Extended Abstracts of the 2014 International Conference on Solid State Devices and Materials, Tsukuba, 2014, pp972-973

# A Flexible Antenna Using a Parylene Film for Wirelessly-Powered Neural Recording Devices

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**Abstract**

**This paper presents a flexible antenna using a parylene film for wireless neural recording devices in which such an antenna requires the flexibility to fit the shape of a brain surface for wireless power transmission. The proposed antenna was fabricated by the metal line coated by a flexible parylene film to make suitable for implantable because a parylene is good biocompatibility. The fabricated parylene film antenna has a gain of -23.05 dBi in vertical direction in saline at frequency of 270 MHz. Furthermore, the effectiveness of the fabricated antenna was also confirmed through demonstration of wireless power transmission using a CMOS rectifier chip for implantable wirelessly-powered devices.**

## 1. Introduction

Neural interfaces have been studied in order to monitor neural activity for several applications such as the brain machine interface (BMI) and scientific researches. The wired neural interface has problems that restrain the BMI user by wired device and increase the risk of infection. Therefore, wireless power transmission (WPT) for neural interface devices is required for long-term implant and measurement to the brain. Although the method using electromagnetic induction by the two coils has been realized, it is difficult to align these two coils and it is short range of communication distance [1]. WPT by radio waves have been proposed to solve these problems [2]. In addition, it is important to understand the change of the characteristics when embedding it on the brain surface.

This study proposes a flexible parylene film antenna to fit the shape of a brain surface which is suitable for implantable wireless neural recording device as shown in Fig.1. The purpose is to assess the behavior of the antenna embedded on the brain through the design, fabrication and measurement of the antenna for WPT.

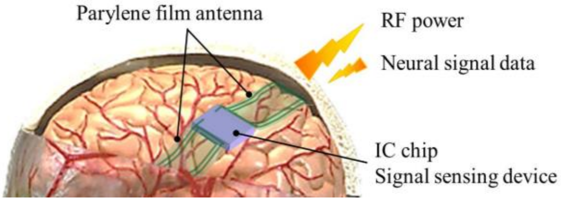


Fig. 1 Concept of implantable wireless neural recording device

## 2. Design of a parylene film antenna

The antenna was designed by using a dipole antenna model because it is difficult to determine the reference as ground when embedding it on the brain. A low frequency radio wave is suitable for WPT because it's lower absorption into the brain tissue [3]. Therefore the antenna line was patterned spiral form to turn down the resonance frequency as shown in Fig.2 [4]. The parylene film antenna has the size of 10mm × 60mm × 5 μm, and the metal line is patterned as the width of 500 μm, the gap of 500 μm and the thickness of 220 nm.

The parylene film antenna was fabricated on a silicon wafer. First, titanium layer is sputtered on a silicon wafer as a sacrificial layer. A parylene is deposited and metal line is patterned. A parylene is deposited thereon and an antenna pads are opened by plasma etching. By etching the sacrificial layer, the parylene film is released from the silicon wafer.

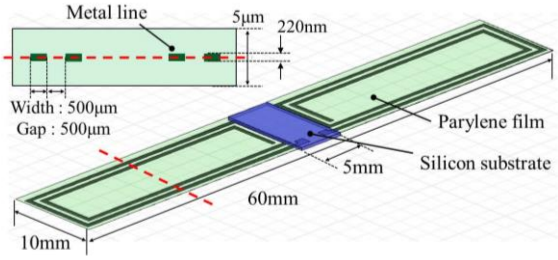


Fig. 2 Design of a parylene film antenna

## 3. Experimental results

The antenna characteristics were assessed by measuring the fabricated antenna immersed in saline as shown in Fig.3. Fig.4 shows the return loss characteristics in air and saline. The resonance frequency shift was observed from 450 to 290 MHz by simulated result and from 405 to 270 MHz by measured result, when the antenna is immersed in saline from air. Fig.5 shows the radiation pattern of X-Z plane of the fabricated antenna in saline, and it was similar to the shape of the standard dipole antenna. The antenna gain in vertical direction was measured by -23.05 dBi and it means the power transmission efficiency of this antenna is about 0.5 % at distance of 10 cm.

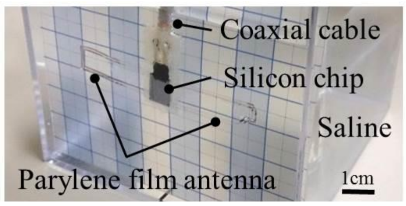


Fig. 3 Measurement systems for characteristics of fabricated antenna immersed in saline

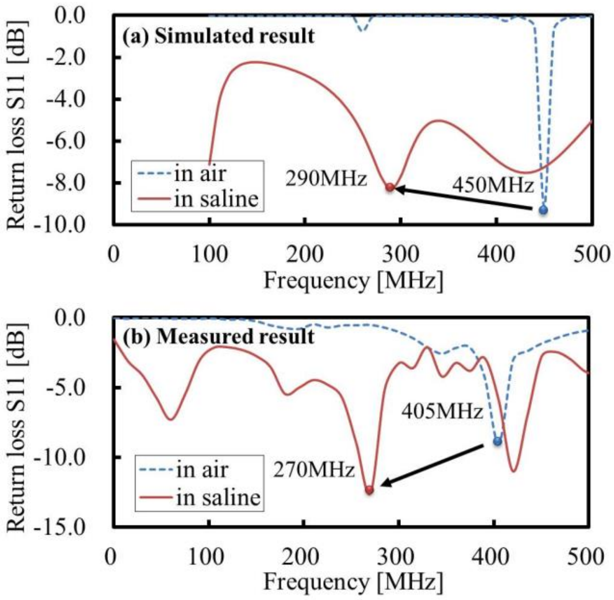


Fig. 4 Simulated and Measured return loss characteristics ($S_{11}$)
(a) Simulated result, (b) Measured result

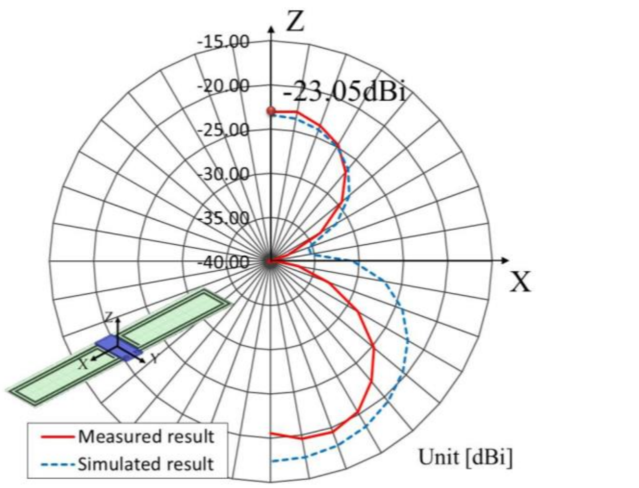


Fig. 5 Radiation pattern of fabricated antenna in saline (XZ-plane)

## 4. Demonstration of Wireless Power Transmission

We demonstrated WPT using the proposed parylene film antenna with a rectifier chip and an impedance matching circuit as shown in Fig.6. Here, a rectifier chip is used a full wave rectifier configuration [5] which has been designed by using CMOS process. Fig.7 shows the full wave rectifier chip photograph and the received circuits of WPT. The RF signal of frequency of 270 MHz and power of 20 dBm was transmitted from the Tx antenna to the fabricated Rx antenna at distance of 10 cm. The load resistance of 100 kΩ and the capacitance of 100 μF were connected to the output port of the rectifier. Fig.8 shows the observed output voltage of the rectifier on an oscilloscope. The output capacitor was charged up during the RF signal was input. The output voltage was confirmed to increase to 680 mV in about 17 seconds after. The WPT total efficiency seen from the transmitting antenna to rectifier was about -40dB (0.01%) including a loss of matching network.

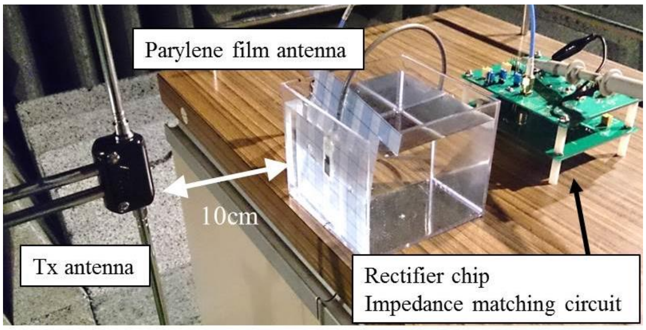


Fig. 6 Measurement systems of WPT demonstration

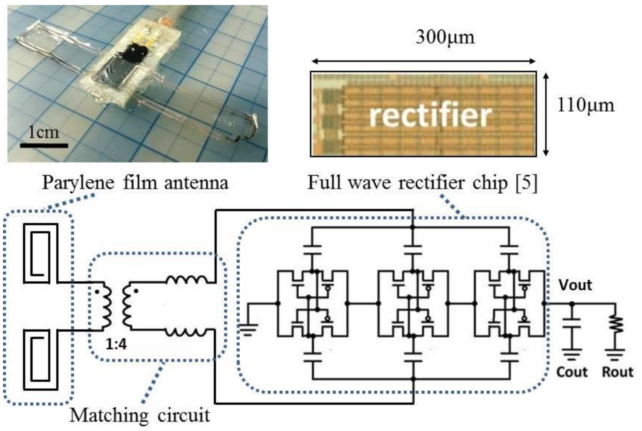


Fig. 7 Full wave rectifier chip and circuits of WPT system

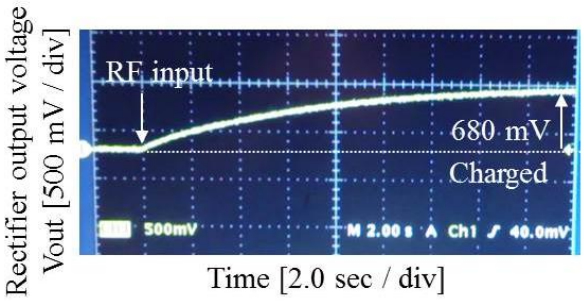


Fig. 8 Measured rectifier output voltage in WPT

## 5. Conclusion

The resonance frequency shift of the parylene film antenna was confirmed through immersion in saline. The transmission efficiency of the antenna in saline was about 0.5 % at a distance of 10 cm. The WPT demonstration using the fabricated antenna and the rectifier circuit was exemplified to be able to supply a power to following circuits by using radio wave. Therefore, the parylene film antenna is expected to apply as a received antenna of WPT for wireless neural recording device.

## References


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