APPLICATION
BRIEF

XeF_2 Etch for MEMS Release

Introduction

Xenon difluoride (XeF_2) provides a highly selective isotropic etch for Si, Mo and Ge and is an ideal solution for etching sacrificial layers to “release” moving components within MEMS devices. It provides numerous unique advantages and capabilities compared to wet and SF_6 plasma etch options.

The process is generally carried out at pressures between 0.5 and 4 torr providing controlled, stiction-free and residue-free etching. Typical vertical and lateral silicon etch rates are in the 0.1 - 10 microns/minute range.

Eliminate Stiction

As XeF_2 is a dry vapour etch there are no surface tension or bubble related problems with etching through small holes or in tight spaces. XeF_2 has been used to etch through holes as small as 25nm in diameter. Similarly, XeF_2 avoids stiction issues, often associated with wet etch processes which can lead to permanent device damage after release/drying.

High Selectivity

As MEMS get more complicated they contain components made from multiple or non standard materials. There is no other isotropic etch that is selective to so many materials. Devices can be made using any combination of silicon dioxide, silicon nitride, polymers, plus most metals and dielectrics.

Because of its selectivity and excellent reach, XeF_2 can be used to make very long undercuts with little or no degradation of etch stop, mask or device layers. For example, silicon dioxide is a very popular mask material with a Si:oxide selectivity of >1,000:1. Silicon dioxide masks have been used to achieve very long undercuts (well over 100µm, see Fig 1) and to protect extremely small or thin devices (less than 30nm)

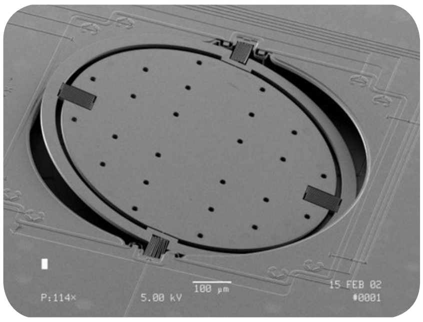

Fig 1 Very long undercuts under a silicon micromirror achieved using XeF_2 and very thin oxide mask layers (Image courtesy of Analog Devices, Inc)

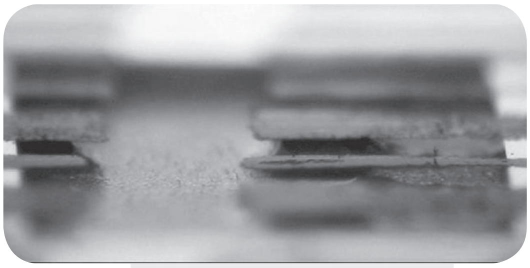

Fig 2 Magnetically actuated SU8 and nickel cantilevers (Image courtesy of Stanford University)

XeF_2 does not attack polymers or other organic films. As a result, low cost photoresist can be used as a cost-effective mask and polymeric passivation layers, such as those from the Bosch Process, can be used as an effective protective layer for trench sidewalls. XeF_2 is also an ideal way to release PDMS, parylene and SU8 (see Fig 2)

XeF_2 does not attack most of the materials typically used in packaging or wafer dicing. As a result, XeF_2 can increase yield by delaying the release of a MEMS device until after dicing or package insertion and wire bonding. XeF_2 has been used successfully to release MEMS devices on diced wafers on the dicing frame and chips inside packages. For more details see Table 1 (overleaf).

XeF_2 Selectivity

Etched Material	Conditionally Etch Materials	High Selectivity Materials	"Infinite" Selectivity Materials (i.e. not etched by XeF_2)		
	(at elevated temp)		Metals	Compounds	Polymers/ Organics
Silicon	Titanium	Thermal oxide	Aluminum	PZT	Photoresists
Molybdenum	TiN	LTO	Nickel	MgO	PDMS
Germanium	Tantalum	Si_3N_4	Chrome	ZnO	C_4F_8
SiGe	TaN	Gold	Platinum	AlN	Silica glass
	Tungsten	Copper	Gallium	GaAs	Dicing tape
	TiW	SiC	Hafnium	HfO_2	PP
				TiO_2	PEN
				Al_2O_3	PET
				ZrO_2	ETFE
					Acrylic

Table 1 List of common materials used in semiconductor devices and their relative reactivity with XeF_2 gas

Application Examples

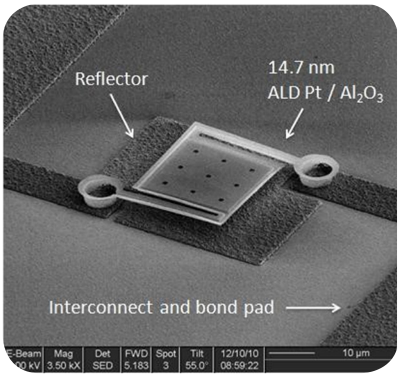

Fig 3 ALD film bolometer
(Image courtesy of J. Provine, Stanford University)

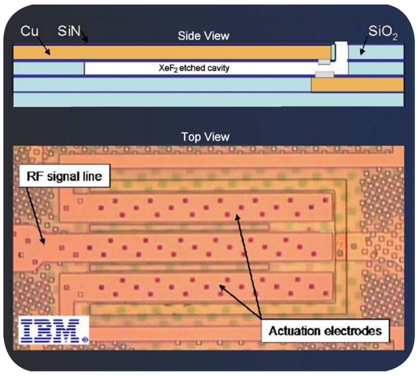

Fig 4 RF switch
(Image courtesy of IBM)

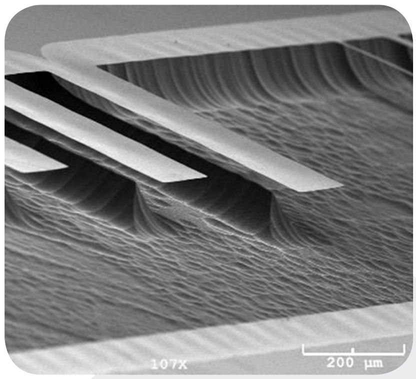

Fig 5 Cantilevers undercut using XeF_2 release etch

Product Range

SPTS offers a choice of XeF_2 release etch systems for R&D to volume production applications:

- **Xactix® e2** - A simple table top etcher, which is the ideal solution for those seeking a low cost R&D xenon difluoride etching system. It is ideal for universities and laboratories who do not need the performance of the Xactix® X4
- **Xactix® X4** - This is the leading XeF_2 etch system for releasing MEMS devices. Its accelerated etch rates and superior components make it ideal for applications from intensive R&D to pilot production.
- **Xactix® CVE** - has a patented chamber design which provides high etch rates, uniformity and efficiency. Compatible with SPTS' c2L & ƒxP cluster platforms allowing the integration of multiple XeF_2 modules with the other technologies from SPTS.

e2

CVE

SPTS Technologies, A KLA company, designs, manufactures, sells, and supports etch, PVD, CVD and MVD® wafer processing solutions for the MEMS, advanced packaging, LED, high speed RF on GaAs, and power management device markets. For more information about SPTS Technologies, email enquiries@spts.com or visit www.spts.com