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Study of controlling initial profile of thin-film torsion-bars of vibrational IR sensor

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The vibration-type IR sensors [Fig. 1-(a)] have been studied to realize high sensitivity [1]. The sensor consisted of bi-materials; poly-Si and metal. The resonator is flat in the initial state [Fig. 1-(b)]. According to the orthogonal relation between torsional and tensile stresses in the bars, the tensile stress does not affect torsional motion. With IR incidence, the resonator is heated and bended upwards due to the difference in thermal expansion. Because the orthogonal relation is broken, a spring constant for torsional vibration is increased depending on the bending displacement. As a result, the resonant frequency is increased. As the demonstration, the sensor was fabricated using bi-materials of poly-Si film and Au/Cr film. For the preliminary experiments, a heater was used to analyze the resonant characteristics of the sensor. As the temperature increased, however, the resonant frequency decreased [Fig. 1-(c)]. The result indicated that the initial profile of the fabricated sensor bended downwards and the profile become flat as the temperature increased [Fig. 1-(d)]. Therefore, to improve sensitivity of the sensor, there are two factors; using material of high coefficient of thermal expansion (CTE) for IR irradiation, and controlling initial profile of the resonator to be flat.

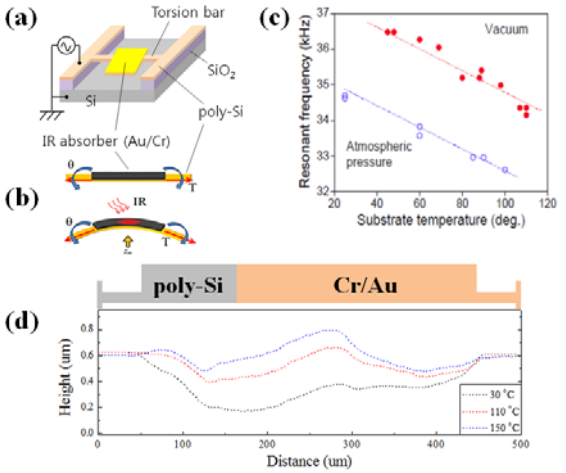

Fig. 1. (a) Schematic diagram of vibration-type IR sensor, (b) principle of hard spring effect for torsion-bar, (c) resonant frequency as a function of substrate temperature, and (d) initial profile of the resonator fabricated using poly-Si and Au/Cr film.

In this study, Al was applied as a high CTE material to fabricate IR sensor [Fig. 2-(a)]. Al has an absorbance spectrum for near infrared ray, and the CTE is 23.6 ppm/°C higher than that of Au (14.2) and Cr (6.2). Because a density of Al is smaller than that of Au and Cr, initial profile of the bar is not distorted by a weight and a residual stress of the Al layer. To increase the residual tensile stress in the Si thin-film torsion bars, an amorphous Si film was annealed at 650 °C to be poly-crystalline generating large crystallization -induced tensile stress. The initial profile was very flat, and there were no distortions caused by the Al layer [Fig. 2-(b)]. With increasing the temperature, the profile showed upward bending, which is promising for achieving high sensitivity. Furthermore, metal-induced lateral crystallization using *Ferritin* supramolecules with Ni nano -particles is under consideration to further increase tensile stress in poly-Si film [2].

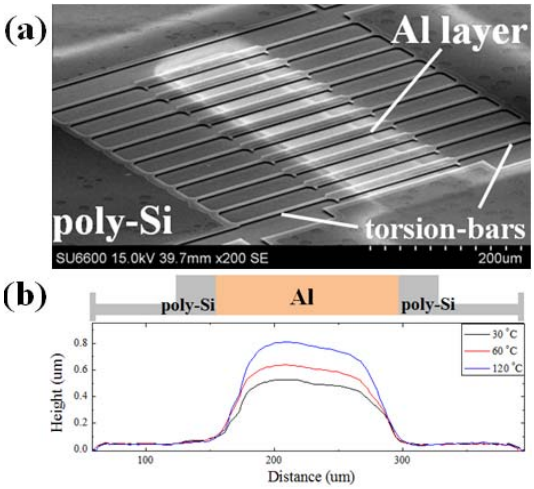

Fig. 2. (a) SEM picture and (b) initial profile of the resonator fabricated using poly-Si and Al film.

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