Sputtering deposition of metals and dielectrics

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EE 412 Final Presentation

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Outline

- New Intlvac sputtering and evaporation deposition systems
- Development of materials in sputtering system
  - Titanium, dual mode AC sputtered
  - Silicon Dioxide, dual mode AC, reactive sputtered
  - Tungsten, RF sputtered
- Future work

Physical Vapor Deposition in SNF

- Innotec e-beam evaporation system
- Gryphon sputtering system
- Metallica sputtering system

Intlvac Sputtering and Evaporation Systems

- Installed within SNF March 2011
- NANOCHROME I evaporator
  - 6 pocket, 8kW e-beam
  - 2 thermal boats
  - Substrate heating and ion beam
- NANOCHROME I sputter
  - Three, 3” cathodes
  - Dual Mode AC, DC and RF
  - Substrate biasing, heating and ion beam

Common Features

- Reactive gas flow
  - Nitrogen, Oxygen
- Integrated ion gun
  - Pre-PVD clean, IBAD
- Substrate heating
- Labview-based computer control system

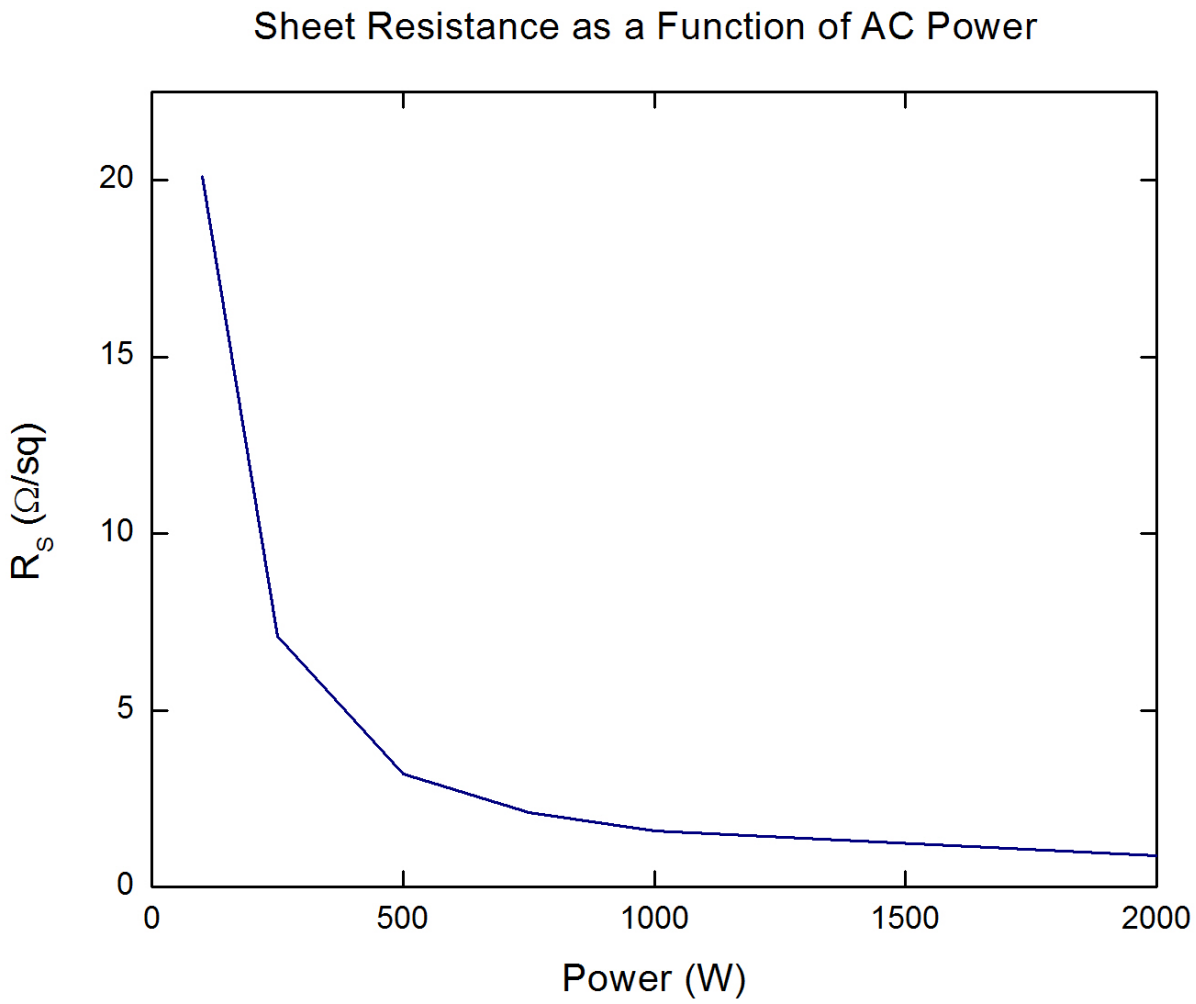
Development of Dual Mode AC sputtered Ti

- Motivation
  - Metallic Ti leading to reactively sputtered TiN and TiO_2 materials
- Experiment
  - Determine metallic deposition rate as a function of sputtering gun power
  - Analyze resistivity and thickness

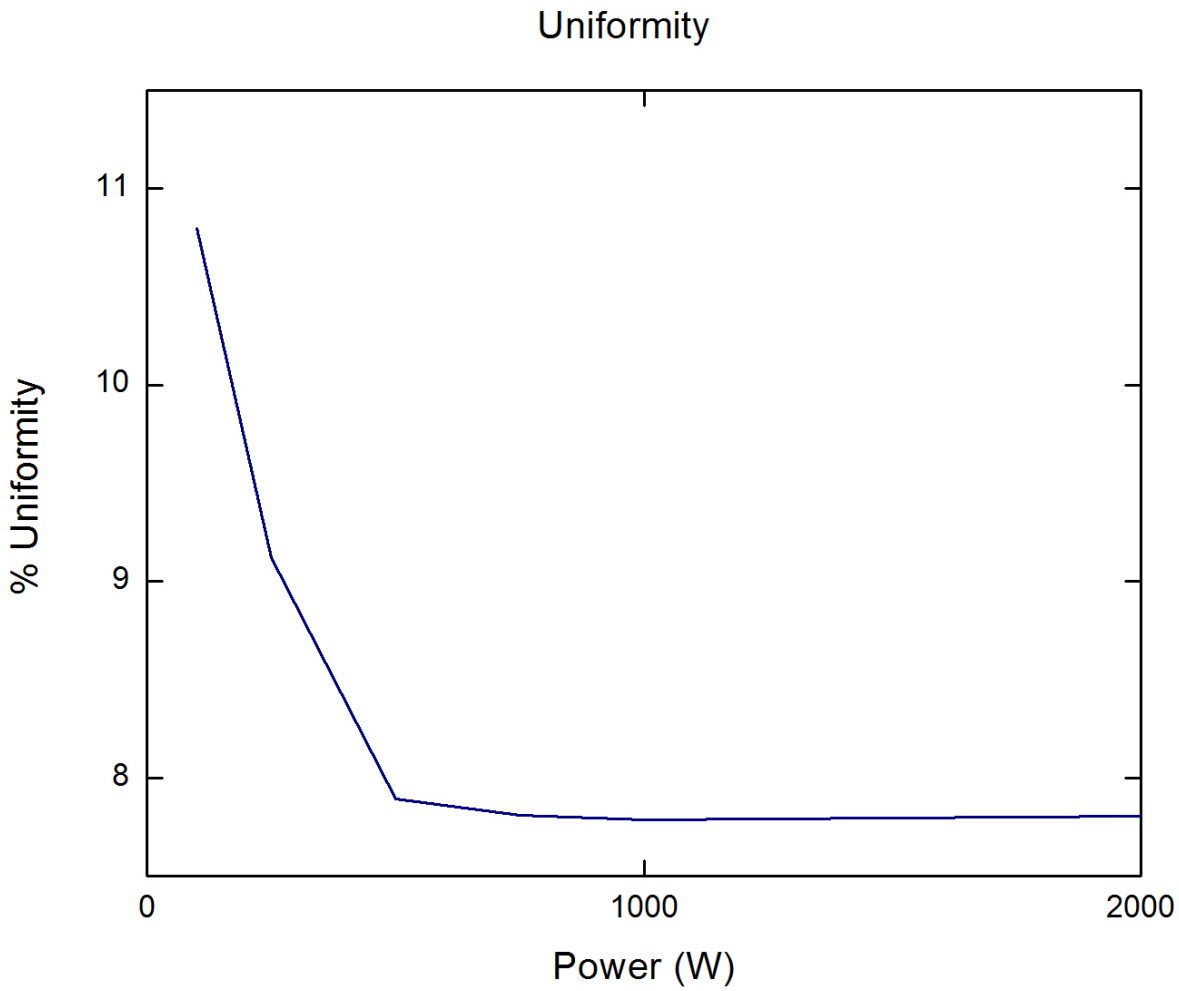
Experimental Method

- Sputter films
  - Titanium targets
  - 10 minutes
  - 45 sccm argon flow (6E-3 Torr)
- Analyze sheet resistance with Prometrix
- Wet etch a portion of the wafer ($HF:H_2O$) and measure step height with Alphastep
- Vary sputtering power
- Calculate deposition rate

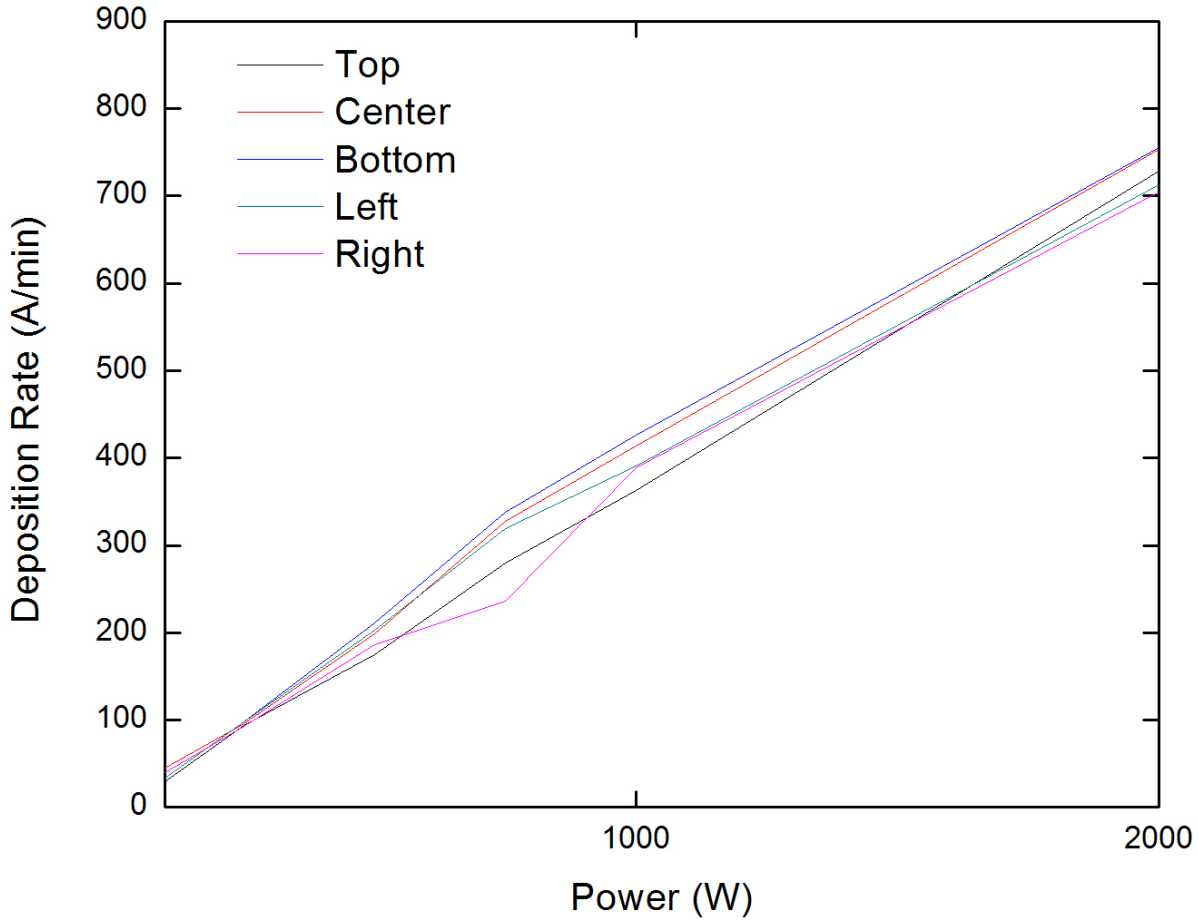
Sheet Resistance



Uniformity



Deposition Rate



Resistivity

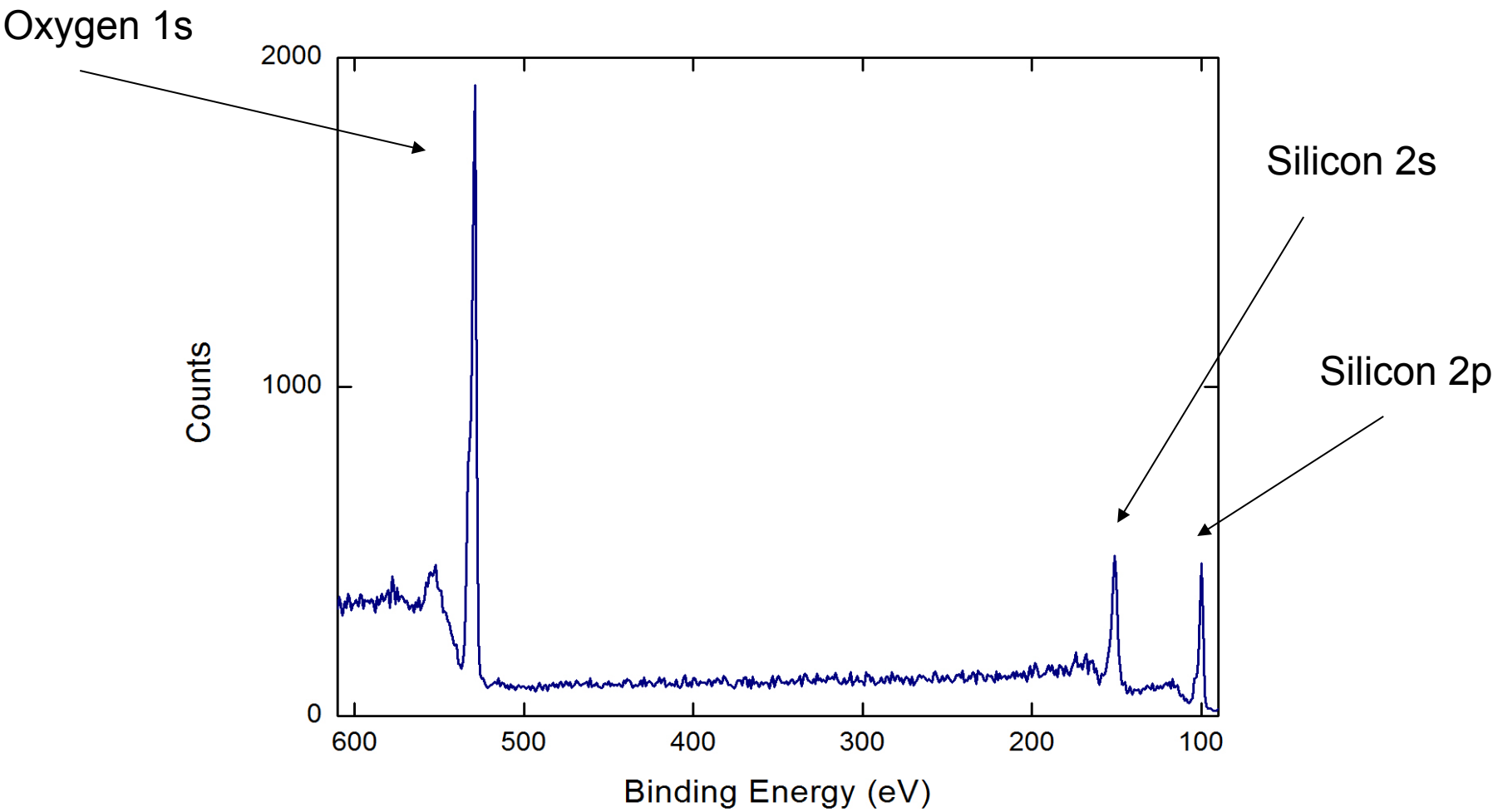
- Resistivity is sheet resistance times thickness

Power	Average Resistivity (Ohms-cm)
100 W	7.283E-5
250 W	6.710E-5
500 W	6.197E-5
750 W	6.367E-5
1000 W	6.286E-5
2000 W	6.516E-5

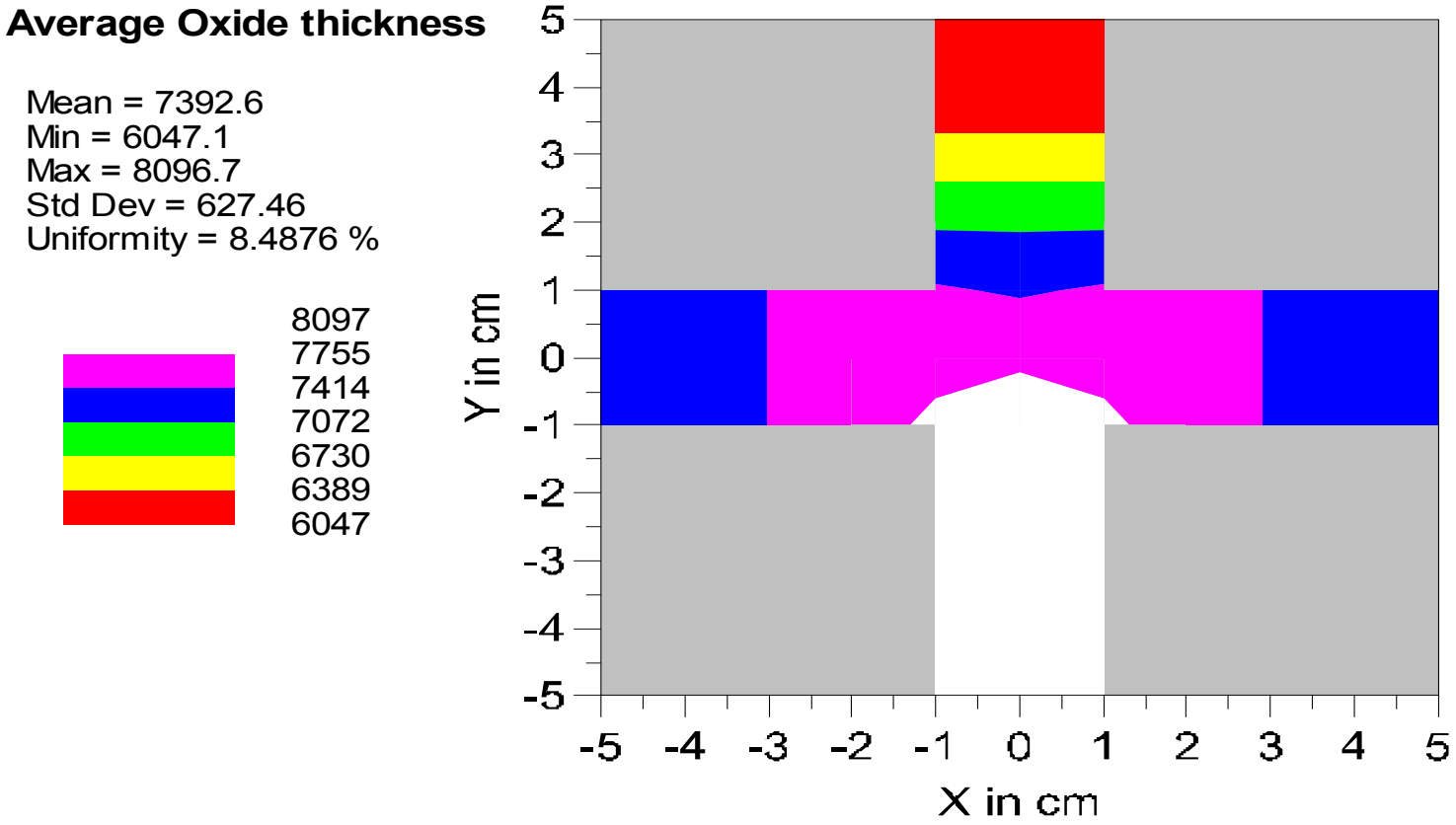
Development of Dual Mode AC reactively sputtered silicon dioxide

- Motivation
  - Non-electronic applications of dielectrics
    - Structural/sacrificial layers in MEMS
  - Low-temperature deposition method
  - Possible electronics applications
- Experiment
  - Introduce/optimize oxygen and argon flow in sputtering chamber
    - 20 minutes
    - 550 W power
    - 10 sccm O_2 flow, 33.8 sscm Ar flow
    - Silicon target
  - Characterize film composition and thickness

XPS Spectrum

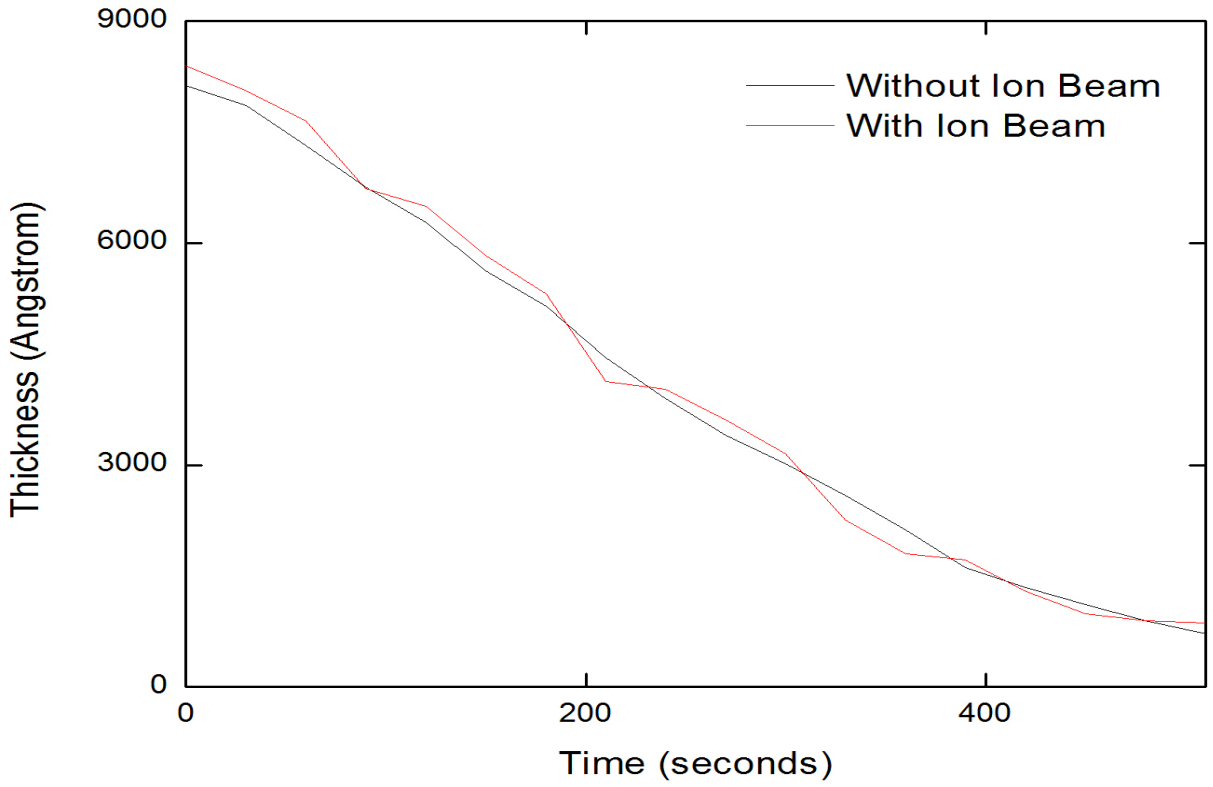


Woollam Ellipsometry



Deposition rate varies from 302 A/min to 405 A/min

Ion Beam Assisted Deposition



Ion Beam: 120 V voltage, 0.5 A discharge current, 0.6 A emission current

Under the current conditions, there is no difference in density/quality

Development of RF sputtered tungsten

- Experiment
  - Determine deposition rate
  - Analyze resistivity and thickness
- Method
  - Sputter films
    - 150 W RF power
    - 20 minutes
    - Tungsten target
    - 45 sccm argon flow (6E-3 Torr)
  - Analyze sheet resistance with Prometrix
  - Wet etch a portion of the wafer (H_2O_2, HF) and measure step height with Alphastep
  - Calculate deposition rate

Results, at 150 W RF

- 1.799 Ω/sq
- 8.847 % uniformity
- Thickness, in Angstroms
  - 796 (Top), 834 (Center), 892 (Left), 872 (Right), 937 (Bottom)
- Average Deposition Rate
  - 44 Angstroms/min

Future

- Incorporate and calibrate new materials within both machines (evaporation and sputtering)
- Take advantage of new capabilities
  - IBAD
  - Reactive deposition
  - Substrate heating
  - Substrate bias (sputtering)
  - Dielectrics

Sputtering	Evaporation
Nickel	Nickel
Nickel-Vanadium	Cobalt
Cobalt	Platinum
Silicon	Aluminum
Tungsten	Hafnium
Aluminum	Tantalum
Titanium	Molybdenum
Hafnium	Tungsten
Tantalum	Titanium
Molybdenum	Chromium
Chromium	Zirconium
Zirconium	Silicon
Niobium	Germanium
Vanadium	Palladium
Indium Tin Oxide	Niobium
Titanium-Tungsten	Vanadium

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