Mechanical characterization of 3C-SiC grown on Si micromachined cantilever

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Resonating microcantilever (MCs) are extremely sensitive mass detectors that have been successfully proposed as chemical, biological and environmental sensors [1]. However, recent works have demonstrated that variation of flexural rigidity due to localization of molecule absorption can induce a positive frequency shift larger than the negative one due to the added mass effect [2].
Goal of our research is to grown and pattern thin 3C-SiC films on Si MC to obtain a huge local increment of beam stiffness, exploiting the outstanding mechanical properties of such material (in particular, its large Young modulus).
First, arrays of MCs (250-500µm long, 50-60µm wide, 2-7µm thick) were fabricated by a combination of bulk and surface micromachining [3], starting from Silicon-On-Insulator (SOI) wafers. Then, cubic silicon carbide (3C-SiC) was deposited on the freestanding microstructures by means of vapor phase epitaxy, using a home made reactor equipped with induction heating, using SiH_4 and C_3H_8 diluted in H_2 as precursors [4]. The standard procedure for 3C-SiC deposition included a chemical etching in HF:H_2O (2:20) for 30'' to remove the Si native oxide, a thermal etch in the reactor chamber at 1000℃ for 10', a carbonization step and the deposition of a thin SiC at 1200℃, with nominal thickness varying approximately from 50 to 100 nm. Beside the cantilever chips another chip of Si (001) was placed in order to have a control deposition of a standard 3C-SiC/Si. XRD analysis on Si control chip confirmed the presence of 3C-SiC and permitted to estimate the thickness of the deposited layer, while film morphology was characterized by means of SEM and AFM.
Different carbonization procedures were tested, in order to try to minimize the stress gradient and the bending of the cantilevers.
Resonance curves (1st and 2nd flexural mode) of MCs before and after 3C-SiC deposition were characterized by an optical lever set-up, described elsewhere [5]. Fig. 1 shows an example of the increment of resonance frequency of a 3C-SiC/Si MC (on the right) respect to the Si bare one (on the left). Young modulus of 3C-SiC layer was evaluated from resonance frequency using the analytical theory for multi-layered cantilever proposed in [6]. Preliminary measurements on 3 different MC arrays showed that an average value for our 3C-SiC thin films of 300±90 GPa.
Fig. 2 reports force curves obtained on bare Si and SiC/Si MC. The difference in the two force curves shows a change in the MC rigidity of about 8%.

Process steps for SiC film patterning on MC surface are currently under test (SiO_2 masking of Si, RIE etching of 3C-SiC).

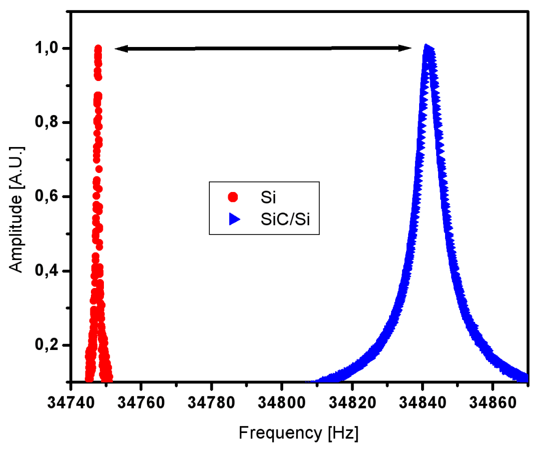

Fig. 1: Resonant curve of Si MC before (left) and after (right) SiC deposition

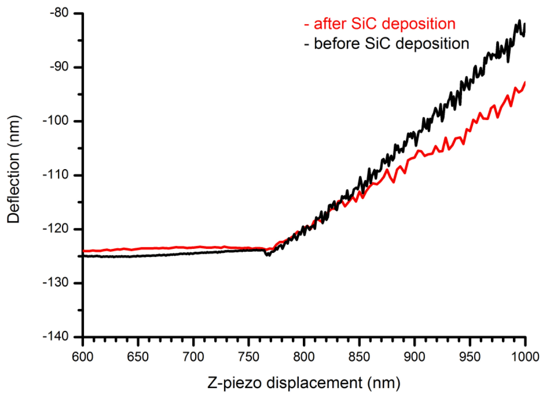

Fig. 2: Force curves obtained by AFM on MC before and after SiC deposition

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