Experimental Study on Vibrating Characteristics of Piezoelectric Artificial Cochlea in Air and Liquid

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Abstract

In this paper, we report the basic vibrating characteristics of the piezoelectric artificial cochlea which consists of piezoelectric and trapezoidal membrane. The width of the membrane is linearly changed from 2.0 to 4.0 mm and the length is 30 mm. The geometry is theoretically designed to realize the frequency selectivity from 0.7 to 3.6 kHz in the lymph liquid. The measurement on the vibrating characteristics is conducted to clarify the effect of the fluid-structure interaction. Consequently, it is found that the fluid with the higher density decreases the resonant frequency of the membrane by increasing the effective mass for the vibration.

Keywords: Artificial cochlea, Frequency selectivity, Vibration, Resonant frequency

1. Introduction

Cochleae are one of the important organs for hearing in the human and animals. In particular, children who have some problems in their hearing get into trouble in their growth and the quality of life.

In this research, we developed a novel piezoelectric artificial basilar membrane for a fully implantable and self contained artificial cochlea. This artificial basilar membrane can detect the frequency and magnitude of acoustic waves. To clarify the vibrating characteristics of the membrane, we carried out the some experiments. The device consists of an artificial basilar membrane made of a piezoelectric material and a fluid channel under the membrane. To realize the frequency selectivity, the shape of the membrane is designed to be trapezoidal. As a model of scala tympani, the fluid channel is designed. The membrane could be assumed as a thin plate and the oscillatory dynamics of the artificial basilar membrane can be predicted using a thin plate bending model with the plane stress conditions [3].

The artificial basilar membrane is made of polyvinyllidinedifluoride (PVDF) (KUREHA, JAPAN) with the thickness of 40 μm. The Young's modulus and the density of PVDF are 4 GPa and 1790 kg/m^3, respectively. The trapezoidal shape is designed as the length of 30 mm along x direction with the varying width from 2.0 to 4.0 mm. The artificial basilar membrane is placed on the fluid channel during the both experiment. Design of the fluid channel is 17 and 4 mm in width and depth, respectively.

The 24 electrodes are fabricated on the upper surface of the artificial basilar membrane. These electrodes are used to measure the electric signal generated by the piezoelectric effect of PVDF.

2.2. Experiment

For both experiments, the acoustic waves are produced by a speaker (FOSTEX, JAPAN) with the magnitude of 75 dBSPL and applied through the atmosphere to the upper side of the artificial basilar membrane. The vibrating amplitude is measured using