Research Topic : **MEMS Rotational Disk Oscillators for High-Frequency Sensors**
Duration : **2005-2007**
Sponsor(s) : **U.S. Army and CAMP/Clarkson University**
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Synopsis of Research and Sponsored Projects

A free-standing rotational oscillator has been developed as a novel detection element in mass sensing in liquid and air media. Traditional oscillators, such as cantilever beams, operate in out-of-plane vibrational modes, which limit the operation frequencies, and result in excessive stresses and high damping (low Q factor) in the device leading to reduced measurement sensitivities. High damping associated with out-of-plane motion is particularly dominant in liquids. Rotational oscillators would drastically decrease damping and stress in liquid phase by providing a rotational mode. Our main research objective is to gain fundamental understanding in vibrational motion of such disks and their uses in practical sensing applications.

In current implementation, the central disk made of SOI wafers is 80 μm in diameter and 5 μm thick, with six spokes extending at regular intervals (Figs. 1 and 2). The spokes are also 5 μm thick, while being 35 μm long, and 2 μm wide. These dimensions were found to provide a rotational oscillator meeting the mode separation requirements. The first two modes were in the range of 500 kHz.

Following a design and analysis effort, a number of test structures have been fabricated at the *Cornell NanoScale Science and Technology Facility* (CNF). The sample disks are tested and characterized at PAR lab using air-coupled excitation in conjunction with a laser vibrometer sensing to determine their resonance frequencies and mode shapes for extracting their Young's modulus, and the stiffness of the spokes.

Experimental results obtained in the PAR lab indicate that the rotational disk has the potential to operate and sense mass in various out-of-plane and in-plane modes. This hybrid operation capability has the potential to significantly increase the sensitivity and selectivity of sensing devices based on the proposed rotational disk design. Our current research interest has focused on the sensing and excitation mechanisms, and applications of these rotational oscillators in sensing chemical and biological agents.

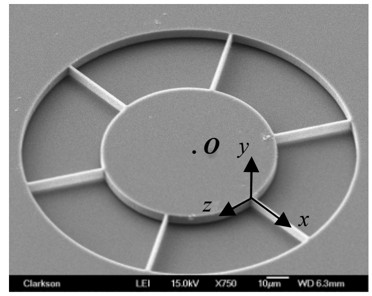

Fig. 1. SEM image of the microscale rotational oscillator.

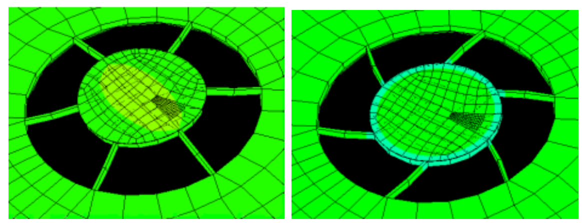

Fig. 2. Vibrational out-of-plane and in-plane modes of the rotational oscillator as determined by FE Analysis.

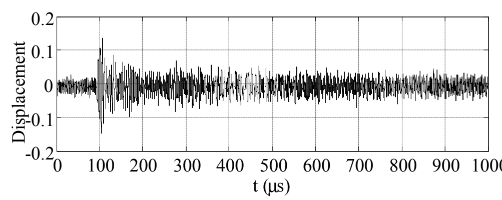

Fig. 3(a). Transient response of the rotational disk under air-coupled excitation.

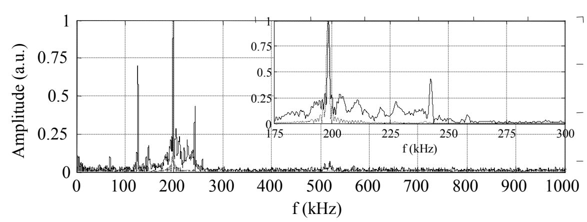

Fig. 3(b). Frequency spectrum of the disk oscillator response.

Recent Publications

J.Ricci, C. Cetinkaya, *Non-contact Method for the Testing and Evaluation of Micro-scale Structures*, Review of Scientific Instruments, Vol. 78, No. 5, 2007.