Dry Etch Capabilities
Penn State Nanofabrication Facility

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Introduction

The implementation of dry etching for material patterning is very common due to its unique ability to achieve anisotropic etching as compared to the traditional wet etching. This type of process is even more critical as the features being transferred become smaller and smaller and the aspect ratio of the structures became larger (i.e. Silicon trench etching for capacitive structures or Through wafer etching for MEMs devices).

In general dry etching refers to the use of a plasma, generated from a reactive gas, for removing material from the substrate surface by creating a volatile species at the substrate surface that is easily pump away in vacuum. In the plasma there are many different gaseous species produced that enable the removal of material which include ions, free radicals, electrons, photons, neutrals, and reaction by-products.

Chamber Configurations

In the most simplistic form a dry etch tool consists of a vacuum chamber, specialty gas delivery system, and an RF generator. However, as devices have become more and more complex the typical dry etching tool configuration has evolved as well. In general there are three basic chamber configurations: Plasma Etcher (PE), Reactive Ion Etcher (also know as a Capacitive Coupled Plasma or CCP), and an Inductively Coupled Plasma (ICP) that are currently used in the Nanofabrication facility.

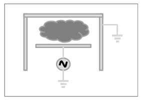


Figure 1. Simplified Schematic of a CCP chamber

Capacitive Coupled Plasma (CCP)
A typical (Capacitive Coupled Plasma) RIE system consists of a vacuum chamber, with a set of electrodes. The electrode on which the substrate sits is electrically isolated from the rest of the chamber and is driven by an RF power supply. Gas enters through the showerhead which is above the wafer and is usually part of the grounded electrode. The types and amount of gas and power used vary depending upon the etch processes being performed.

Plasma Etcher
Is similar to the CCP with the exception that the powered electrode is actually the top electrode while the bottom electrode is grounded.

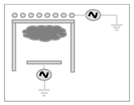


Figure 1. Simplified Schematic of a ICP chamber

Inductively Coupled Plasma (ICP)
An inductively coupled plasma (ICP) RIE uses a inductive coil (which can be configured several different ways) to generate the plasma. The plasma is generated by coupling the RF powered magnetic field through a quartz window. A second RF power supply is connected to the electrode where the substrate sits and is used to develop a RF bias which generates a directional electric field for anisotropic etching.

M4L:

Plasma system is configured as a low density plasma chamber (PE). The system is primarily used for Resist descum and surface modification.

Gases Available
-C_2F_6
-O_2
-He

Typical Materials Processed
-PDMS
-Resist
-Parylene
-Polypyrrole
-LOR
-SU8
-Polyimdes

Applied Materials MERIE:

-The MERIE is a magnetically enhanced CCP system. The addition of the magnets allows for a higher density plasma due to the confinement of the electrons by the magnetic field.

Gases Available
-CF_4
-CHF_3
-O_2
-Ar

Typical Materials Processed
-SiO2
-Si3N4
-Quartz
-SilSpin
-Transpin
-Polyimide

Alcatel “Speeder 100”:

The Alcatel “Speeder 100” is an ICP Etching system which is configured for etch silicon using either the patented BOSCH Deep Silicon Etch Process or a Cryogenic etch process.

Gases Available
-C_4F_8
-SF_6
-O_2
-Ar

Typical Materials Processed
-Si >2μm
-Silicon thru wafer

PT 720:

-RIE system consists of a vacuum load lock connected to a simple CCP chamber for dry etching semiconductor, dielectric, and metal samples.

Gases Available
-CF_4
-SF_6
-C_2F_6
-CHF_3
-O_2
-Ar
-Cl_2
-H_2

Typical Materials Processed
-SiO2
-Si3N4
-Gold
-Chrome
-Titanium
-Aluminum
-Silicon
-III-V
-Parylene
-SU-8

Tegal 6500:

-A high-density plasma etch tool featuring Tegal’s unique HRe-™ reactor, and patented dual-frequency RF power technology and magnetic plasma confinement. The system is a critical enabler for etching many complex oxide materials.

Gases Available
-CF_4
-SF_6
-O_2
-Ar
-Cl_2
-BCl_3

Typical Materials Processed
-PZT
-PMN-PT
-Al_2O_3
-ZnO_3
-Platinum
-Aluminum
-Silicon
-HfO_3

New PlasmaTherm Versalock:

-The Versalock is an ICP etching system which is configured with two separate chambers. Each chamber is designated for processing different materials based on etch gas chemistries.

Gases Available
-CF_4
-SF_6
-O_2
-Ar
-Cl_2
-BCl_3
-C_2F_6
-CHF_3

Typical Materials Processed
-SiO2
-Si3N4
-Gold
-Chrome
-Titanium
-Aluminum
-Al_2O_3
-TiW
-TiO_2
-GaN
-AlGaN
-Silicon
-III-V

Xactix XeF_2:

-The Xactix is a non-plasma based etch system used for isotropically etching Silicon. The XeF_2 will spontaneously react with silicon creating a volatile byproduct, plasma confinement.

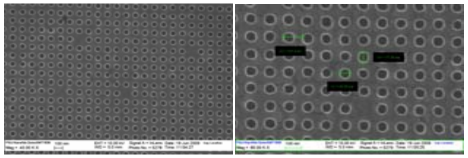
Gases Available
-XeF_2

Typical Materials Processed
-Silicon

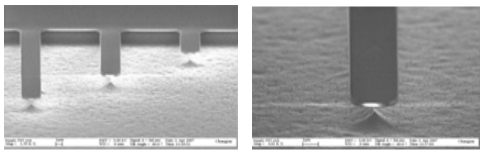
Results

Si Trench Etching using ICP

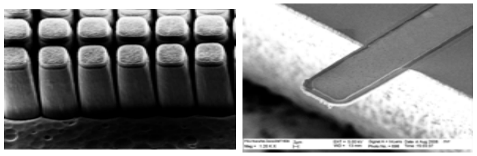
Aluminum Etching using CCP etching



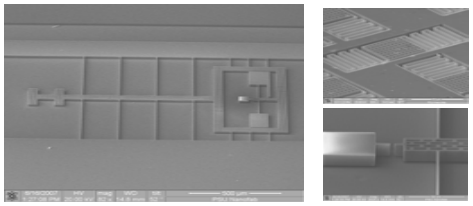
Cantilever fabrication using CCP system and XeF2



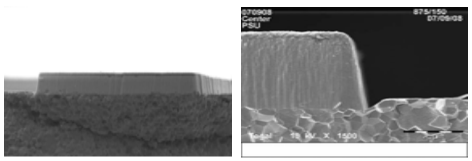
Complex Oxide Etching using ICP system



Deep Silicon Etching via Special ICP Process



Complex Oxide Etching using CCP system



In Summary

Each tool and technique has its advantages and disadvantages. The details of the processes and materials needed for the fabrication of the end product combined with the tool capabilities ultimately determine which tools are best suited for use in a particular fabrication process sequence. In order to expedite the choice of a toolset for each fabrication process, users are encouraged to interface closely with the staff.

There are several mechanisms currently in place to help facilitate these interactions:
- New User Project Overviews
- Tool trainings
- Follow-up meeting with the staff as needed.

For more information on what tools are available or how to get started please visit:

http://www.mri.psu.edu/facilities/NNIN