Imaging MEMS motion at nano scale by time-resolved scanning electron microscopy

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Background
Reconfigurable micro-optics and on-chip integrated photonics often rely on micro-opto-electro-mechanical-systems to provide dynamical optical processing such as beam steering and focusing or optical coupling and phase tuning. In the process of design and fabrication of micro-electro-mechanical-systems (MEMS), and to assess their quality, a local and direct measurement of their motion on a point-by-point basis would provide unprecedented supporting information. Such a technique must be fast enough to track the MEMS dynamics with sub-micron resolution.

Methods
We introduce and discuss the implementation of dynamical imaging of MEMS by time-resolved scanning electron microscopy (TR-SEM). MEMS resonators are actuated in-operando close to their resonance frequencies, and a synchronized comb of electron pulses is used to image stroboscopically the device at a controlled time delay with respect to the beginning of its oscillation period.

Results and conclusions
We demonstrate the acquisition of stroboscopic movies by a proper sequential acquisition of secondary electron signal. Unprecedented information about local trajectory is provided, in the microsecond scale and at tens of nanometer lateral scale. In-operando nonlinearities in the response of the system, interpretable as related to system hardening are brought into evidence. We also discuss strategies to reach the ultrafast time scale.

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Graphic:

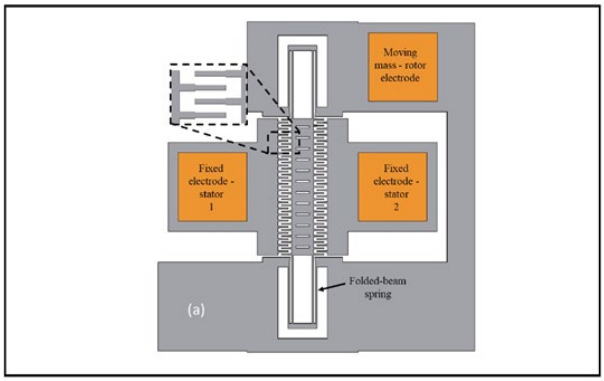

Figure 1. MEMS resonator (*layout*)

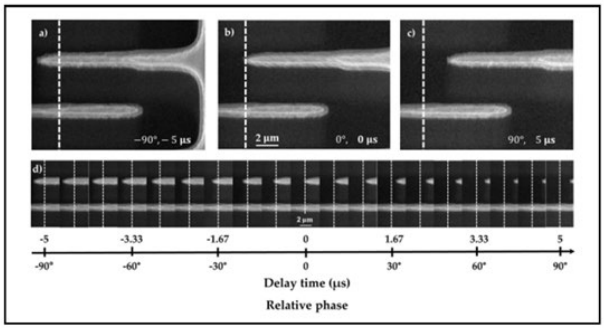

Figure 2. Stroboscopic TR-SEM delay time series, dynamics of the rotor tooth.

Keywords:

MEMS, SEM, Dynamics, Nanoscale, Strain