

Free-standing Nanostructures in Single-crystal Quartz

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Quartz has been one of the most widely used piezoelectric materials in engineering, especially in timing and sensing applications[1]. Attraction of quartz is largely due to its piezoelectricity as well as superior mechanical[2] and optical[3] properties.

Further miniaturization of quartz promises on-chip devices with a better sensitivity. However, fabrication on nanoscale typically requires thin film technology – *single-crystal* quartz on a sacrificial layer, like SOI wafer for silicon. Recently, there have been several advancements in this regard, such as an epitaxial growth of polycrystalline nanostructured quartz films[4] as well as the thin film quartz device made by wafer bonding and grinding[5]. In this work, we demonstrate a different approach to make a free-standing quartz structures by using *angled-etching technique*, whose utility has been adopted to fabricate single-crystal diamond nanodevices[6].

Using conventional inductively coupled plasma reactive-ion etching (ICP RIE) for silicon dioxide in combination with angled-etching technique, free-standing nanostructures were made on bulk single-crystal quartz. Figure 1 shows quartz cantilevers with the same width and different lengths. Commercial quartz tuning forks are typically ~100 μm thick and a few millimeters long, whereas devices in Figure 1 are submicron thick and tens of micrometers long. Although these devices were fabricated on Z-cut quartz crystal, the simple nature of the fabrication process implies its applicability to any crystal orientation.

In conclusion, we have demonstrated the fabrication of free-standing nanostructures made on single-crystal quartz substrate. In the future, on-chip quartz device is expected to be a versatile platform for nanoelectromechanical systems(NEMS), nanophotonics and the nano-optomechanical systems, by taking advantage of its piezoelectric and electro-optic properties.

References

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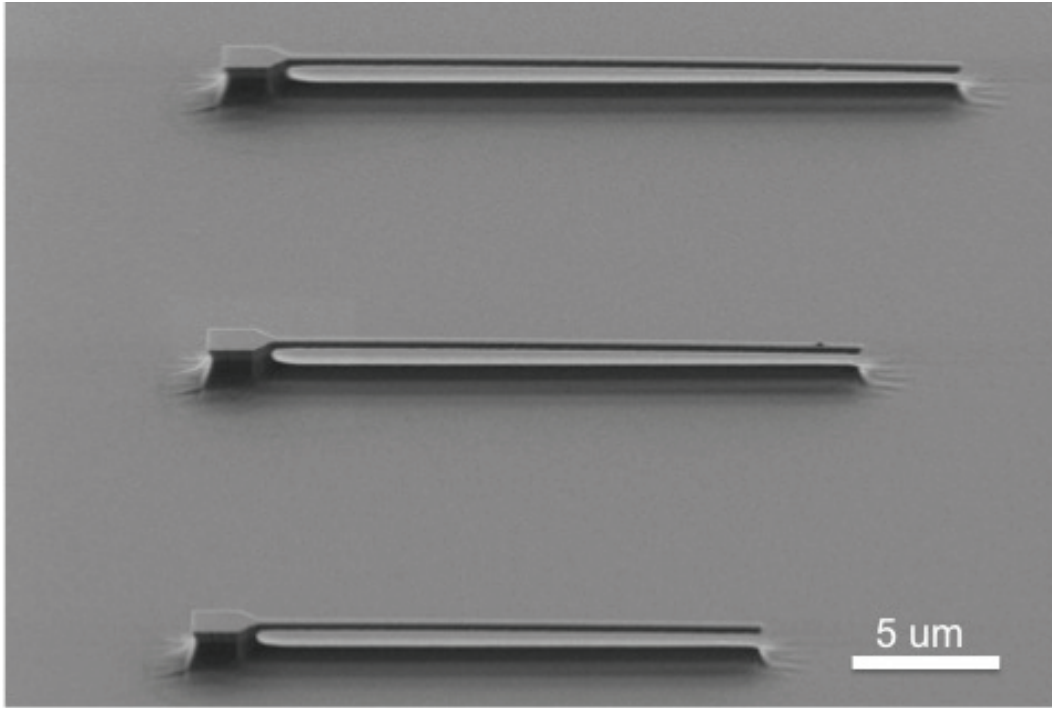


Figure 1: SEM image of cantilevers fabricated in Z-cut *single-crystal* quartz substrate.