MEMS/NEMS Resonators: New Advances and Applications

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The global market for sensors is driven by an exponential need across a wide range of classical and novel applications and is projected to reach USD 128.56 billion by 2026, with a compound annual growth rate of 8.86% during 2021-2026. Notably, MEMS/NEMS resonators have been the main building block of many sensors and actuators that serve a wide range of applications. The resonator-based devices represent the backbone of this industry. This can be attributed to their unique advantages of high sensitivity, small size, and low power consumption. Resonators (e.g., simple structures such as beams, plates, and membranes, or complex shapes) can be linearly or nonlinearly driven using different actuation schemes such as thermal, electrostatic, electromagnetic, and piezoelectric. Different dynamical approaches have been employed to improve the performance of resonator-based devices, such as higher-order modes activation to improve the sensitivity of mass and gas sensors, multimode activation to simultaneously measure multiple physical parameters using a single device, internal resonance to improve resonator stability, and modal coupling and their applications in signal processing. Also, multiple resonators can be coupled electrically or mechanically to improve resonator sensitivity, minimize environmental disturbances, and improve the signal-to-noise ratio.

Particularly, special attention is increasingly devoted to the nonlinear phenomena arising in MEMS/NEMS and its potential in a wide range of applications. Driving the response deep into the nonlinear regime, MEMS/NEMS can experience various nonlinear features and exhibit complex bifurcation structures. Significant research has been recently conducted where the nonlinear phenomena observed in MEMS/NEMS are deeply explored, theoretically and experimentally, including softening and hardening behavior, internal resonances, multistability, and chaotic dynamics. The complexity induced by the nonlinearities offers outstanding capabilities for applications. Several recent studies investigate in-depth the possibility of deliberately operating MEMS/NEMS in the nonlinear regime, showing their potential to fabricate novel devices capable of satisfying more sophisticated requirements and achieving superior performances.

Accordingly, this Special Session seeks to showcase research works that focus on theoretical and experimental research studies in MEMS/NEMS investigating nonlinear dynamic phenomena and their potential implementation in emerging applications.

Keywords:

- Nonlinear dynamics of MEMS/NEMS
- Theoretical modeling of MEMS/NEMS
- Nonlinear damping in MEMS/NEMS
- Modal coupling in MEMS/NEMS
- MEMS/NEMS applications
- MEMS energy harvester
- MEMS/NEMS sensors, actuators, and switches