Nanoresonators with Integrated circuitry for high sensitivity and high resolution mass detection

Results in Brief

Sensors with attogram mass detection sensitivity

Nanoelectromechanical resonators have been monolithically integrated on preprocessed complementary metal-oxide semiconductor chips by a technology that allows the combination of standard with novel nanofabrication methods.

DIGITAL ECONOMY

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Nanoelectromechanical systems (NEMS) derive their enhanced functionalities from the advantages of miniaturising mechanical structures such as resonating cantilevers down to submicron dimensions. It is this reduction of mechanical transducers' dimensions that has lead to an unprecedented improvement of sensor systems' sensitivity, spatial resolution and time to response.

A resonating nanocantilever excited by a parallel driver electrode has been used within the NANOMASS-II project as the transducing element of a sensor developed for mass detection with attogram resolution. Moreover, a complementary metal-oxide semiconductor (CMOS) circuitry was monolithically integrated with the cantilever-based transducer to amplify the capacitive current, used as a readout signal.

Mass detection is based on monitoring the resonant frequency shift when nanometre-sized particles are deposited on the cantilever. Since changes in the cantilever resonance frequency are detected as capacitance change, the readout circuitry integrated 'on-chip' ensures the minimum parasitic capacitance by external bonding pads and wires.

During the course of the NANOMASS-II project, different nanolithography processes were compared to evaluate their advantages in terms of dimensions reduction, throughput and importantly, their compatibility with standard CMOS technology. Several demonstrators were fabricated from cantilevers with polysilicon as a structural layer and integrated with the CMOS read-out circuit by means of electron beam or laser lithography.

From experimental mass measurements performed with these integrated NEMS sensors at the Universitat Autònoma de Barcelona, a mass sensitivity of a few attograms has been determined. The ultimate goal of the NANOMASS-II project partners is to develop nanoresonator devices as integral parts of a portable system for biological, physical and chemical sensing applications.

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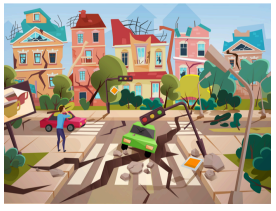

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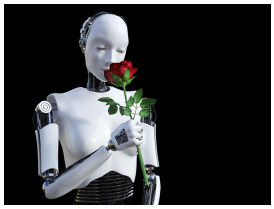

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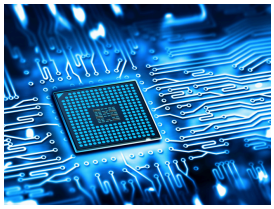

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