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Deep Dry Etching of Silicon— A Novel Micromachining Tool

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Deep dry etching techniques for silicon micromachining are reported. Reactive ion etching with chlorine/fluorine gases enables the creation of 30-μm-deep silicon steps using photoresist or silicon dioxide as masking material. In particular, vertical sidewalls with practically no undercut can be realized with a photoresist mask. Etch rates of half a micron per minute are typical for chlorine/fluorine gas mixtures. Plasma etching with fluorine/oxygen gases leads to greater etch rates of about one micron per minute, but a large undercut is observed. The major advantage of fluorine/oxygen plasmas is very high selectivities of 20, 85 and more than 300 for photoresist, silicon dioxide and aluminum masks, respectively. Thus, etch depths of up to several hundreds of microns have been achieved. Since these dry etching techniques are, in addition, reproducible and highly controllable, they indicate favorable features for application in silicon micromachining. Examples are entirely plasma-etched silicon membranes for use as thin substrates and free-standing thin-film microstructures (out of aluminum or silicon dioxide) for application as resonators or switches. For many structures the combination of dry etching and KOH etching turns out to be an essential processing step. Three examples are described: bipolar-compatible accelerometers, perforated membranes for flow cells and cantilevers with square cross sections for scanning force microscopy.