A Silicon Directional Microphone With Second-Order Directivity Inspired by the Ears of the Parasitoi Fly, Ormia Ochracea

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Abstract:
A prototype of a miniature microphone that is capable of achieving second-order directional sensitivity to sound was successfully fabricated and tested. A second-order directional microphone detects the difference between the gradients measured at two locations, yielding an estimate of the second spatial derivative of the pressure. The diaphragms we designed were inspired by our earlier studies of directional hearing in the fly Ormia ochracea. They have significant potential for overcoming challenges that compromise the performance of traditional second-order microphones. Measured results are shown for devices that have been fabricated out of polycrystalline silicon [1].

Research Summary:
A microphone diaphragm concept has been demonstrated that can achieve a second-order directional response. This is accomplished by creating a diaphragm that consists of two first-order differential microphone diaphragms that are coupled together by a flexible hinge. The first-order differential microphone diaphragm developed is inspired by the mechanically coupled ears of the fly Ormia ochracea. It is designed to behave like a rigid plate that rotates about a highly compliant central hinge due to an applied moment resulting from an incident sound wave [2-4].

Microphones that exhibit directionally sensitive response to acoustic pressures must detect differences in the pressure at a minimum of two spatial locations. First-order directional microphones detect the difference in pressure at two points, which for small separations between the measurement points, is proportional to the pressure gradient. Second-order directional microphones detect the difference between the gradients measured at two locations, yielding an estimate of the second spatial derivative of the pressure. While second-order directional microphones may be shown to provide a greater ability to reject off-axis unwanted sounds, they also suffer from significantly reduced sensitivity compared to that of first-order microphones, particularly at low frequencies. In addition, their performance is very strongly influenced by any inaccuracies in phase or amplitude in the detected pressures.

The second-order microphone diaphragms we designed have significant potential for overcoming challenges that compromise the performance of traditional second-order microphones. They have been designed and fabricated out of polysilicon according to the concept shown in Figure 1 [5]. The design of the diaphragms is described in reference [6]. Figure 2 shows a fabricated device along with an image of the design model. The
diaphragm design incorporates stiffeners to ensure that the two coupled first-order diaphragms vibrate according to the desired shape depicted in Figure 1.

The sound-induced vibration of the fabricated devices measured using a Polytec scanning laser vibrometer is shown in Figure 3 along with the deflection that is predicted using a finite element model. The figure shows that the fabricated device vibrates in the essential mode shape in which the two differential microphone diaphragms vibrate in the manner shown in Figure 1. The response to sound is shown to be proportional to the difference in the gradients detected by the two coupled diaphragms [1].

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References:


