



US010574208B2

(12) **United States Patent**
Goto et al.

(10) **Patent No.:** **US 10,574,208 B2**
(45) **Date of Patent:** **Feb. 25, 2020**

(54) **ACOUSTIC WAVE FILTERS WITH
THERMALLY CONDUCTIVE SHEET**

(71) Applicant: **Skyworks Solutions, Inc.**, Woburn,
MA (US)

(72) Inventors: **Rei Goto**, Osaka (JP); **Toru Yamaji**,
Nagaokakyou (JP)

(73) Assignee: **Skyworks Solutions, Inc.**, Woburn,
MA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/011,367**

(22) Filed: **Jun. 18, 2018**

(65) **Prior Publication Data**

US 2018/0367116 A1 Dec. 20, 2018

Related U.S. Application Data

(60) Provisional application No. 62/522,603, filed on Jun.
20, 2017, provisional application No. 62/522,588,
filed on Jun. 20, 2017.

(51) **Int. Cl.**

H03H 9/02 (2006.01)
H03H 9/10 (2006.01)
H04B 1/38 (2015.01)
H04B 11/00 (2006.01)
H03H 9/145 (2006.01)
H03H 9/25 (2006.01)
H03H 9/64 (2006.01)
H03H 9/72 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC **H03H 9/02834** (2013.01); **H03F 3/19**
(2013.01); **H03F 3/195** (2013.01); **H03F 3/21**
(2013.01); **H03F 3/245** (2013.01); **H03H**

9/02559 (2013.01); **H03H 9/02897** (2013.01);
H03H 9/0576 (2013.01); **H03H 9/1064**
(2013.01); **H03H 9/145** (2013.01); **H03H 9/25**
(2013.01); **H03H 9/6483** (2013.01); **H03H**
9/6489 (2013.01); **H03H 9/725** (2013.01);
H04B 1/38 (2013.01); **H04B 11/00** (2013.01);
H04B 15/00 (2013.01); **H03F 2200/451**
(2013.01)

(58) **Field of Classification Search**

CPC **H03H 9/02834**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,037,176 A 7/1977 Ono et al.
5,446,330 A 8/1995 Eda et al.
(Continued)

OTHER PUBLICATIONS

Kadota, et al., "Improved Quality Factor of Hetero Acoustic Layer
(HAL) SAW Resonator Combining LiTaO₃ Thin Plate and Quartz
Substrate," 2017 IEEE International Ultrasonics Symposium (IUS),
Sep. 2017.

Primary Examiner — Wen W Huang

(74) *Attorney, Agent, or Firm* — Knobbe, Martens, Olson
& Bear, LLP

(57) **ABSTRACT**

Aspects of this disclosure relate to a surface acoustic wave
assembly that includes a first surface acoustic wave filter, a
second surface acoustic wave filter, and a thermally con-
ductive sheet configured to dissipate heat from the first
surface acoustic wave filter in an area corresponding to the
second surface acoustic wave filter. The thermally conduc-
tive sheet can be thinner than a piezoelectric layer of the first
surface acoustic wave filter. Related radio frequency mod-
ules and methods are disclosed.

20 Claims, 8 Drawing Sheets

