単結晶ダイヤモンド機械共振子のエネルギー散逸機構

Energy Dissipation in Single Crystal Diamond Mechanical Resonators

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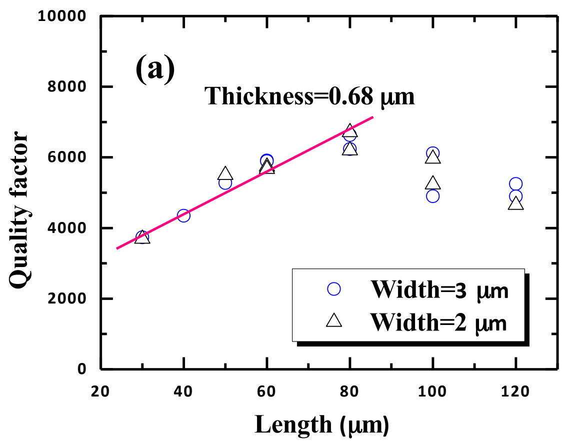
Diamond is attractive for micro- or nano-electromechanical system (MEMS/NEMS) due to its superior properties, such as high mechanical strength, low coefficient of thermal expansion, tunable electrical conductivity, and the highest thermal conductivity among semiconductors. Steady-state progress has been 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. By using ion-implantation assisted lift-off technique (IAL), we developed the batch fabrication of nanoscale SCD resonators and NEMS switches in a controlled manner.[1] In order to develop high-Q factor SCD resonators by this facile IAL method, it is essential to investigate the energy dissipation in such SCD resonators. In this work, we examine the energy dissipation mechanisms limiting the Q factors in the SCD resonators fabricated by the IALT method. For this purpose, we fabricate SCD cantilevers with various dimensions in length, width, and thickness. The dependence of the Q factors on the cantilevers dimensions is examined.

The single crystal diamond cantilevers were fabricated by ion implantation assisted technique and had length ranging from 30-206 μm, width from 2-5 μm, and thickness from 0.68 to 1.7 μm. The resonance frequency well followed the inverse power law relationship with the length of the cantilevers and exhibited a high reproducibility with varying the dimensions. The quality factors were in the range of 2000-7000, shown in Fig.1. The energy dissipation decreased with increasing the cantilever length and saturated or reduced at a certain value. For the shorter cantilevers, clamping loss governed the energy dissipation. As the cantilever length increased to a certain value, defects relaxation or surface effect became dominant. The possible origins for these energy dissipations were discussed.



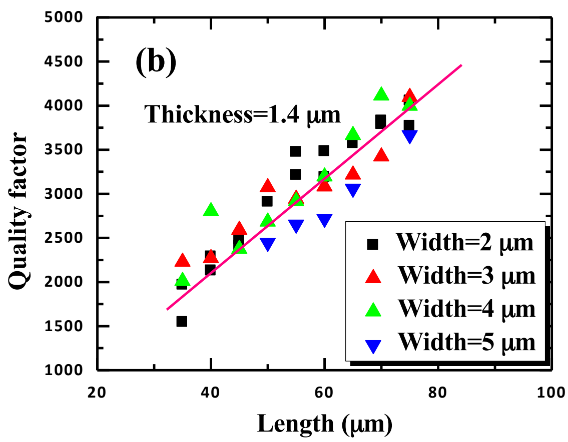


Fig. 1 Quality factor dependence of SCD cantilevers with different thicknesses (a) 0.68 μm and (b) 1.4μm

References

1 M.Y. Liao, S. Hishita, E. Watanabe, S. Koizumi, Y. Koide, Adv. Mat. 22, 5393 (2010).