Microfluidics integrated in MEMS resonators for biosensing

Proposers

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Introduction

MEMS resonators have the potential of being extremely sensitive mass sensors. With appropriate surface functionalization, these mass sensors can be used as transducers in biosensing. The main challenge to achieve high mass sensitivity results from the need to operate in water, a dense and viscous fluid. An alternative that was proposed and demonstrated by Manalis at MIT was to integrate a microchannel in the MEMS resonator, which would then vibrate in air or vacuum. The complexity of the system, built by a combination of bulk and surface micromachining in SOI wafers plus complex encapsulation procedures, has limited its practical application. Thin-film silicon MEMS, with their large-area, low processing temperature capabilities, as well as easier to integrate bulk micromachining techniques will facilitate fluidic integration in the MEMS devices.

Partner 1

The Thin-Film MEMS and BioMEMS group at INESC MN has extensive experience developing and characterizing thin-film silicon MEMS resonators as well as PDMS-based microfluidics.

Partner 2

The Microfabrication and Exploratory Nanotechnology group of INL has deep expertise in integration of technologies, combining MEMS/NEMS, flexible devices, sensors, semiconductors and magnetic detectors, graphene and microfluidic features into unique systems.

Project outline/goal

Several approaches for integration of fluidics in MEMS will be taken: (i) in the first, a surface micromachined channel implemented in a thin-film silicon microresonator will be implemented, in which a silica structure is defined with a core Al sacrificial layer or alternatively the silicon films are machined with a SiO2 sacrificial layer, selectively removed at the end of the fabrication.; (ii) in the second, an open capillary system will be defined with the MEMS bridge or cantilever resonator. Both approaches will use PDMS-based microfluidics to interface with the microchannels in the MEMS structure. (iii) in the third, one will explore an approach in which buried microfluidics channels are defined underneath surfaces (on a Si substrate or thin film) in a process combining deep reactive ion etching (DRIE) of Si, XeF_2 isotropic etching for defining the buried channels and followed by closing the channels by means of a thick passivation layer. Such approach also allows obtaining topography-free, Si substrates in which sensors and electronics can still be processed atop. Since the resonance measurements will be performed in air, the MEMS structure will be optimized for its quality factor in this medium. The effect of the presence of a filled microchannel in the resonator performance will be studied. After detailed characterization, the sensitivity of the transducer to the presence of biomarkers such as nucleic acids, proteins, and cell will be studied.

Student profile

Profile sought: preference, but not limited, to students with a background in Engineering Physics and Materials Science and Engineering and an interest in exploring complex advanced microsystems for practical applications. Experience in Micro and Nanofabrication would be helpful.