Title :

Thermal piezoresistive back action in suspended silicon nanowires based MEMS

Keywords :

MEMS, silicon nanowire, resonator, thermal piezoresistive back action, thermoelasticity, piezoresistivity, damping, self-sustained oscillation

Abstarct :

The development of new technologies, either in consumer electronic domain (smartphones, internet of things...) or in automotive domain (autonomous vehicles), largely boosted the increasing demand of miniaturized and highly performant sensors. Piezoresitive transduction by means of silicon nanowire is particularly interesting to improve detection capability of current sensors. Various benefits of this transduction have been identified for NEMS and MEMS applications, and in particular, high sensitivity and excellent compactness. Moreover, power consumption remains a major issue for miniaturized sensors. Optimized use of nanowires could eventually lead to significant improvement of this transduction mechanism for low power and high performances sensors.

Thermal Piezoresistive Back Action (TPBA), highlighted in DC-biased nanowires, allows to finely control electromechanical response and optimize the transduction mechanism of MEMS. Based on a thermal, electrical and mechanical coupling, this phenomenon particularly allows to reach a self-sustained oscillation regime that could be used to monitor the resonance frequency of a resonator.

The objective of this thesis is to study this back action mechanism in nanowires used for M&NEMS components developed at CEA-Leti. A complete study of silicon nanowires properties, whose typical dimensions are 250 nm x 250 nm x 5 µm, allows to evaluate their interest to implement this mechanism. Based on analytical models and finite element modeling, a model of this phenomenon is proposed. Then, it is confronted with experimental results achieved on existing components and others fabricated during this thesis. Finally, a discussion on the perspectives of this study evaluates the gain brought by this mechanism and its potential applications.