Microfabricated Shearing Probes for Measuring Material Properties of the Tectorial Membrane at Audio Frequencies

J.W. Gu, A.J. Aranyosi, W. Hemmert, D.M. Freeman
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The tectorial membrane (TM) is ideally located to exert shearing forces on sensory hair cells in the cochlea in response to sound. Consequently, measuring the shear impedance of the TM is important for understanding the mechanical basis of hearing. However, few direct measurements of TM shear impedance exist, because the small size of the TM and the need to measure its properties at audio frequencies render traditional impedance measurement methods infeasible. We have overcome these limitations by designing and microfabricating shearing probes that are comparable in size to the TM and that can exert forces at audio frequencies.

The probes consist of systems of cantilevers designed to apply forces in two dimensions (Figure 1). Forces applied to the base of the probe are coupled through the cantilevers to a shearing plate, which is brought into contact with the TM. By measuring the relative deflection of the base and plate and knowing the probe stiffness, we can determine the shear impedance of the TM. A variety of probes with different stiffnesses and geometries allow measurement of impedance over many orders of magnitude. Figure 2 shows a probe whose shearing plate is in contact with the TM. To determine TM impedance at audio frequencies, we have coupled these probes to a computer microvision system that allows measurements of nanometer-scale motions at high frequencies [1]. The probes were calibrated, and could exert forces with amplitudes in the range 3-300 nN at frequencies from 10-9000 Hz, a large fraction of the hearing range. Measurements of TM shear impedance, using these microfabricated probes, have helped to characterize this enigmatic component of the cochlea.

REFERENCES: