Smart-Cut Method for Diamond NEMS Fabrication by Efficient Oxygen Etching

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Single-crystal diamond (SCD) stands out as the ideal semiconductor material for micro- or nano-electromechanical system (MEMS/NEMS) sensors with high performance [1-3]. NEMS technology provides higher sensitivity and speed compared to larger micron-sized resonators, thanks to the superior mechanical characteristics. In this work, we proposed a smart-cut technique for SCD NEMS fabrication through oxygen etching in high temperatures. **Fig. 1** displays the relationship between the resonance frequency (*f*) and the length of SCD cantilevers following different temperatures of oxygen etching processes. These cantilevers' resonance frequency and length closely follow the law provided by Euler-Bernoulli beam theory at every turn. The etching treatments result in a decrease in the resonance frequency of the diamond cantilevers due to the reduction in thickness. The reduced thickness of the diamond cantilevers can be determined through the resonance frequency, as depicted in **Fig. 2**. It was noted that there was a marginal reduction in thickness before 600°C, whereas a significant decrease was observed at 685°C. Considering both top and bottom sides of the cantilevers, the average etching rate of diamond is assessed to be approximately 5 nm/h at 685°C in pure oxygen environment. Following each etching, the surface morphology and crystal quality of diamond were further investigated by atomic force microscopy (AFM), 3D laser scanning microscope, and Raman. This study presents a smart-cut strategy for fabricating diamond NEMS by the atomic-scale etching of SCD cantilevers in an oxygen atmosphere.

[1] G. Chen, and Liao et.al, *Appl. Phys. Express*. APEX-107790.R1 (2024).
[2] G. Chen, and Liao et.al, *Diam. Relat. Mater*. 138, 110240 (2023).
[3] G. Chen, and Liao et.al, *Proc. TRANSDUCERS 2023*, pp. 2185-2188 (2023).

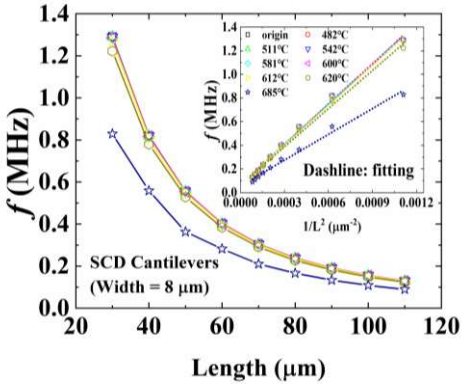


Fig. 1 Dependence of the resonance frequency (*f*) on the SCD cantilever length after oxygen etching for 10 h at different temperatures.

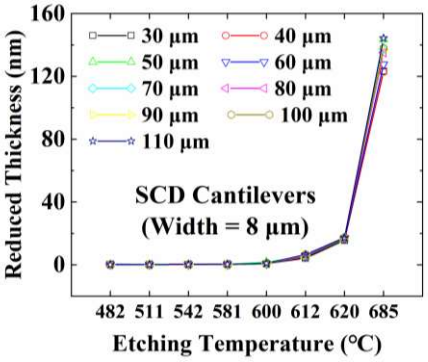


Fig. 2 Reduced thickness of SCD cantilevers with various lengths at different etching temperatures in O_2 ambient for a duration of 10 h.