Fabricating Diamond Membranes Using Reactive-Ion Etching

The rate of dry etching of silicon is more than 3 times that of hot KOH.

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A process for the fabrication of a polycrystalline diamond membrane involves chemical vapor deposition (CVD) of diamond onto a silicon substrate, followed by conventional photolithography and subsequent reactive-ion etching to remove part of the substrate (see figure). This process is an improvement over an older process in which the substrate is etched in a hot KOH solution. This process can be used to fabricate diamond polycrystalline membranes as parts of microelectromechanical sensors.

The starting substrate is a mirror-smooth (100)-oriented single-crystal silicon wafer with n or p doping to a resistivity <20 [Image]·cm. To increase the density of nucleation sites for diamond and thereby make it possible to obtain a pinhole-free diamond deposit, the front (top in the figure) surface of the substrate is scratched by use of diamond paste. A polycrystalline diamond film is grown on the scratched surface by CVD from a flowing mixture or methane and hydrogen, typically at a total pressure of 45 torr (6 kPa) and a substrate temperature of 950 °C.

After deposition of diamond to the required thickness, aluminum is deposited on the back (bottom in the figure) surface of the substrate by electron-beam evaporation. The aluminum film is patterned photolithographically, then etched by a commercial solution containing phosphoric and acetic acids, thereby forming a mask to define the areas to be protected from, and exposed to, reactive ion etching. Next, reactive-ion etching is effected by use of a radio-frequency-induced SF6 plasma.

In an experiment, the rate of reactive-ion etching was found to be about 3.6 μm per minute; in contrast, the rate of etching in hot KOH is about 1 μm per minute. It was also found that reactive-ion etching undercut the masked portion of the substrate at a rate of about 3.5 μm per minute. The diamond membrane exposed by etching of the substrate was found to be in a state of compressive stress.

[Image]

The Processing Sequence is depicted here schematically in terms of the status of the workpiece at various stages.

This work was done by Rajeshuni Ramesham of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com under the Materials category. NPO-2047