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単結晶ダイヤモンド機械共振特性の研究

Single crystal diamond mechanical resonators

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Diamond possesses superior mechanical properties for high-performance micro- or nanoelectromechanical system (MEMS/NEMS) devices. Polycrystalline diamond mechanical resonators were demonstrated by hetero-grown diamond on foreign substrates. However, the energy dispassion within the polycrystalline diamond limited the quality factor of the diamond mechanical resonators. In this work, the frequency resonance characteristics of single crystal diamond (SCD) mechanical resonators were measured and analyzed. Various factors such as the geometrical effect, vacuum pressure, and temperature that determine the quality factor were investigated.

The SCD resonators were fabricated by ion-implantation, homoepitaxial diamond growth, lithography, and etching process. The length of the SCD cantilevers was ranged from 30 to 150 µm. The thickness of the SCD cantilevers was from 0.68 to 2.25 µm. The length was from 2-10 µm. The resonant frequency of the SCD cantilever was measured by piezoelectric actuation and optical detection. A typical frequency spectrum measured in vacuum was shown in Fig. 1, with a quality factor around 8000 at RT. Air damping significantly decreased the quality factor of the SCD resonators by more than 10 times. The measured resonant frequency dependence on the cantilever length followed well with the theoretical predication, as shown in Fig. 2. This suggests the good reproducibility of the batch fabrication process. The quality decreased with decreasing the cantilever length, implying that the claming loss was also one of the main energy loss mechanisms. As increasing the temperature, the resonant frequency decreases slightly, possibly due to the reduction of the Young's modulus at elevated temperatures. However, the quality factor increased at elevated temperatures.

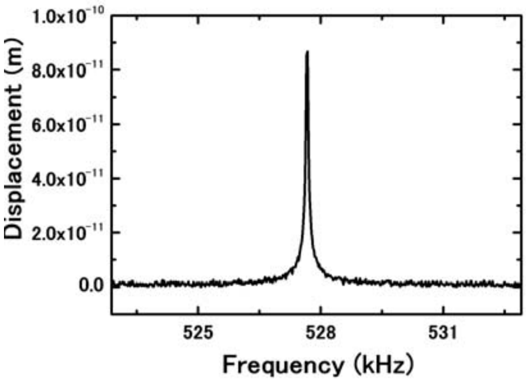

Fig. 1 Resonant frequency spectrum from a SCD cantilever.

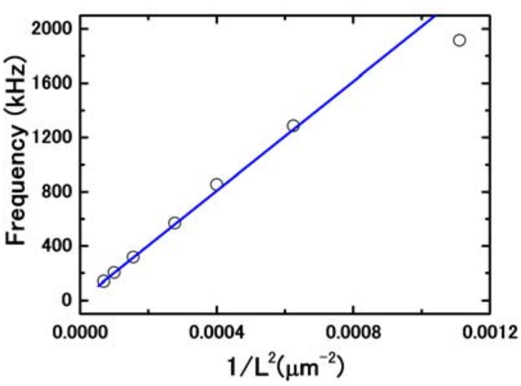

Fig. 2 Resonant frequency dependence on the SCD cantilever length.