A frequency reconfigurable slot dipole antenna using surface PIN diodes

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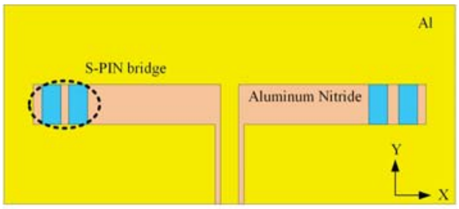
***Abstract*—We propose a frequency reconfigurable slot dipole antenna mounted with surface PIN (S-PIN) diodes. Instead of using conventional chip-packaged PIN diodes, a plasma channels induced on the S-PIN diodes with high carrier concentrations are used to electrically change effective lengths of the slots. Thus, by turning on and off the S-PIN diodes, we can make our antenna operate in three different frequency bands. Reasonably high realized gain near at each resonant frequency confirms that the plasma channel well mimics a desired metallic property rather than absorbing RF signals. In addition, we can also estimate appropriate conductivity of the proposed S-PIN diodes by parametric study of simulations, which was not clear in conventional researches.**

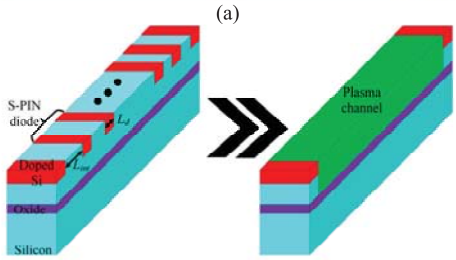
Keywords — Surface PIN diode; frequency reconfigurable antenna; slot dipole antenna

I. INTRODUCTION

Frequency reconfigurable antennas (FRAs) have widely been studied to cope with problems of increasing data traffic and lack of frequency resources. For various FRAs, active RF elements such as PIN or varactor diodes have drawn great attentions [1-3]. For instance, operating frequencies can be controlled by changing current paths according to ON and OFF states of PIN diodes. There have also been challenging attempts to integrate bare semiconductor devices, which are known as surface PIN (S-PIN) diodes, into various antennas [4-6]. Although the studies have shown promising feasibility of fully silicon based FRAs, most of the studies have not compared carrier concentrations with specific conductivity that is essentially required to evaluate how well the S-PIN behaves like metal. In this paper, we mount S-PIN diodes on a slot dipole antenna, which is reconfigurable according to the states of the S-PIN diode. Moreover, we can also evaluate the conductivity range of the S-PIN diodes from intensive simulations.



(a)



(b)

Fig. 1. (a) Antenna configuration and (b) left: real configuration of S-PIN diodes, right: an equivalent channel representing S-PIN diodes used in simulations

II. ANTENNA CONFIGURATION WITH S-PIN

The configuration of the slot dipole antenna is shown in Fig. 1(a). The antenna has two radiating slots fed by a 50 Ω coplanar waveguide, and two semiconductor channels are attached at far end part of each slot. An aluminum nitride substrate is used for its high thermal conductivity, which is suitable to dissipate the heat generated from the S-PIN diodes [4]. A configuration of the S-PIN diodes and a channel models used in antenna simulations are given in Fig. 1(b), in which the plasma channel has effective conductivity representing those of whole S-PIN diodes. In order that the S-PIN diodes provide

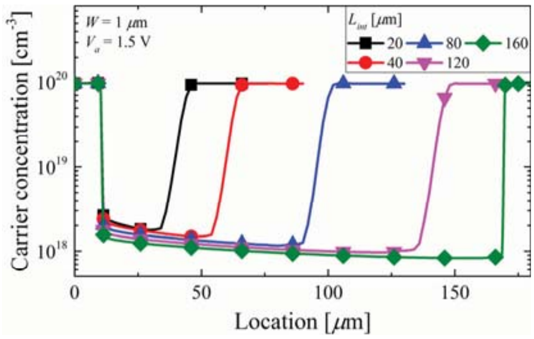


Fig. 2. Carrier concentration of the S-PIN diode (W: S-PIN's width, V_a: activating voltage)

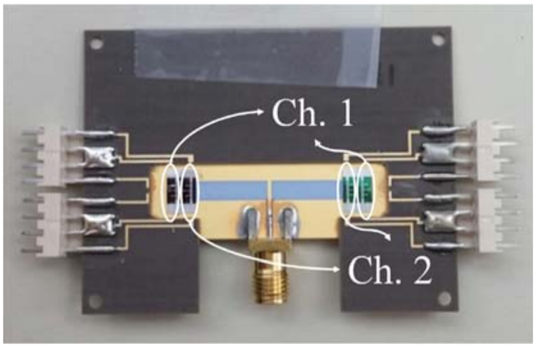
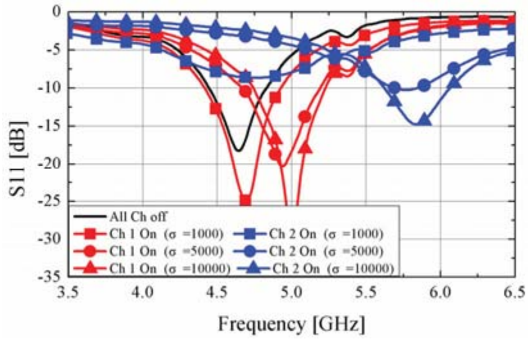
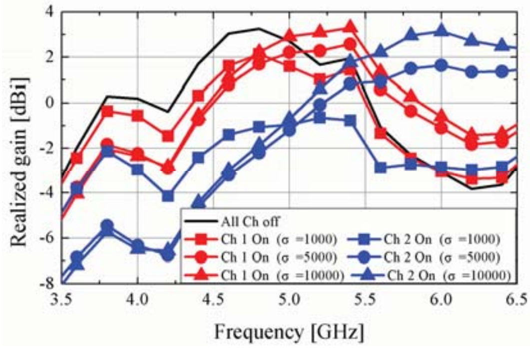


Fig. 3. Fabricated antenna with the S-PIN diodes and external bias lines



(a)



(b)

Fig. 4. (a) Comparison of reflection coefficients and (b) comparison of realized gain

enough high conductivity within acceptable DC power consumption, we trade off the length of the S-PIN diode by considering carrier concentration shown in Fig 2. As a result, in fabrication, each bridge consists of 4 groups of the channels, and each group has 9 or 12 unit S-PIN diodes.

III. Antenna performance

The fabricated antenna with S-PIN diodes and DC bias lines are given in Fig. 3. For the channel, we have fabricated two different types S-PIN diodes with the L_{int} of 20 and 40 μm and the same L_d, but the lengths of the S-PIN bridges are fixed at 3 mm. Antenna input reflection coefficients (S11) and realized gain varying with the channels' states are shown in Fig. 4. As we expected, the operating frequency hops well according to the states of the S-PIN diodes. In addition, parametric results show that the conductivity of the S-PIN diodes should be higher than at least 5000 S/m for good impedance matching and high antenna gain. Accordingly, we can expect the effective conductivity of the S-PIN diodes with respect to the carrier concentrations.

IV. Conclusion

In this paper, we propose a frequency reconfigurable slot dipole antenna. To make the antenna electrically tunable, we have installed S-PIN diodes working as changeable current paths according to their ON and OFF states. The S-PIN diodes were designed considering carrier concentrations for enough conductivity to control the effective length of the radiation slots. Also, we suggest that the conductivity of the S-PIN diode should have at least 5000 S/m for desirable reconfigurable operation.

Acknowledgment

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