単結晶ダイヤモンド機械共振子の品質係数の向上

The Improvement of the Quality Factor of the Single Crystal Diamond Mechanical Resonators

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The outstanding mechanical and tribological properties, the highest thermal conductivity, exceptional chemical inertness, and outstanding thermal stability of diamond make it attractive for micro- or nano-electromechanical system (MEMS/NEMS). Steady-state progress has been made in the fabrication of various diamond MEMS/NEMS structures by using polycrystalline, nanocrystalline or ultrananocrystalline diamond. Recently, single crystal diamond (SCD) MEMS/NEMS has aroused growing interest due to the "true" diamond properties for extremely high performance. Although the process of bonding and thinning of SCD slice could obtain high-quality SCD MEMS structures, this technique is difficult for the compact integration with the electronic parts and others. By using ion-implantation assisted lift-off (IAL) technique, we developed the batch fabrication of nanoscale SCD resonators and NEMS switches in a controlled manner.[1] The IAL method provides the facile systematic integration for MEMS/NEMS applications. For all the diamond MEMS devices, the quality factor (Q-factor) is the key figure-of-merit to achieve the high performance. In order to develop high-Q factor SCD resonators by using the IAL method, we had investigated the energy dissipation mechanism in such SCD resonators.[2] It is disclosed that the defects induced by ion-implantation limit the ultimate Q-factor. In this work, we make efforts to improve the Q-factor by improving the crystal quality of the SCD MEMS cantilevers or bridges.

The single crystal diamond cantilevers were fabricated by using the IAL method. In order to improve the crystal quality of the SCD cantilevers, relative thick intrinsic SCD epilayers were grown on the implanted HPHT type Ib-diamond substrates. The length of the SCD cantilevers ranges from 30-140 µm, width from 2-12 µm, and thickness from 0.17 to 1.98 µm. The resonance frequency well followed the inverse power law relationship with the length of the cantilevers with an estimated Young's modus around 1100GPa, consistent with our previous reports. As a result, the Q-factor was significantly improved from several hundred to more than ten thousand after growing the thick SCD epilayers. The maximum Q-factor at this moment reaches up to 39417.

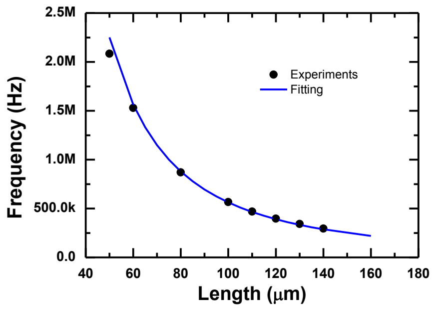

Fig. 1 Resonance frequency dependence on the SCD cantilever length.

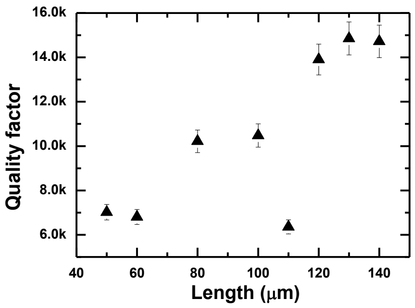

Fig. 2 Q-factor dependence on the SCD cantilever length.

References

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