# A Study on Vibration Dynamics of Bionic Auditory Membrane for Artificial Cochlea

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**ABSTRACT**

The cochlea in the inner ear is an important organ for hearing. In this work, we develop a novel artificial cochlea using P(VDF-TrFE) to realize the fully implantable system for sensorineural hearing loss by microfabrication and thin films technologies. The device consists of a piezoelectric membrane made of P(VDF-TrFE) fabricated on a silicon substrate and discrete electrodes on the surface. The membrane converts mechanical deformation induced by acoustic waves to electric signals due to the piezoelectric effect. The geometry of the membrane is designed to realize the frequency selectivity at the range of 500 ~ 5,000 Hz. The experiment is carried out to investigate the vibrating characteristics of the membrane. To model the cochlear duct, the device is mounted on a substrate with a fluid channel filled with silicone oil. The results show that the resonant frequency is changed along the position due to the varying local mechanical boundary condition governed by the geometrical configuration. Furthermore, based on the relationship between position and the resonant frequency, it is found that the device can realize the frequency selectivity at the range of 1.45 ~ 10.65 kHz.

Keywords: Artificial cochlea, Frequency selectivity, P (VDF-TrFE), Vibration, Fluid-structure interaction

## 1. Introduction

Hearing is very important for human to communicate with others. In particular, children who have problem with their hearing get into trouble in their growth and the quality of life. In normal hearing, sound waves are converted into vibrations of basilar membrane (BM) in the inner ear. The hair cells on BM convert the sound wave into electric signals which are transferred to the brain via auditory nerve [1][2]. At present, there are several prostheses, i.e. cochlear implant, to help human who have hearing impairment that caused by malfunction of the hair cells in the cochlea. These cochlear implants consist of two parts; implantable stimulating electrodes (receiver and electrodes) and an extracorporeal device (batteries, processor and microphone). In our research we develop a fully implantable and self contained artificial cochlea using the piezoelectric membrane made of P(VDF-TrFE). The

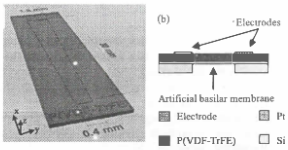


Fig. 1 Schematic of artificial cochlea (a) three dimensional view and (b) cross sectional view

frequency of acoustic wave range from 500 to 5,000 Hz by the device, the width of the membrane is linearly changed from 0.4 to 1.2 mm along $x$, whereas the length is designed to be 30 mm. The artificial cochlea is fabricated based on MEMS (Microelectromechanical