Integration Of Nanomechanical Structures With CMOS Circuits

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Micro-Electromechanical Systems (MEMS) have wide application in the development of sensors for the detection of magnitudes in almost every domain. A reduction of the dimensions of the mechanical transducer leads to a new generation of systems called Nano-Electromechanical Systems (NEMS), which represent an improvement on sensitivity, spatial resolution, energy efficiency and time of response. For example, a silicon cantilever can be used as an universal platform for sensing applications by using the deflection of the cantilever or the change in resonance frequency as a signal for measuring different magnitudes. Decreasing the dimensions of the cantilever to the nanometer scale increases the sensitivity, up to the point that it is possible to perform single molecule detection. Other applications of nanomechanical devices are in the field of Telecommunications, where a resonating structure can be used to fabricate a high frequency oscillator.

Several aspects are relevant in the fabrication of silicon based nanomechanical devices. Sub-micron definition of the mechanical structures requires an increase control of the deposition and etching processes, a lithography process capable of defining the device and development of methods for combination with micro/macro structures for interfacing with external devices. In the present communication, we will focus on the nanolithography and nanopatterning alternatives to optical lithography for the fabrication of nanomechanical devices integrated in CMOS.

A practical application of nanomechanical systems requires its combination with micrometer size structures, and in many cases, its integration with CMOS circuits. For example, an appropriate way of detecting the change in deflection or resonance frequency of a cantilever consists on integrating the adequate conditioning circuit. In the framework of different European [1,2] and national [3] projects, we are exploring the integration of nanomechanical devices with CMOS circuits for sensing [1,2] and telecommunication applications. In one approach [1], a mass sensor is developed based on a laterally resonating cantilever, placed at nanometer distance of a fixed electrode. The electrode is used for electrostatic excitation and the capacitance of the system is used to monitor de cantilever oscillation. The integrated CMOS circuit acts as an analog amplifier, transducing the mechanical signal into an electrical signal. In this way, the capacitance due to large bonding pads and external wires is eliminated. In the second approach [2], submicron piezoresistive cantilevers are defined by optical and e-beam lithography and usded for detection of intermolecular forces

[1] *"Nanoresonators with integrated circuitry for high sensitivity and high spatial resolution mass detection"* IST-2001-33068. http://www.uab.es/nanomass/
[2] *"Diagnosis Tool Based on the Measurement of Molecular Interaction". IST-2001-34544.* http://www.biofinger.org
[3] "*sistemas micro/nano-electromecanicos con circuitos cmos de bajo consumo para la transduccion y procesamiento de señales en aplicaciones portables, Nanosys"* TIC2003-07237