**Characterization of a Batch HF Vapor Processor for MEMS Release Etching**

Julien Chiaroni, Hubert Grange
LETI-CEA Grenoble 17 Rue des Martyrs 38054 Grenoble Cedex 09, France
Olivier Pollet, Eric Bergman
Semitool, Inc., 655 West Reserve, Kalispell, MT

MEMS devices are increasing in complexity and are finding numerous applications in industrial and consumer products. One of the critical processing steps for many such devices is the "release etch." In this step, a sacrificial layer is removed from certain regions to allow a range of motion of specific device features. The amount of material to be removed may vary from a few hundred angstroms to several microns. Where the sacrificial or "release layer" is silicon dioxide based, fluorinated chemistries have been applied in order to achieve the release etch. Many of these etching systems are based on a single-wafer configuration, with a relatively low throughput, especially if the release structure requires the removal of microns of material.

This paper will characterize a batch HF vapor etching system and its application for performing MEMS release etching. The system uses a patented HF/alcohol vapor process, with vapor generated from a liquid source using MFC controlled carrier gas flows. The etchant vapor is delivered to a high density polyethylene chamber which can accommodate up to 25 wafers up to 200mm in diameter. To be feasible in a production environment, the process must be repeatable, provide uniform undercut and no stiction on released structures. Figure 1 shows the etch uniformity achieved in multiple runs of 200mm wafers in this system. Process uniformity on blanket films is typically less than 7% ($3\sigma/x$). While this is suitable for the current application, further improvement is anticipated through hardware modification.

The release etch must be predictable and provide for a uniform undercut on devices. The progression of the etch with respect to time is shown in Figure 2. The procession of the undercut is relatively linear, which indicates that the vapor is able to diffuse into the etch cavity, react and diffuse the reaction products back out with relatively little inhibition.

Performing the release etch without causing stiction is of paramount importance for the proper functioning of devices. If the etch rate is too high, the supply of vapor, and hence the formation of condensate on the device surface can lead to excessive wetting of the surface and stiction. In addition, water is evolved as a byproduct of the reaction and can aggravate a marginal etch condition. The combination of the HF vapor with the IPA vapor helps to eliminate this issue. The IPA enhances the formation of the microscopic condensate film in which the oxide etch reaction occurs. This promotes a more uniform boundary layer leading to a more uniform etch, which is especially important in undercutting features such as polysilicon where the surface tension of a purely aqueous media differs significantly from the surface tension on silicon dioxide. At the same time, the presence of the IPA helps to reduce the surface tension within the condensate film, which further aids in preventing stiction and promotes the uniformity of the undercut.

Figure 3 shows an IR image of an accelerometer structure which has been released in the vapor etch process. The undercut boundary is essentially equidistant from the edge of the device feature.

As can be seen in Figure 4, high aspect ratio device features can be successfully etched with the HF/IPA vapor system. The process has been used on accelerometers, motors, beams, waveguides and other MEMS devices with success.

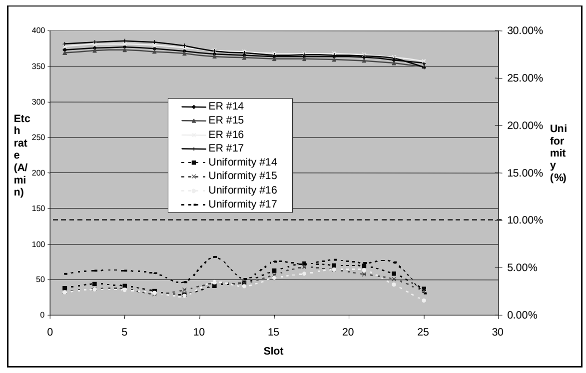

Figure 1: 10:00 Batch HF Vapor Etch Performance

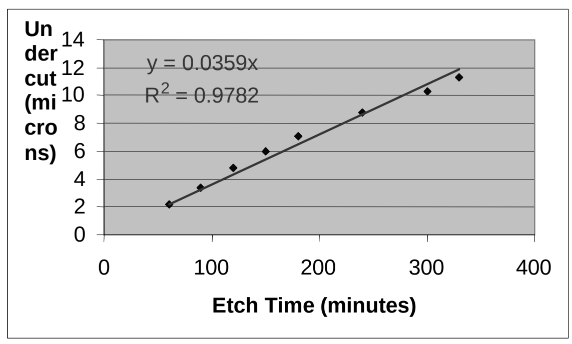

Figure 2: Lateral Undercut of Silicon Beam Structures

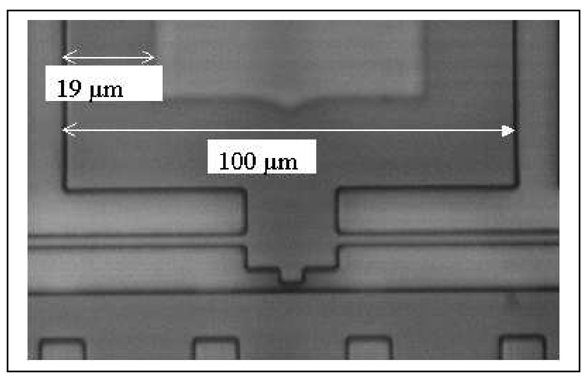

Figure 3: IR Image of Vapor Etch Undercut on Anchor Beam

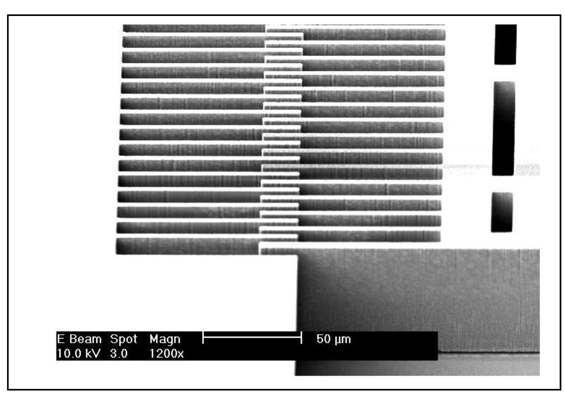

Figure 4: Accelerometer Structure Released In a Batch Vapor Etch