Nanofabrication with Si(311)

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Bulk micromachining was mainly developed for Si (100) and Si (110) wafers and is based on crystallographic etching of silicon in KOH and other basic solutions, in order to obtain useful 3-dimensional structures[1]. The hereby study investigated the particularities of crystal-orientation dependent etching of Si (311) wafers and resulted in a series of engineering recipes and solutions enabling their use in applications. While the characteristic etch patterns for Si(100) are 4-faceted V-grooves, and for Si (110) – the deep-etched trenches with vertical walls, Si (311) can be used to obtain 3-faceted pyramidal V-grooves and deep trenches with tilted parallel walls. The paper reports on etching rates in various solutions, under-etching diagrams for radial grid ("wagon wheel") patterns[2], characteristics of the 3-faceted pyramid V-grooves, results on oxidation sharpening of these pyramids, and presents useful designs for etched alignment marks for these wafers. The etchants investigated were KOH solutions with various concentrations and temperatures, with and without the use of surfactants as anisotropy inhibitors[3]. Finally, applications of Si (311) for molded tips for scanning probe microscopy are presented[4]. For these, Si (311) V-grooves have the advantage of always ending in single-pointed pyramids despite large allowed variations in alignment and lithography, versus similar Si (100) V-grooves, which frequently end in wedges. Applications for deep tilted-wall trenches are blazed diffraction gratings and 3D arrays of free-standing beams for optical band gap structures.

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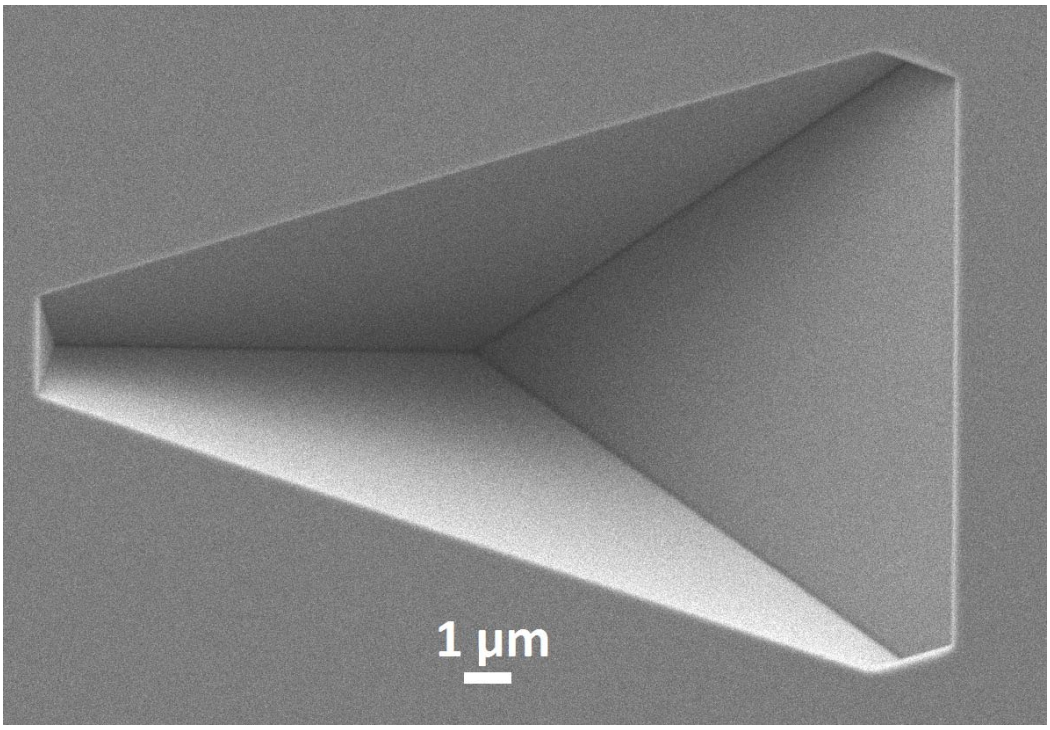

Figure 1: Typical 3-faceted V-groove etched in Si (311)

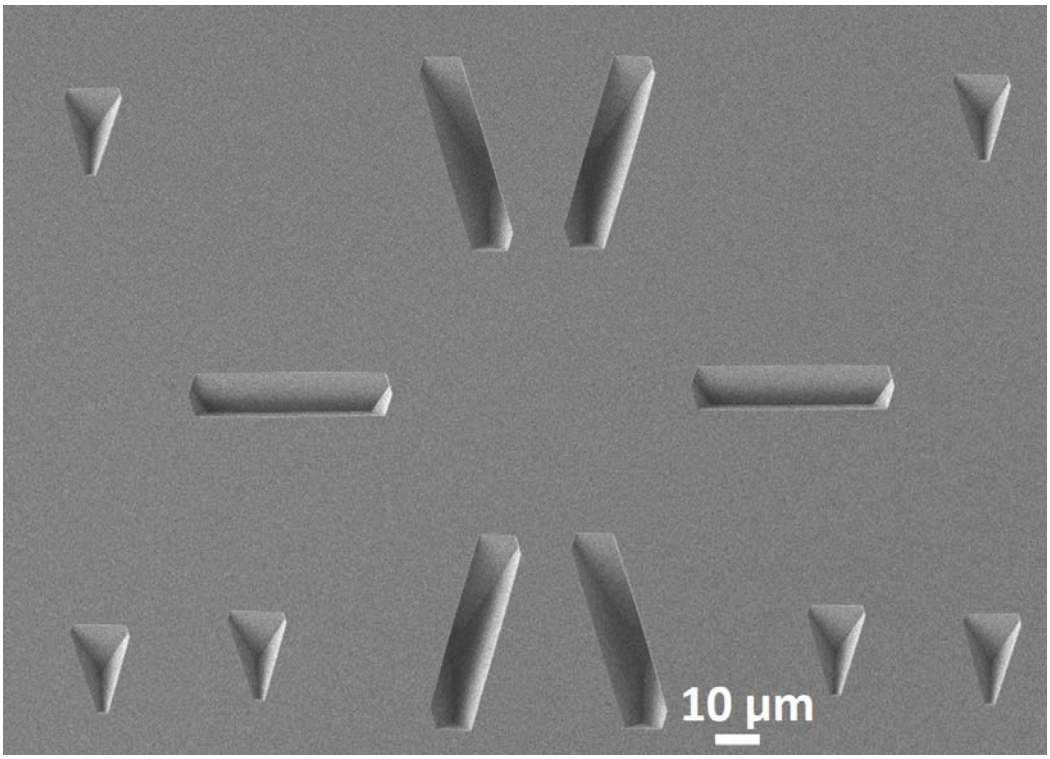

Figure 2: V-grooves and alignment marks for Si (311)