APPLICATION **BRIEF**

Introduction to HF Vapor Etch

Introduction

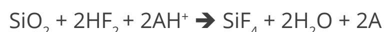
Nearly all silicon microelectromechanical systems (MEMS) devices are created using a sacrificial silicon oxide layer, which when removed, "releases" the silicon MEMS structure and allows free movement.

Silicon oxide is typically etched by hydrogen fluoride :

$$SiO_2 + 4\,HF \rightarrow SiF_4 + 2\,H_2O$$

The most widespread method of HF based etch release is wet chemical etching using a mixture of HF and water. However, as the HF, or subsequent rinsing solutions dry, it can cause "stiction" by pulling the free-moving microstuctures together which remain adhered to each other after release, reducing device yields. Another potential issue with wet HF etching is that it will corrode any exposed metals, most notably aluminium, which is widely used on MEMS wafers. To avoid these issues, dry HF vapor can be used. A gaseous etchant also penetrates smaller features more easily and allows longer undercuts.

Alcohol (A) ionises the HF vapor and acts as a catalyst:

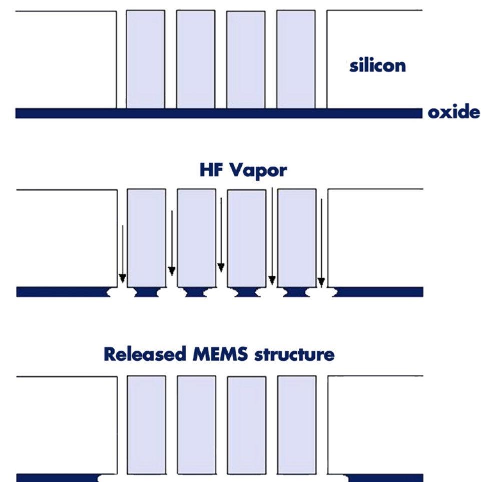


$$SiO_2 + 2HF_2 + 2AH^+ \rightarrow SiF_4 + 2H_2O + 2A$$

Water, a by-product of the reaction, also acts as a catalyst and must therefore be carefully controlled and removed from the system.

KLA's patented Primaxx® HF/alcohol process employs a reduced pressure, elevated temperature, gas phase environment for the isotropic etch removal of sacrificial oxide layers.

The process is generally carried out at pressures between 75 and 150 torr providing controlled, residue-free etching. Typical vertical and lateral oxide etch rates are in the 0.01 - 1µm/min range.



Schematic illustration of HF vapor release etch

Why Use Dry Release Etch?

- Eliminates stiction with device yields typically ~ 100%
- Provides repeatable, stable performance with a wide process window
- Compatible with a wide range of metals, especially unprotected Al mirrors and bond pads
- No complex waste management issues, small footprint, no process consumables

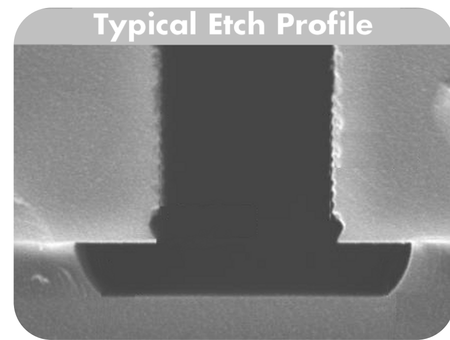
Why Use Reduced Pressure?

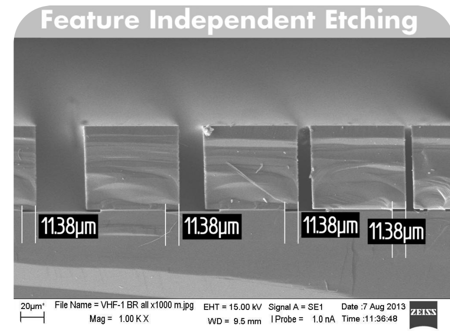
- Keeps etch by-products in the gas phase ensuring high selectivities to metals
- Maximum feature penetration without localized loading effects
- Broad process window for optimizing productivity and etch results
- Scalability to batch processing for high volume manufacturing

Material Compatibility

Material	Sacrificial Oxide	Protective Layer	Metal/Electrode /Adhesion
Thermal oxide, TEOS	●		
SOI bonded oxide	●		
Quartz	●		
PECVD oxide	○		
Spin on oxide	○		
Alumina		●	
ALD alumina		●	
Aluminium		●	●
Silicon carbide		●	
Si-rich LPCVD nitride		○	
Gold			●
Copper			○
TiW			●
Nickel			●

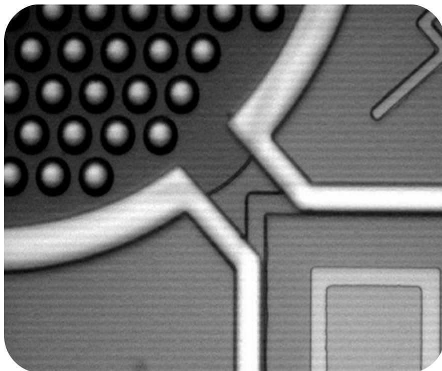
Isotropic Etching



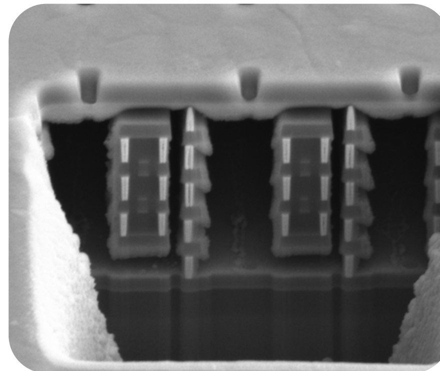


Images courtesy of RAFAEL – Advanced Defense Systems LTD

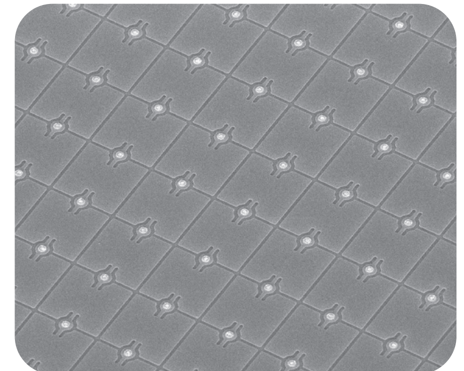
Application Examples



MEMS microphone



CMOS MEMS (Image courtesy of Baolab Microsystems)



MEMS micromirror array (Image courtesy of FhG-IPMS)

Product Range

KLA offers a choice of HF vapor etch systems for R&D to volume production applications:

- **Primaxx® Monarch300 -** a 13-wafer batch process module for 200mm or 300mm wafers combined with the 300mm Primaxx® fxP wafer handling platform, for high volume production applications.
- **Primaxx® Monarch25** - a 25-wafer batch process module for wafers up to 200mm, in volume production compatible with the 200mm Primaxx® *f*xP or Primaxx® c2L.
- **Primaxx® Monarch3** - compact module includes a 3-wafer process chamber, and is designed for research laboratory and small volume production environments.
- **Primaxx® uEtch** - low cost, single-wafer system specifically designed for university and small research laboratories.

uEtch

Monarch300

The **SPTS Divison of KLA** designs, manufactures, sells, and supports etch, PVD, CVD and MVD® wafer processing solutions for the MEMS and sensors, advanced packaging, photonics, high speed RF, and power device markets. For more information, email SPTS-enquiries@kla.com

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