PRIMAXX® VHF Etch Release Technology

Dry Vapor HF University/Corporate R&D Tool for Sacrificial SiO_2 Etch Release Processing

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PRIMAXX® VHF Technology/Company

Installs

80 Etch Release Process Modules

60 Customers

Gen 1 CET3-M open load

Gen 1 CET25 (Dalsa)

Gen 2 CET25/3 modules

IP : 25 wafer VHF system, Primaxx VHF process patents

Lucent AHF project - stiction free release

Primaxx acquired by SPP

Gen 3 Monarch 3 module

uEtch system

Primaxx integrated into SPTS

Primaxx fxP platform/ software

Gen 3 Monarch 25 module

2002	2004	2006	2008	2010	2012

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PRIMAXX® "DRY" VHF Technology

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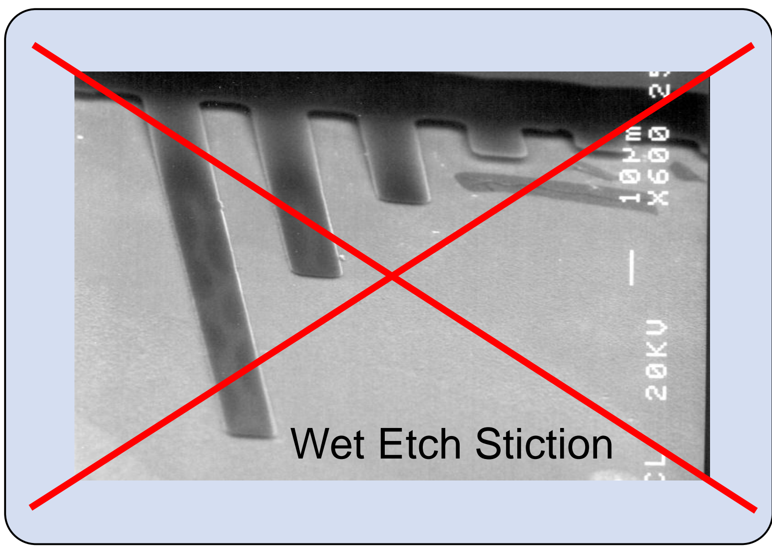
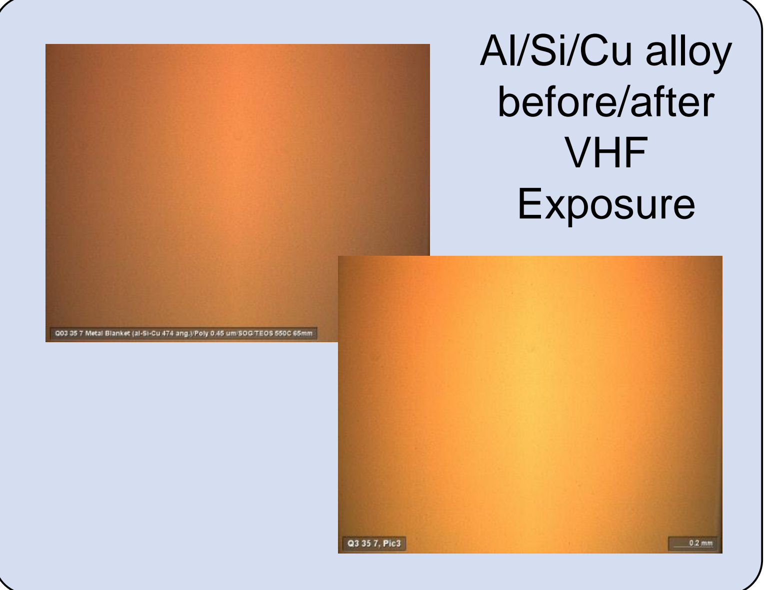
Stiction Free VHF Etch Processing





- PRIMAXX® Vapor HF etches sacrificial SiO_2 in MEMS :
  - **DRY** vapor phase process
  - Reduced pressure, elevated temperature
  - Large process window
- Key technology benefits :
  - **Eliminates stiction** – repeatable, controlled, low cost process
  - Compatible with many metals/typical MEMS materials (Al)
  - Uses anhydrous HF, semi grade alcohol

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PRIMAXX® DRY VHF Process Chemistry

- Desorption steps most important
  - SiF_4 (ads) ⇆ SiF_4 (gas)
  - A (ads) ⇆ A (gas)
  - H_2O (ads) ⇆ H_2O (gas)

Water is also a catalyst. Must be controlled by pressure to keep as vapor, and etch rate to limit generation rate to prevent further catalysis

SiO_2 + AHF Vapor + Alcohol Vapor Catalyst → Alcohol Vapor Catalyst + SiF_4 Gas + WATER VAPOR

Alcohol not directly consumed but binds with water too

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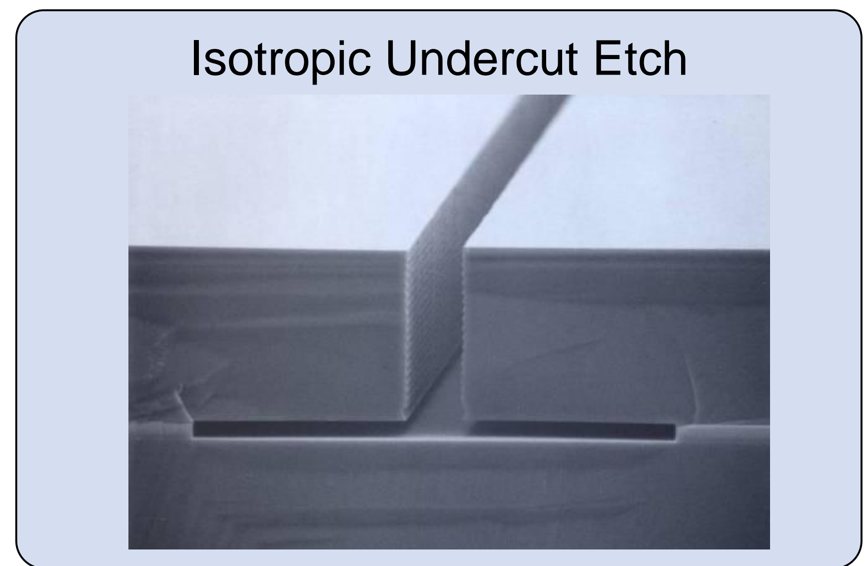
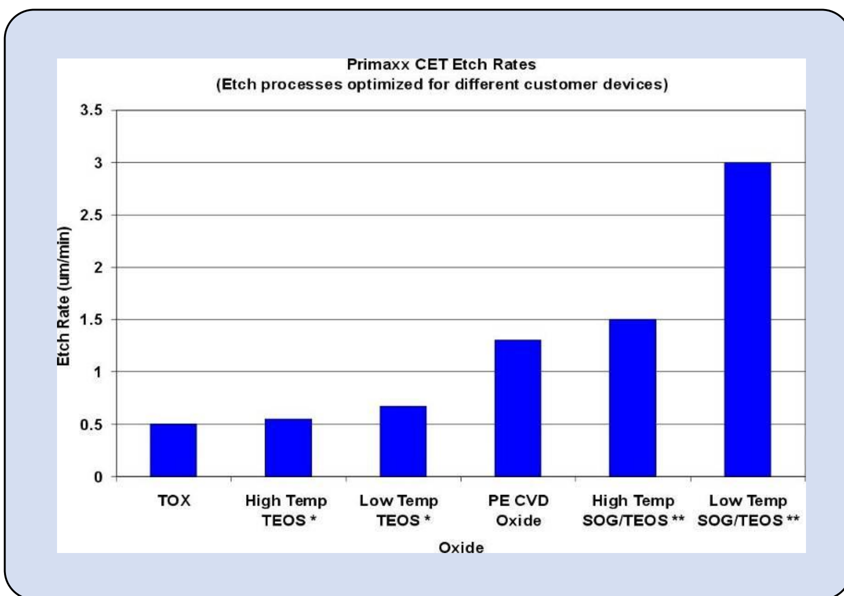
PRIMAXX® VHF Capabilities

- Etch rates (isotropic)
  - Variable T, P, reagent flows – wide etch rate range
  - 0.05 um/min (dense oxides, small spaces) to >> 1 um/min
  - Maximum rate limited by exposed metals, SiO_2 area, uniformity needs
  - Oxide types (densities), not compatible with doped oxides
- Excellent WIW, W2W, R2R uniformities/repeatabilities
- Selective to
  - Si, Al_2O_3, SiC, Al/Au/Ni/Cr/ etc, silicon nitride (1:1 - 30:1, Si-rich LPCVD best)

Isotropic Undercut Etch





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PRIMAXX® VHF Etch Release Technology

Product Range, Applications

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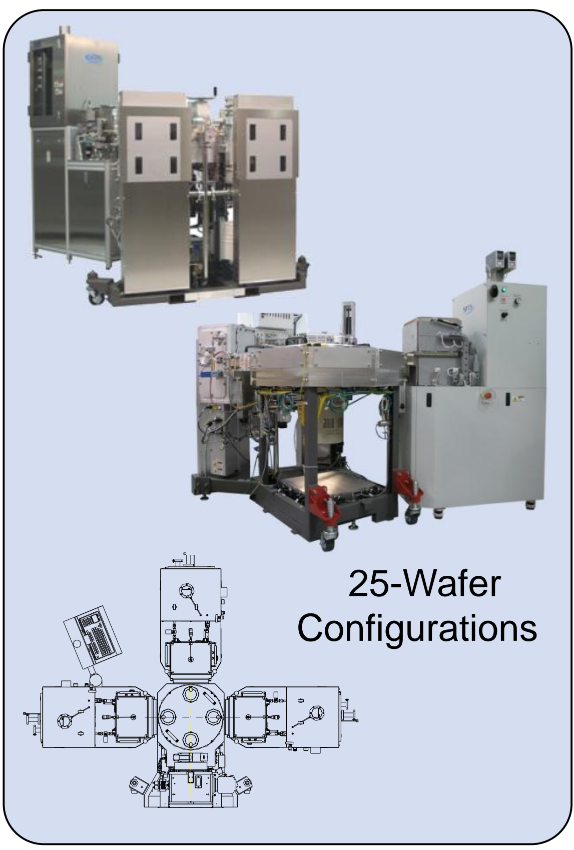
PRIMAXX® Product Range Overview



- Process space (P, T, flows) is similar across product range
- Processes scalable from uEtch through CET25/Monarch25

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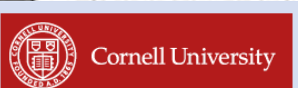
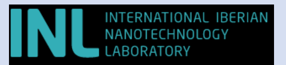
VHF Technology – Segments/Customers

Universities and Small Corporate R&D labs – uEtch





Corporate/Institutional R&D – Monarch/CET 3

sensonor

Low/Medium Volume Production (foundries, device mfrs) – Monarch 3, CET25

Institut Siliziumtechnologie

National
Panasonic
Matsushita
Electric
Works, Ltd.

High Volume Production Foundries/Device Manufacturers – 25-wafer Systems

Murata Electronics Oy

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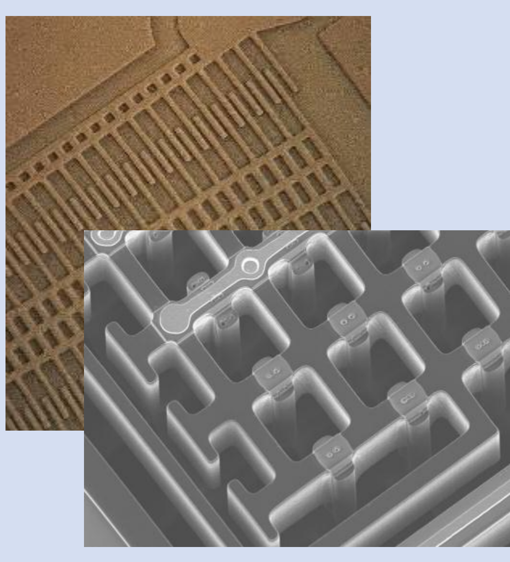
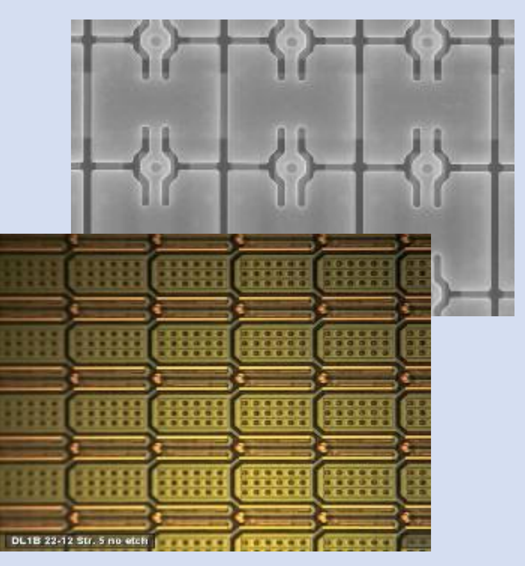
VHF Etch Release Applications

Accelerometers and Gyroscopes



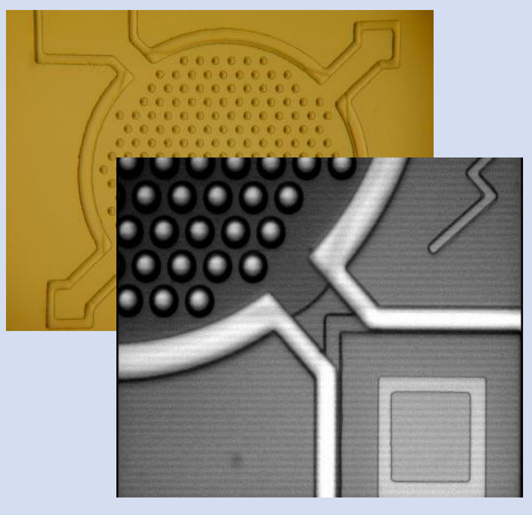
- VHF release essential with most inertial designs

Mirrors/Arrays



- Long undercuts
- Narrow "streets"
- Al/alloy OK

Silicon Microphones



- Stress free membrane release
- No doped oxide

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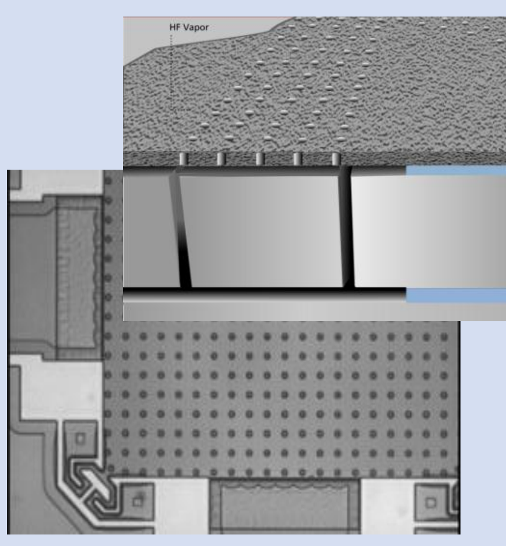
VHF Etch Release Applications

Silicon Resonators

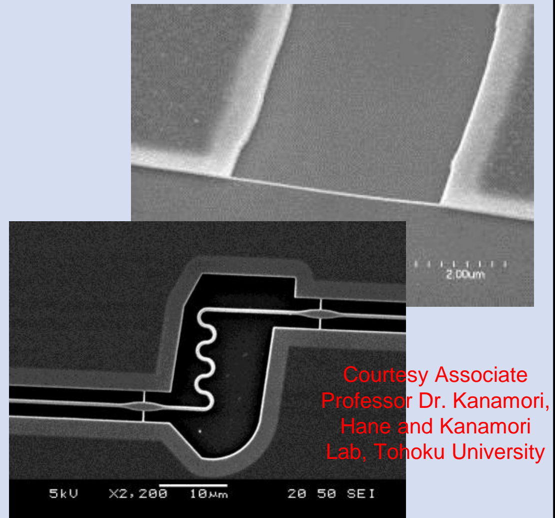


- Large proof mass devices

Silicon Actuators, Components

- Full, complete die release
- Watch components:
  - Springs
  - Wheels/gears
- Autofocus components

Nanoscale Structures



Courtesy Associate Professor Dr. Kanamori, Hane and Kanamori Lab, Tohoku University

- Silicon nanowires
- Silicon (wire) waveguides

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PRIMAXX® VHF Etch Release Technology

Process Chamber

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uEtch Chamber, Fab-Proven Technology

Patented cross-flow gas delivery provides pathway for scalability

Heated & Hinged Access Lid
Wafer Supports
Supply Inlet
Heated Chamber
Exhaust
Diffusion Manifold
Exhaust

Heated Process Chamber
Access Lid
Diffusion Plates
Baratron
Supply Inlet
Exhaust
Chemraz O-rings
Graphite Plates
Isolation Valve
Maintenance Door
Heated Transfer Chamber
Indexing Elevator

1 - Wafer

3 - Wafer

25 - Wafer

*** not to scale***

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uEtch System Parameter Controls

- Gas Delivery
  - HF vapor flow control : 0 - 750 sccm, open loop controlled ALD valve (600 torr inlet pressure)
  - Alcohol vapor flow control : 0 - 250 sccm ethanol vapor, open loop controlled low dead volume liquid isolation valve/heated vaporizer
  - Process nitrogen flow control : 0 - 2 slm, open loop controlled ALD valve < 10 psig delivery pressure
- Pressure
  - Operating pressure range 50 - 150 torr, base pressure and pump down time are pump dependent; manual vernier metering valve
- Wafer Temperature
  - Resistive element heaters with PID controller
- Process Control
  - Multi-channel Process/Program Controller with touch screen operation for Alarm monitoring and Recipe creation and running

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100mm - 200mm Capability

- Loader handles 100 - 200mm wafers
- Chips/die can be processed using a carrier wafer or optional custom pocket fixture

200 mm wafer

PVDF carrier with numerated pockets for sample ID

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Gas and Vapor Delivery

GASES (HF and N_2)

Regulated upstream pressure and electronically pulsed ALD valve

VAPOR (EtOH)

Vented liquid vessel, pulsed low dead volume liquid isolation valve and vaporizer

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