Etching process characterization of nitride and polysilicon layer using trion III Etcher

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Project Objectives
Goal: Through multiple tests we hope to characterize and understand the Trion III etcher better for integration of etch recipes for nitride and polysilicon layers in future device etch steps.
The target is to achieve anisotropic profile of nitride/polysilicon layer with good uniformity and selectivity.

Motivation
• As technology is evolving and we are pushing the boundaries of Node Scaling, Etch profile and etch control of sub nm layers are becoming critical for device yield and performance.
• Dry plasma Etching offers the capability of Anisotropic etching over Isotropic profiles which becomes a critical attribute as we go down the node scale.
• Factors used to characterize effectiveness of etch process:
  1. Etch-rate
  2. Etch-rate uniformity
  3. Etch profile(isotropic or Anisotropic)
  4. Selectivity between films
  5. Etch bias

Test Setup

Test setup Nitride:
- Gas used: CF4, SF6 and O2
- RIE Power: 125 - 250 Watts
- Pressure: 75 mTorr - 150 mTorr

Test setup Polysilicon:
- Gas used: CHF3, SF6 and O2
- RIE Power: 120 - 160 Watts
- Pressure: 60 mTorr - 120 mTorr

Trion III Dry Etching
• In this research the Trion III minilock etcher was used to characterize the Nitride and Polysilicon Layer.
• Dry etching is the preferred method going forward in this industry for most thin films because of its ability of anisotropic etching profiles.
• For the process of plasma etching an RF glow discharge is created which produce chemically reactive species (atoms, ions etc) these reactive species react with chosen gases to react with nitride or polysilicon layer to etch them off.

Results
Nitride Experiment:
Nitride deposition was done on top of oxide wafer with target thickness of around 250 nm. From the data below of deposition it is understood that the deposition uniformity across the wafer was around 1.2% with Std deviation of around 3 nm

Using the Nitride wafers, 780nm of photoresist were coated and exposed and developed using our in house GCA Stepper. The following data shows the etch selectivity between the layers and the separate etch rates

Below is further nitride etch rate data from different tests carried out on patterned wafers.

Below is the imaging of etch micrograph data showing etch profiles of around 1.2um.

Results (cont)

Polysilicon Experiment:
After the process of RCA clean of bare silicon wafers, 250nm of oxide was deposited on top and then 500nm of polysilicon was deposited using LPCVD method. The table below shows the Non uniformity data of the polysilicon deposition layer

From previous data from now decommissioned Drytek Etcher we established a etch time of 5 min. This resulted in being over etching the wafers hence showing a variation between the tools. Below we show the new etch rate of the polysilicon layer.

V. Conclusions
• Nitride data showed varied difference in etch rate with the change in gas combination and percentage of oxygen present in chamber.
• Low base pressure lead to slow etch rates whereas high RIE forward power resulted in high etch rate with more directionalism
• Polysilicon etch rates showed faster etch rates across the DOE compared to previous data gathered from Drytek Quad.

Future Work
• Next step of this study will be to have the profile checked using SEM and understand the impact of the gas combination to the power and pressure levels of the system.

References
• Dr Fullers powerpoint slides of CMOS factory process
• Microchip Manufacturing by S.Wolf
• Etching Wikipedia
• Dr Jacksons Thin films LPCD data

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