単結晶ダイヤモンドサブマイクロ機械共振子の高温酸素アニール効果

The Effect of Annealing in Oxygen Ambient on the Single Crystal Diamond Mechanical Resonators

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The exceptional mechanical and tribological properties, the highest thermal conductivity, chemical inertness, and outstanding thermal stability of diamond make it attractive for micro- or nano-electromechanical system (MEMS/NEMS). Due to the high reproducibility in the fabrication of single crystal diamond (SCD) MEMS/NEMS structures and the high reliability of the corresponding devices, SCD MEMS/NEMS has aroused growing interest. We have developed the ion-implantation assisted lift-off (IAL) technique for the batch fabrication of nanoscale SCD resonators and NEMS switches in a controlled manner.[1] The IAL method offers the facile systematic integration for MEMS/NEMS applications. Generally, the quality factor (Q-factor) is the most important key figure-of-merit for MEMS/NEMS. We realized that the Q-factor of the IAL SCD resonator was strongly degraded by the ion-implantation induced damaged layer.[2] Therefore, we made efforts in improving the Q-factor by growing thick SCD layer to reduce the effect of the damaged layer at the cantilever bottom.[3] On the other hand, it is expected the Q-factor could be much improved if the whole damaged layer could be removed.

In this work, we investigate the effect of the high-temperature annealing in oxygen ambient on the resonance properties of the SCD cantilevers. The single crystal diamond cantilevers were fabricated by using the IAL method. The cantilevers contain intrinsic epilayers grown by microwave plasma chemical vapour deposition (CVD) on the ion-implantation damaged HPHT diamond layers. The length of the SCD cantilevers ranges from 30-150 μm, the width is 12 μm, and the thickness is 0.34 μm. The SCD cantilevers were annealed in an oxygen ambient with different time durations at 430-500 ºC. The mechanical resonance of the SCD cantilevers was measured by a laser Doppler technique. We confirmed that the resonance frequency well followed the inverse power law relationship with the length of the cantilevers, giving an estimated Young's modus around 1100GPa. It was observed that the Q-factors were significantly by nearly two times, as shown in Fig. 1. A shift of the resonance frequency was also observed, supporting the etching effect by oxygen. The improvement in the Q-factor may be attributed to the preferential partial removal of the damaged diamond layer.

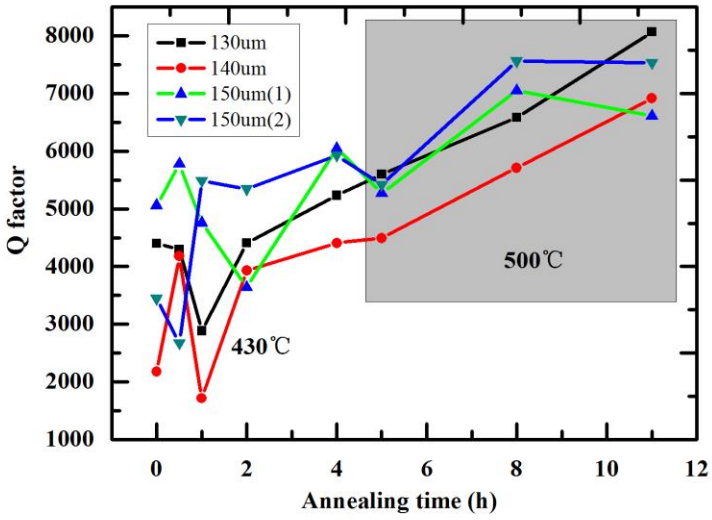

Fig. 1 Dependence of the Q-factor of the SCD cantilevers on the annealing time at 430 and 500ºC.

References
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