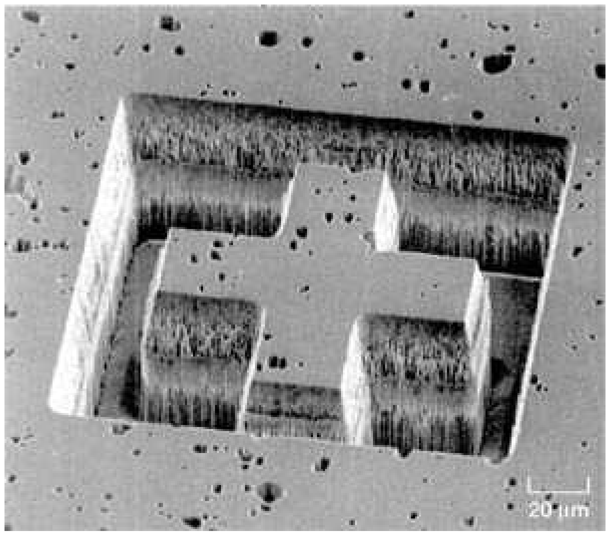
Deep Etching Process Developed for the Fabrication of Silicon Carbide Microsystems



Scanning electron micrograph of 60-mm-deep etch in SiC.

Silicon carbide (SiC), because of its superior electrical and mechanical properties at elevated temperatures, is a nearly ideal material for the microminiature sensors and actuators that are used in harsh environments where temperatures may reach 600 °C or greater. Deep etching using plasma methods is one of the key processes used to fabricate silicon microsystems for more benign environments, but SiC has proven to be a more difficult material to etch, and etch depths in SiC have been limited to several micrometers. Recently, the Sensors and Electronics Technology Branch at the NASA Glenn Research Center at Lewis Field developed a plasma etching process that was shown to be capable of etching SiC to a depth of 60 µm.

Deep etching of SiC is achieved by inductive coupling of radiofrequency electrical energy to a sulfur hexafluoride (SF_6) plasma to direct a high flux of energetic ions and reactive fluorine atoms to the SiC surface. The plasma etch is performed at a low pressure, 5 mtorr, which together with a high gas throughput, provides for rapid removal of the gaseous etch products. The lateral topology of the SiC microstructure is defined by a thin film of etch-resistant material, such as indium-tin-oxide, which is patterned using conventional photolithographic processes. Ions from the plasma bombard the exposed SiC surfaces and supply the energy needed to initiate a reaction between SiC and atomic fluorine. In the absence of ion bombardment, no reaction occurs, so surfaces perpendicular to the wafer surface (the etch sidewalls) are etched slowly, yielding the desired vertical sidewalls.

The figure shows a scanning electron micrograph of a 60-µm-deep plasma etch of SiC. This etch was performed at a rate of 0.3 µm/min, which is greater than the rates for previous processes that were demonstrated to be capable of only much shallower etches. The holes in the top surface are the result of pinholes in the indium-tin-oxide, which opened up as the initially 120-nm-thick mask was eroded to a thickness of less than 20 nm. Use of a thicker mask is expected to eliminate these holes. These preliminary results clearly demonstrate the feasibility of etching deep vertical-walled structures in SiC. This etch process will be used to fabricate a SiC pressure sensor for use at 500 °C.

Here, a 60-µm-deep hole, approximately 1 mm in diameter, will be etched into an 80-µm-thick piece of SiC to produce a 20-µm-thick pressure-sensing diaphragm. Work is in progress to refine the etch process to increase the etch rate and reduce the roughness of the etch sidewalls, since smooth sidewalls will be required for other applications requiring deep etching, such as vertical structure high-voltage diodes.

Find out more about this research http://www.grc.nasa.gov/WWW/SiC/SiC.html.

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