19**; the major surfaces opposite to the mounting board **9** side of the SMDs are exposed at the major surface **191** of the second resin layer **19**. This structure reduces the height of the radio-frequency module **100***c*. During the manufacturing process of the radio-frequency module **100***c*, the second resin layer **19**, the SMDs disposed on the second major surface **92** of the mounting board **9**, and the external connection terminals **8** are ground from the side opposite to the mounting board **9** side, and as a result, the height of the radio-frequency module **100***c* is further reduced.

(118) When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the receive filter **171** overlaps the IC chip **108** as illustrated in FIG. **9**. When viewed in plan view in the thickness direction D**1** of the mounting board **9**, the entire portion of the receive filter **171** coincides with a portion of the IC chip **108**; this is not to be interpreted as limiting, and the entire portion of the receive filter **171** may coincide with the entire portion of the IC chip **108**. A portion of the receive filter **171** may coincide with the entire portion of the IC chip **108**, a portion of the receive filter **171** may coincide with a portion of the IC chip **108**. In the radio-frequency module **100***c* according to the third modification, the three receive filters **171**, **172**, and **173** may overlap the IC chip **108**.

(119) In the radio-frequency module **100***c*, when viewed in plan view in the thickness direction D**1** of the mounting board **9**, the transmit filter **131** does not overlap the IC chip **108** as illustrated in FIG. **9**.

(120) In the radio-frequency module **100***c* according to the third modification, as with the radio-frequency module **100** according to the first embodiment, the third major surface **23** of the electronic component body **2** of the electronic component **1** forms the major surface **11** of the electronic component **1**, and the third major surface **23** is in contact with the conductive layer **6**. The outer electrodes **3** are arranged on the fourth major surface **24** of the electronic component

body **2**, but the outer electrodes **3** are not extended over the third major surface **23**. As a result, in the radio-frequency module **100***c* according to the third modification, the element value (capacitance) of the circuit element **15** included in the electronic component **1** can be increased. In the radio-frequency module **100***c* according to the third modification, as with the radio-frequency module **100** according to the first embodiment, the third major surface **23** of the electronic component body **2** forms the major surface **11** of the electronic component **1**, and the third major surface **23** is in contact with the conductive layer **6**. This structure enables the electrical insulating portion **21** to be made thicker than the case where the electronic component **1** is not in contact with the conductive layer **6**. As a result, in the radio-frequency module **100***c* according to the third modification, it is possible to increase the number of first inner electrodes **28** and second inner electrodes **29** included in the conductive portion **14** forming a portion of the circuit element **15** (it is possible to increase the number of pairs of the first inner electrode **28** and the second inner electrode **29**), and consequently increase the capacitance of the circuit element **15**.

Second Embodiment

(121) A radio-frequency module **100***d* according to a second embodiment will be described with reference to FIGS. **12** and **13**. Regarding the radio-frequency module **100***d* according to the second embodiment, the same reference characters are assigned to the same constituent elements as the radio-frequency module **100** according to the first embodiment, and descriptions thereof are not repeated. The radio-frequency module **100***d* according to the second embodiment includes, as with the radio-frequency module **100***c* according to the third modification of the first embodiment, the IC chip **108** including the low-noise amplifier **121** and the first switch **104**. The IC chip **108** is mounted on the second major surface **92** of the mounting board **9** as illustrated in FIG. **12**.

(122) In the radio-frequency module **100***d* according to the second embodiment, one or some of the outer electrodes **45** of the second electronic component **4** are in contact with the conductive layer **6**. The outer electrode **45** in contact with the conductive layer **6** is extended through the second electronic component **4** in the thickness direction of the second electronic component **4**.

(123) In the radio-frequency module **100***d* according to the second embodiment, as illustrated in FIG. **13**, the structure of the transmit filter **131** and the structure of the receive filter **171** are different from the structure of the transmit filter **131** and the structure of the receive filter **171** in the radio-frequency module **100** according to the first embodiment.

(124) In the transmit filter **131** of the radio-frequency module **100***d* according to the second embodiment, the substrate **401** is a silicon substrate. The transmit filter **131** includes a low acoustic velocity film **420** provided on the first major surface **411** of the substrate **401** and a piezoelectric layer **430** provided on the low acoustic velocity film **420**. In the transmit filter **131**, the substrate **401**, the low acoustic velocity film **420**, and the piezoelectric layer **430** form a piezoelectric substrate. In the transmit filter **131**, the circuit portion **414** including the IDT electrodes **415** is formed on the piezoelectric layer **430**.

(125) When viewed in plan view in the thickness direction of the substrate **401**, the low acoustic velocity film **420** is positioned away from the outer periphery of the substrate **401**. The transmit filter **131** further includes an insulating layer **450** that covers, of the first major surface **411** of the substrate **401**, an area not covered with the low acoustic velocity film **420**. The insulating layer **450** is electrically non-conductive. The insulating layer **450** is formed along the outer edges of the substrate **401** on the first major surface **411** of the substrate **401**. The insulating layer **450** is provided around the IDT electrodes **415**. When viewed in plan view in the thickness direction of the substrate **401**, the insulating layer **450** is shaped as a frame (for example, a rectangular frame). A portion of the insulating layer **450** overlaps the outer periphery of the piezoelectric layer **430** in the thickness direction of the substrate **401**. The insulating layer **450** covers the outer side surface of the piezoelectric layer **430** and the outer side surface of the low acoustic velocity film **420**. The material of the insulating layer **450** is, for example, epoxy resin or polyimide.

(126) The material of the piezoelectric layer **430** is, for example, lithium niobate or lithium

tantalate. The low acoustic velocity film **420** is configured such that the velocity of a bulk wave propagating in the low acoustic velocity film **420** is lower than the velocity of a bulk wave propagating in the piezoelectric layer **430**. The material of the low acoustic velocity film **420** is, for example, silicon oxide, but not limited to silicon oxide. The velocity of a bulk wave propagating in the substrate **401** is higher than the velocity of an acoustic wave propagating along the piezoelectric layer **430**. The bulk wave propagating in the substrate **401** here denotes one bulk wave of the lowest acoustic velocity among bulk waves propagating in the substrate **401**.
(127) The transmit filter **131** may further include a high acoustic velocity film provided between the substrate **401** and the low acoustic velocity film **420**. The high acoustic velocity film is configured such that the velocity of a bulk wave propagating in the high acoustic velocity film is lower than the velocity of an acoustic wave propagating along the piezoelectric layer **430**. The material of the high acoustic velocity film may be, for example, silicon nitride. The material of the high acoustic velocity film is, however, not limited to silicon nitride, and may include at least one material selected from the group consisting of diamond-like carbon, aluminum nitride, silicon carbide, silicon nitride, silicon oxynitride, silicon, sapphire, lithium tantalate, lithium niobate, quartz-crystal, zirconia, cordierite, mullite, steatite, forsterite, magnesia, and diamond.
(128) The thickness of the piezoelectric layer **430** is, for example, 3.5λ or less, where λ is a wave length of an acoustic wave determined by the cycle period of electrode fingers of the IDT electrodes **415**. The thickness of the low acoustic velocity film **420** is, for example, 2.0λ or less.
(129) The transmit filter **131** may include, for example, a fixing layer interposed between the low acoustic velocity film **420** and the piezoelectric layer **430**. The fixing layer is made of, for example, resin (epoxy resin or polyimide resin). The transmit filter **131** may include a dielectric film between the low acoustic velocity film **420** and the piezoelectric layer **430**, on the piezoelectric layer **430**, or under the low acoustic velocity film **420**.
(130) The outer electrode **45** in contact with the conductive layer **6** is extended through the substrate **401**, the insulating layer **450**, the spacer layer **417**, and the cover member **418**. Of the outer electrode **45** in contact with the conductive layer **6**, a portion extended through the substrate **401** is, for example, a through-silicon via (TSV).
(131) In the receive filter **171** of the radio-frequency module **100***d* according to the second embodiment, the substrate **1001** is a silicon substrate. The receive filter **171** includes a low acoustic velocity film **1020** provided on the first major surface **1011** of the substrate **1001** and a piezoelectric layer **1030** provided on the low acoustic velocity film **1020**. In the receive filter **171**, the substrate **1001**, the low acoustic velocity film **1020**, and the piezoelectric layer **1030** form a piezoelectric substrate. In the receive filter **171**, the circuit portion **1014** including the IDT electrodes **1015** is formed on the piezoelectric layer **1030**.
(132) When viewed in plan view in the thickness direction of the substrate **1001**, the low acoustic velocity film **1020** is positioned away from the outer periphery of the substrate **1001**. The receive filter **171** further includes an insulating layer **1050** that covers, of the first major surface **1011** of the substrate **1001**, an area not covered with the low acoustic velocity film **1020**. The insulating layer **1050** is electrically non-conductive. The insulating layer **1050** is formed along the outer edges of the substrate **1001** on the first major surface **1011** of the substrate **1001**. The insulating layer **1050** is provided around the IDT electrodes **1015**. When viewed in plan view in the thickness direction of the substrate **1001**, the insulating layer **1050** is shaped as a frame (for example, a rectangular frame). A portion of the insulating layer **1050** overlaps the outer periphery of the piezoelectric layer **1030** in the thickness direction of the substrate **1001**. The insulating layer **1050** covers the outer side surface of the piezoelectric layer **1030** and the outer side surface of the low acoustic velocity film **1020**. The material of the insulating layer **1050** is, for example, epoxy resin or polyimide.
(133) The material of the piezoelectric layer **1030** is, for example, lithium niobate or lithium tantalate. The low acoustic velocity film **1020** is configured such that the velocity of a bulk wave propagating in the low acoustic velocity film **1020** is lower than the velocity of a bulk wave

propagating in the piezoelectric layer **1030**. The material of the low acoustic velocity film **1020** is, for example, silicon oxide. The material of the low acoustic velocity film **1020** is, however, not limited to silicon oxide, and may include at least one material selected from the group consisting of tantalum oxide, and compounds made by adding fluorine, carbon, or boron to silicon oxide.
(134) The receive filter **171** may further include a high acoustic velocity film provided between the substrate **1001** and the low acoustic velocity film **1020**.
(135) In the radio-frequency module **100***d* according to the second embodiment, as with the radio-frequency module **100** according to the first embodiment, the third major surface **23** (see FIG. **3**) of the electronic component body **2** of the electronic component **1** forms the major surface **11** of the electronic component **1**, and the third major surface **23** is in contact with the conductive layer **6**. The outer electrodes **3** are arranged on the fourth major surface **24** of the electronic component body **2**, but the outer electrodes **3** are not extended over the third major surface **23** (see FIG. **3**). As a result, in the radio-frequency module **100***d* according to the second embodiment, the element value (inductance) of the circuit element **15** (see FIG. **3**) included in the electronic component **1** can be increased.
(136) Further, in the radio-frequency module **100***d* according to the second embodiment, the outer electrode **45** in contact with the conductive layer **6** is extended through the second electronic component **4** in the thickness direction of the second electronic component **4**. This structure makes the ground in the transmit filter **131** implemented as the second electronic component **4** stronger.
Other Modifications
(137) The first and second embodiments described above are merely examples of various embodiments of the present disclosure. Various modifications to the above examples including the first and second embodiments may be made for, for example, different designs when the possible benefits of the present disclosure can be achieved; different constituent elements of different embodiments may be combined in any appropriate manner.
(138) For example, in the first electronic component **1**, the outer electrodes **3** are not necessarily provided over both the fourth major surface **24** and the outer side surface **25** of the electronic component body **2**; it is sufficient that the outer electrodes **3** be provided over the fourth major surface **24** out of the fourth major surface **24** and the outer side surface **25**.
(139) The first electronic component **1** is not limited to an inductor or capacitor; the first electronic component **1** may be, for example, an LC filter as illustrated in FIG. **14**. The first electronic component **1** implemented by the LC filter illustrated in FIG. **14** includes four outer electrodes **3** provided over the fourth major surface **24** and the outer side surface **25** of the electronic component body **2**. The four outer electrodes **3** include an outer electrode **3** corresponding to an input terminal of the LC filter, an outer electrode **3** corresponding to an output terminal of the LC filter, and two outer electrodes **3** corresponding to two ground terminals of the LC filter. When the first electronic component **1** is an LC filter, the circuit elements included in the first electronic component **1** are an inductor and a capacitor. The LC filter is, for example, a low pass filter or a high pass filter. When the LC filter is, for example, a low pass filter, the LC filter is provided in a signal path between the antenna terminal **81** (see FIG. **5**) and the first switch **104** (see FIG. **5**).
(140) In the radio-frequency modules **100***a*, **100***b*, **100***c*, and **100***d*, the resin layer **5** does not necessarily cover the entire portion of the outer side surface **13** of the first electronic component **1**; it is sufficient that the resin layer **5** cover at least a portion of the outer side surface **13**. The resin layer **5** does not necessarily cover the entire portion of the outer side surface **43** of the second electronic component **4**; it is sufficient that the resin layer **5** cover at least a portion of the outer side surface **43**. The resin layer **5** does not necessarily cover the entire portion of the outer side surface **73** of the third electronic component **7**; it is sufficient that the resin layer **5** cover at least a portion of the outer side surface **73**. The resin layer **5** does not necessarily cover the entire portion of the major surface **71** of the third electronic component **7**; it is sufficient that the resin layer **5** cover at least a portion of the major surface **71**. The resin layer **5** does not necessarily cover the entire

portion of the outer side surface **103** of the fourth electronic component **10**; it is sufficient that the resin layer **5** cover at least a portion of the outer side surface **103**.
(141) In the radio-frequency modules **100***a*, **100***b*, **100***c*, and **100***d*, the conductive layer **6** does not necessarily cover the entire portion of the major surface **51** of the resin layer **5**; it is sufficient that the conductive layer **6** cover at least a portion of the major surface **51** of the resin layer **5**. The conductive layer **6** does not necessarily cover the entire portion of the major surface **11** of the first electronic component **1**; it is sufficient that the conductive layer **6** cover at least a portion of the major surface **11** of the first electronic component **1**. The conductive layer **6** does not necessarily cover the entire portion of the major surface **41** of the second electronic component **4**; it is sufficient that the conductive layer **6** cover at least a portion of the major surface **41** of the second electronic component **4**. The conductive layer **6** does not necessarily cover the entire portion of the major surface **101** of the fourth electronic component **10**; it is sufficient that the conductive layer **6** cover at least a portion of the major surface **101** of the fourth electronic component **10**.
(142) In the radio-frequency module **100**, when viewed in plan view in the thickness direction D**1** of the mounting board **9**, the first electronic component **1** may be positioned between the first inductor L**1** included in the output matching network **113** and the second inductor L**2** included in the input matching network **123**. In this case, in the radio-frequency module **100**, it is possible to inhibit the electromagnetic coupling between the first inductor L**1** included in the output matching network **113** and the second inductor L**2** included in the input matching network **123**.
(143) In the radio-frequency modules **100***a*, **100***b*, **100***c*, and **100***d*, the circuit components of the second group to be mounted on the second major surface **92** of the mounting board **9** may be mounted on the first major surface **91** instead of the second major surface **92** of the mounting board **9**. In this case, in the radio-frequency modules **100***a*, **100***b*, **100***c*, and **100***d*, no circuit component is mounted on the second major surface **92** of the mounting board **9**.
(144) In the radio-frequency modules **100**, **100***b*, and **100***d*, as with the radio-frequency module **100***c*, the major surface opposite to the mounting board **9** side of a circuit component mounted on the second major surface **92** of the mounting board **9** (a second-major-surface-side electronic component) may be exposed at the major surface **191** opposite to the mounting board **9** side of the second resin layer **19**. This structure reduces the height of the radio-frequency modules **100**, **100***b*, and **100***d*. The circuit component mounted on the second major surface **92** of the mounting board **9** and having the major surface exposed opposite to the mounting board **9** side may be, for example, a capacitor, an inductor, an LC filter, an acoustic wave filter, and an IC chip. The circuit component mounted on the second major surface **92** of the mounting board **9** and having the major surface exposed opposite to the mounting board **9** side may be a multilayer ceramic capacitor or a capacitor formed on a silicon substrate.
(145) The transmit filters **131** to **133** and the receive filters **171** to **173** are not limited to surface acoustic wave filters; the transmit filters **131** to **133** and the receive filters **171** to **173** may be, for example, bulk acoustic wave (BAW) filters. A resonator in the BAW filter is, for example, a film bulk acoustic resonator (FBAR) or solidly mounted resonator (SMR). The BAW filter includes a substrate. The substrate is, for example, a silicon substrate.
(146) The transmit filters **131** to **133** and the receive filters **171** to **173** are not limited to ladder filters; the transmit filters **131** to **133** and the receive filters **171** to **173** may be, for example, longitudinally coupled resonator-type surface acoustic wave filters.
(147) The acoustic wave filters use a surface acoustic wave or bulk acoustic wave; but this is not to be interpreted as limiting; the acoustic wave filters may be acoustic wave filters using, for example, a boundary acoustic wave or plate wave.
(148) The circuit configuration of the radio-frequency modules **100** to **100***d* is not limited to the examples described above. The radio-frequency modules **100** to **100***d* may include, as a circuit configuration, for example, a multi input multi output (MIMO) radio-frequency front-end circuit.
(149) The communication device **300** according to the first embodiment may include, instead of the

radio-frequency module **100**, the radio-frequency module **100***a*, **100***b*, **100***c*, or **100***d*.

Aspects

(150) This specification discloses the following aspects.

(151) A radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a first aspect includes a mounting board (**9**), an electronic component (**1**), a resin layer (**5**), and a conductive layer (**6**). The mounting board (**9**) has a first major surface (**91**) and a second major surface (**92**) that are opposite to each other. The electronic component (**1**) is mounted on the first major surface (**91**) of the mounting board (**9**). The resin layer (**5**) is provided on the first major surface (**91**) of the mounting board (**9**). The resin layer (**5**) covers at least a portion of an outer side surface (**13**) of the electronic component (**1**). The conductive layer (**6**) covers at least a portion of a major surface (**51**) opposite to the mounting board (**9**) side of the resin layer (**5**) and at least a portion of a major surface (**11**) opposite to the mounting board (**9**) side of the electronic component (**1**). The electronic component (**1**) includes an electronic component body (**2**) and a plurality of outer electrodes (**3**). The electronic component body (**2**) includes an electrical insulating portion (**21**) and a conductive portion (**14**) provided inside the electrical insulating portion (**21**), forming at least a portion of a circuit element (**15**) of the electronic component (**1**). The electronic component body (**2**) has a third major surface (**23**) and a fourth major surface (**24**), which are opposite to each other, and an outer side surface (**25**). In the electronic component (**1**), the third major surface (**23**) of the electronic component body (**2**) forms the major surface (**11**) of the electronic component (**1**), and the third major surface (**23**) is in contact with the conductive layer (**6**). The plurality of outer electrodes (**3**) are provided on the fourth major surface (**24**) of the electronic component body (**2**), but the plurality of outer electrodes (**3**) are not extended over the third major surface (**23**).

(152) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the first aspect, the element value of the circuit element (**15**) included in the electronic component (**1**) can be increased.

(153) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a second aspect, with respect to the first aspect, the plurality of outer electrodes (**3**) are provided over both the fourth major surface (**24**) of the electronic component body (**2**) and the outer side surface (**25**) of the electronic component body (**2**).

(154) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the second aspect, the strength of connecting the mounting board (**9**) and the electronic component (**1**) can be improved.

(155) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a third aspect, with respect to the first or second aspect, the electronic component (**1**) is a capacitor, an inductor, or an LC filter.

(156) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the third aspect, when the electronic component (**1**) is a capacitor (C**3**), the capacitance can be increased; when the electronic component (**1**) is an inductor (the second inductor L**2**), the inductance can be increased; when the electronic component (**1**) is an LC filter, at least either the inductance of an inductor included in the LC filter or the capacitance of a capacitor included in the LC filter can be increased.

(157) In the radio-frequency module according to a fourth aspect, with respect to the third aspect, the material of the electrical insulating portion (the multilayer ceramic structure **20**) includes a ceramic. The third major surface (**23**) of the electronic component body (**2**) is a portion of a part made of a ceramic of the electronic component body (**2**).

(158) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a fifth aspect, with respect to the fourth aspect, the electronic component (**1**) is a multilayer ceramic capacitor, a multilayer ceramic inductor, or a multilayer ceramic LC filter.

(159) The radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a sixth aspect, with respect to any one of the first to fifth aspects, includes a second electronic component (**4**) different from a first electronic component (**1**) that is the electronic component (**1**); the second electronic

component (**4**) is mounted on the first major surface (**91**) of the mounting board (**9**). The resin layer (**5**) covers at least a portion of an outer side surface (**43**) of the second electronic component (**4**). The conductive layer (**6**) covers at least a portion of a major surface (**41**) opposite to the mounting board (**9**) side of the second electronic component (**4**). The major surface (**41**) of the second electronic component (**4**) is in contact with the conductive layer (**6**).
(160) The height of the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the sixth aspect can be reduced.
(161) In the radio-frequency module (**100***d*) according to the seventh aspect, with respect to the sixth aspect, the second electronic component (**4**) includes a plurality of outer electrodes (**45**). One or some outer electrodes (**45**) of the plurality of outer electrodes (**45**) of the second electronic component (**4**) are in contact with the conductive layer (**6**).
(162) In the radio-frequency module (**100***d*) according to the seventh aspect, one or some outer electrodes (**45**) of the second electronic component (**4**) are electrically coupled to the conductive layer (**6**).
(163) In the radio-frequency module (**100***d*) according to the eighth aspect, with respect to the seventh aspect, the one or some outer electrodes (**45**) of the plurality of outer electrodes (**45**) are extended through the second electronic component (**4**) in the thickness direction of the second electronic component (**4**).
(164) In the radio-frequency module (**100***d*) according to the eighth aspect, the ground in the second electronic component (**4**) is made stronger.
(165) The radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a ninth aspect, with respect to any one of the sixth to eighth aspects, the second electronic component (**4**) includes a substrate (**401**) and a circuit portion (**414**). The substrate (**401**) has a first major surface (**411**) and a second major surface (**412**) that are opposite to each other. The circuit portion (**414**) is formed on the first major surface (**411**) side of the substrate (**401**). In the second electronic component (**4**), the second major surface (**412**) of the substrate (**401**) forms the major surface (**41**) of the second electronic component (**4**). The second electronic component (**4**) is an acoustic wave filter or integrated circuit (IC) chip.
(166) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*) according to the tenth aspect, with respect to the ninth aspect, the second electronic component (**4**) is an acoustic wave filter. The substrate (**401**) is a lithium tantalate substrate or a lithium niobate substrate.
(167) In the radio-frequency module (**100***d*) according to an eleventh aspect, with respect to the ninth aspect, the substrate (**401**) is a silicon substrate.
(168) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the twelfth aspect, with respect to any one of the sixth to eleventh aspects, when a plane including at least a portion of the first major surface (**91**), perpendicular to a thickness direction (D**1**) of the mounting board (**9**), is designated as a reference plane (RP**1**), a first distance (H**1**) between the reference plane (RP**1**) and the major surface (**11**) of the first electronic component (**1**) is equal to a second distance (H**2**) between the reference plane (RP**1**) and the major surface (**41**) of the second electronic component (**4**).
(169) The height of the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the twelfth aspect in the thickness direction (D**1**) of the mounting board (**9**) can be reduced.
(170) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the thirteenth aspect, with respect to any one of the sixth to twelfth aspects, the major surface (**11**) of the first electronic component (**1**) and the major surface (**41**) of the second electronic component (**4**) are rough surfaces.
(171) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the thirteenth aspect, the fixity of the major surface (**11**) of the first electronic component (**1**) and the major surface (**41**) of the second electronic component (**4**) with the conductive layer (**6**) can be improved.
(172) The radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the fourteenth

aspect, with respect to the thirteenth aspect, further includes a third electronic component (**7**). The third electronic component (**7**) is mounted on the first major surface (**91**) of the mounting board (**9**). The third electronic component (**7**) is lower in height than the first electronic component (**1**) and the second electronic component (**4**). The resin layer (**5**) covers a major surface (**71**) opposite to the mounting board (**9**) side of the third electronic component (**7**). The maximum height roughness of the major surface (**11**) of the first electronic component (**1**) and the maximum height roughness of the major surface (**41**) of the second electronic component (**4**) are greater than the maximum height roughness of the major surface (**71**) of the third electronic component (**7**).
(173) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the fourteenth aspect, the fixity of the major surface (**11**) of the first electronic component (**1**) and the major surface (**41**) of the second electronic component (**4**) with the conductive layer (**6**) can be improved.
(174) The radio-frequency module (**100***b*) according to the fifteenth aspect, with respect to the fourteenth aspect, further includes a fourth electronic component (**10**) mounted on the first major surface (**91**) of the mounting board (**9**). The resin layer (**5**) covers at least a portion of an outer side surface (**103**) of the fourth electronic component (**10**). The conductive layer (**6**) covers at least a portion of a major surface (**101**) opposite to the mounting board (**9**) side of the fourth electronic component (**10**). The major surface (**101**) of the fourth electronic component (**10**) is in contact with the conductive layer (**6**). The first electronic component (**1**), the second electronic component (**4**), and the fourth electronic component (**10**) are different from each other with respect to the material of a portion in contact with the conductive layer (**6**).
(175) The radio-frequency module (**100***c*) according to the sixteenth aspect, with respect to any one of the sixth to fourteenth aspects, further includes a fourth electronic component (**10**). The fourth electronic component (**10**) is mounted on the first major surface (**91**) of the mounting board (**9**). The second electronic component (**4**) is a transmit filter (**131**). The fourth electronic component (**10**) is a receive filter (**171**). When viewed in plan view in the thickness direction (D**1**) of the mounting board (**9**), the first electronic component (**1**) is positioned between the second electronic component (**4**) and the fourth electronic component (**10**).
(176) In the radio-frequency module (**100***c*) according to the sixteenth aspect, the electromagnetic coupling between the transmit filter (**131**) implemented as the second electronic component (**4**) and the receive filter (**171**) implemented as the fourth electronic component (**10**) is inhibited. Moreover, in the radio-frequency module (**100***c*) according to the sixteenth aspect, the transmit filter (**131**) as the second electronic component (**4**) is in contact with the conductive layer (**6**). This structure suppresses the temperature increase of the transmit filter (**131**). As a result, in the radio-frequency module (**100***c*), the temperature characteristic of the transmit filter (**131**) is made stable, and consequently, the characteristics of the radio-frequency module (**100***c*) can be made stable.
(177) The radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the seventeenth aspect, with respect to any one of the first to sixteenth aspects, further includes a power amplifier (**111**), an output matching network (**113**), a low-noise amplifier (**121**), and an input matching network (**123**). The power amplifier (**111**) is mounted on the first major surface (**91**) of the mounting board (**9**). The output matching network (**113**) is coupled to an output terminal of the power amplifier (**111**). The low-noise amplifier (**121**) is mounted on the second major surface (**92**) of the mounting board (**9**). The input matching network (**123**) is coupled to an input terminal of the low-noise amplifier (**121**). The output matching network (**113**) includes a first inductor (L**1**). The input matching network (**123**) includes a second inductor (L**2**). When viewed in plan view in the thickness direction (D**1**) of the mounting board (**9**), the electronic component (**1**) is positioned between the first inductor (L**1**) and the second inductor (L**2**).
(178) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the seventeenth aspect, it is possible to inhibit the electromagnetic coupling between the first inductor (L**1**) included in the output matching network (**113**) and the second inductor (L**2**) included in the input matching network (**123**).

(179) The radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the eighteenth aspect, with respect to any one of the first to seventeenth aspects, further includes a plurality of external connection terminals (**8**). The plurality of external connection terminals (**8**) are provided on the second major surface (**92**) of the mounting board (**9**). The plurality of external connection terminals (**8**) include a ground terminal (**85**) coupled to the conductive layer (**6**).
(180) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the eighteenth aspect, the electric potential at the conductive layer (**6**) can be set at almost the same potential as the ground terminal (**85**).
(181) The radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a nineteenth aspect, with respect to any one of the first to eighteenth aspects, further includes a circuit component (the first inductor L**1**, the third inductor L**3**) mounted on the second major surface (**92**) of the mounting board (**9**).
(182) When viewed in plan view in the thickness direction (D**1**) of the mounting board (**9**), the size of the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the nineteenth aspect can be reduced.
(183) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a twentieth aspect, with respect to the nineteenth aspect, the circuit component is a capacitor, an inductor, an LC filter, an acoustic wave filter, or an IC chip.
(184) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to the twentieth aspect, when the circuit component is a capacitor, the capacitance can be increased; when the circuit component is an inductor (the first inductor L**1**, the third inductor L**3**), the inductance can be increased; when the circuit component is an LC filter, at least either the inductance of an inductor included in the LC filter or the capacitance of a capacitor included in the LC filter can be increased.
(185) In the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to a twenty-first aspect, with respect to the twentieth aspect, the circuit component is a multilayer ceramic capacitor or a capacitor formed on a silicon substrate.
(186) The radio-frequency module (**100**; **100***b*; **100***c*; **100***d*) according to the twenty-second aspect, with respect to any one of the nineteenth to twenty-first aspects, further includes a second resin layer (**19**) different from a first resin layer (**5**) that is the resin layer (**5**). The second resin layer (**19**) is provided on the second major surface (**92**) of the mounting board (**9**), and the second resin layer (**19**) covers at least a portion of an outer side surface of the circuit component.
(187) In the radio-frequency module (**100**; **100***b*; **100***c*; **100***d*) according to the twenty-second aspect, the circuit component is protected by the second resin layer (**19**).
(188) In the radio-frequency module (**100**; **100***b*; **100***c*; **100***d*) according to a twenty-third aspect, with respect to the twenty-second aspect, a major surface (SL**1**, SL**3**) opposite to the mounting board (**9**) side of the circuit component (the first inductor L**1**, the third inductor L**3**) is exposed at a major surface (**191**) opposite to the mounting board (**9**) side of the second resin layer (**19**).
(189) The height of the radio-frequency module (**100**; **100***b*; **100***c*; **100***d*) according to the twenty-third aspect can be reduced.
(190) A communication device (**300**) according to a twenty-fourth aspect includes the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*) according to any one of the first to twenty-third aspects and a signal processing circuit (**301**). The signal processing circuit (**301**) is coupled to the radio-frequency module (**100**; **100***a*; **100***b*; **100***c*; **100***d*).
(191) In the communication device (**300**) according to the twenty-fourth aspect, the element value of the circuit element (**15**) included in the electronic component (**1**) can be increased. **1** electronic component (first electronic component) **11** major surface (first major surface) **13** outer side surface **14** conductive portion **15** circuit element **2** electronic component body **20** multilayer ceramic structure **21** electrical insulating portion **23** third major surface **24** fourth major surface **25** outer side surface **26** winding portion **27** conductive layer **28** first inner electrode **29** second inner electrode **3** outer electrode **4** second electronic component **41** major surface **43** outer side surface

45 outer electrode **401** substrate **411** first major surface **412** second major surface **414** circuit portion **415** IDT electrode **417** spacer layer **418** cover member **420** low acoustic velocity film **430** piezoelectric layer **5** resin layer (first resin layer) **51** major surface **53** outer side surface **6** conductive layer **7** third electronic component **8** external connection terminal **81** antenna terminal **82** signal input terminal **83** signal output terminal **84** control terminal **85** ground terminal **9** mounting board **91** first major surface **92** second major surface **93** outer side surface **10** fourth electronic component **101** major surface **103** outer side surface **1045** outer electrode **1001** substrate **1011** first major surface **1012** second major surface **1014** circuit portion **1015** IDT electrode **1017** spacer layer **1018** cover member **19** second resin layer **191** major surface **193** outer side surface **104** first switch **140** common terminal **141**, **142**, **143** selection terminal **105** second switch **150** common terminal **151**, **152**, **153** selection terminal **106** third switch **160** common terminal **161**, **162**, **163** selection terminal **108** IC chip **111** power amplifier **113** output matching network **114** matching network **115** controller **1150** substrate **1151** first major surface **1152** second major surface **1154** circuit portion **121** low-noise amplifier **123** input matching network **131** transmit filter (first transmit filter) **132** transmit filter (second transmit filter) **133** transmit filter (third transmit filter) **171** receive filter (first receive filter) **172** receive filter (second receive filter) **173** receive filter (third receive filter) **100**, **100***a*, **100***b*, **100***c*, **100***d* radio-frequency module **300** communication device **301** signal processing circuit **302** RF signal processing circuit **303** baseband signal processing circuit **310** antenna C**3** capacitor D**1** thickness direction H**1** first distance H**2** second distance H**3** third distance H**4** fourth distance H**5** fifth distance L**1** first inductor SL**1** major surface L**2** second inductor L**3** third inductor SL**3** major surface r**1** signal path T**1** node

Claims

1. A radio-frequency module comprising: a mounting board having a first major surface and a second major surface, the first major surface and the second major surface being opposite to each other; a first electronic component mounted on the first major surface of the mounting board; a first resin layer provided on the first major surface of the mounting board, the first resin layer covering at least a portion of an outer side surface of the first electronic component; and a conductive layer covering at least a portion of a major surface opposite to a mounting board side of the first resin layer and at least a portion of a major surface opposite to a mounting board side of the first electronic component, wherein the first electronic component includes an electronic component body including an electrical insulating portion and a conductive portion provided inside the electrical insulating portion, the conductive portion forming at least a portion of a circuit element of the first electronic component, the electronic component body having a third major surface, a fourth major surface and an outer side surface, the third major surface and the fourth major surface being opposite to each other, and a plurality of outer electrodes, and in the first electronic component, the third major surface of the electronic component body forms the major surface of the first electronic component, and the third major surface of the electronic component body is in contact with the conductive layer, and the plurality of outer electrodes are provided on the fourth major surface of the electronic component body, and the plurality of outer electrodes are not extended over the third major surface.
2. The radio-frequency module according to claim 1, wherein the plurality of outer electrodes are provided over both the fourth major surface of the electronic component body and the outer side surface of the electronic component body.
3. The radio-frequency module according to claim 1, wherein the first electronic component is a capacitor, an inductor, or an LC filter.
4. The radio-frequency module according to claim 3, wherein a material of the electrical insulating portion includes a ceramic, and the third major surface of the electronic component body is a portion of a ceramic part of the electronic component body.

5. The radio-frequency module according to claim 4, wherein the first electronic component is a multilayer ceramic capacitor, a multilayer ceramic inductor, or a multilayer ceramic LC filter.
6. The radio-frequency module according to claim 1, further comprising: a second electronic component different from the first electronic component, the second electronic component being mounted on the first major surface of the mounting board, wherein the first resin layer covers at least a portion of an outer side surface of the second electronic component, the conductive layer covers at least a portion of a major surface opposite to a mounting board side of the second electronic component, and the major surface of the second electronic component is in contact with the conductive layer.
7. The radio-frequency module according to claim 6, wherein the second electronic component includes a plurality of outer electrodes, and one or some outer electrodes of the plurality of outer electrodes of the second electronic component are in contact with the conductive layer.
8. The radio-frequency module according to claim 7, wherein the one or some outer electrodes of the plurality of outer electrodes are extended through the second electronic component in a thickness direction of the second electronic component.
9. The radio-frequency module according to claim 6, wherein the second electronic component includes a substrate having a first major surface and a second major surface, the first major surface and the second major surface being opposite to each other, and a circuit portion provided on a first major surface side of the substrate, in the second electronic component, the second major surface of the substrate forms the major surface of the second electronic component, and the second electronic component is an acoustic wave filter or an integrated circuit (IC) chip.
10. The radio-frequency module according to claim 9, wherein the second electronic component is the acoustic wave filter, and the substrate is a lithium tantalate substrate or a lithium niobate substrate.
11. The radio-frequency module according to claim 9, wherein the substrate is a silicon substrate.
12. The radio-frequency module according to claim 6, wherein when a plane including at least a portion of the first major surface, perpendicular to a thickness direction of the mounting board, is designated as a reference plane, a first distance between the reference plane and the major surface of the first electronic component is equal to a second distance between the reference plane and the major surface of the second electronic component.
13. The radio-frequency module according to claim 6, wherein the major surface of the first electronic component and the major surface of the second electronic component are rough surfaces.
14. The radio-frequency module according to claim 13, further comprising: a third electronic component mounted on the first major surface of the mounting board, the third electronic component being lower in height than the first electronic component and the second electronic component, wherein the first resin layer covers a major surface opposite to a mounting board side of the third electronic component, and each of a maximum height roughness of the major surface of the first electronic component and a maximum height roughness of the major surface of the second electronic component is greater than a maximum height roughness of the major surface of the third electronic component.
15. The radio-frequency module according to claim 14, further comprising: a fourth electronic component mounted on the first major surface of the mounting board, wherein the first resin layer covers at least a portion of an outer side surface of the fourth electronic component, the conductive layer covers at least a portion of a major surface opposite to a mounting board side of the fourth electronic component, the major surface of the fourth electronic component is in contact with the conductive layer, and the first electronic component, the second electronic component, and the fourth electronic component are different from each other with respect to a material of a portion in contact with the conductive layer.
16. The radio-frequency module according to claim 6, further comprising: a fourth electronic component mounted on the first major surface of the mounting board, wherein the second

electronic component is a transmit filter, the fourth electronic component is a receive filter, and when viewed in plan view in a thickness direction of the mounting board, the first electronic component is positioned between the second electronic component and the fourth electronic component.

17. The radio-frequency module according to claim 1, further comprising: a power amplifier mounted on the first major surface of the mounting board; an output matching network coupled to an output terminal of the power amplifier; a low-noise amplifier mounted on the second major surface of the mounting board; and an input matching network coupled to an input terminal of the low-noise amplifier, wherein the output matching network includes a first inductor, the input matching network includes a second inductor, and when viewed in plan view in a thickness direction of the mounting board, the first electronic component is positioned between the first inductor and the second inductor.

18. The radio-frequency module according to claim 1, further comprising: a plurality of external connection terminals provided on the second major surface of the mounting board, wherein the plurality of external connection terminals include a ground terminal coupled to the conductive layer.

19. The radio-frequency module according to claim 1, further comprising: a circuit component mounted on the second major surface of the mounting board.

20. The radio-frequency module according to claim 19, wherein the circuit component is a capacitor, an inductor, an LC filter, an acoustic wave filter, or an IC chip.

21. The radio-frequency module according to claim 20, wherein the circuit component is a multilayer ceramic capacitor or a capacitor provided on a silicon substrate.

22. The radio-frequency module according to claim 19, further comprising: a second resin layer different from the first resin layer, wherein the second resin layer is provided on the second major surface of the mounting board, and the second resin layer covers at least a portion of an outer side surface of the circuit component.

23. The radio-frequency module according to claim 22, wherein a major surface opposite to a mounting board side of the circuit component is exposed at a major surface opposite to a mounting board side of the second resin layer.

24. A communication device comprising: the radio-frequency module according to claim 1; and a signal processing circuit coupled to the radio-frequency module.