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Characterization of ALD Gate Oxide Films Via Electrical Measurements, Wet Etch, and Other Techniques

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Cambridge, MA



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- Mentor: Mac Hathaway



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Purpose

Advanced characterization of ALD (atomic layer deposition) oxide films for enhanced application to user requirements.



Research Outline



- Depositing a variety of oxides onto silicon wafers at 100C - 240C with the ALD
- Deposition materials include: Al_2O_3
 HfO_2
 TiO_2
 ZrO_2
 SiO_2
- Wet etch rate from 100:1 HF >>> Film Density
- Ellipsometer measurement >>> Film Thickness
- Electrical testing with eGain liquid metal probe >>> Electrical Breakdown Voltage
- FTIR Spectroscopy >>> OH content

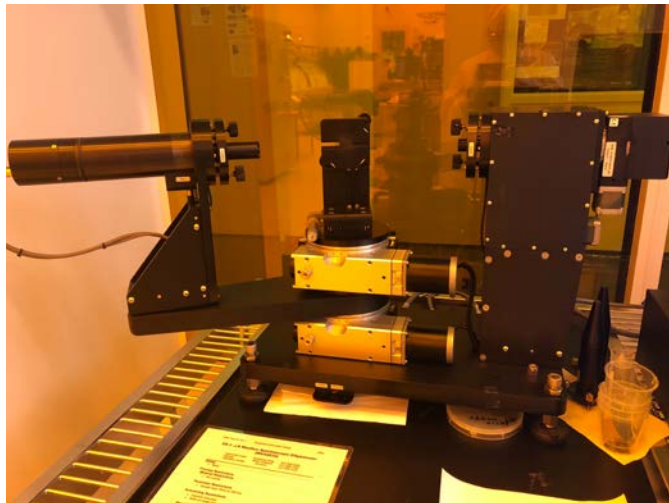
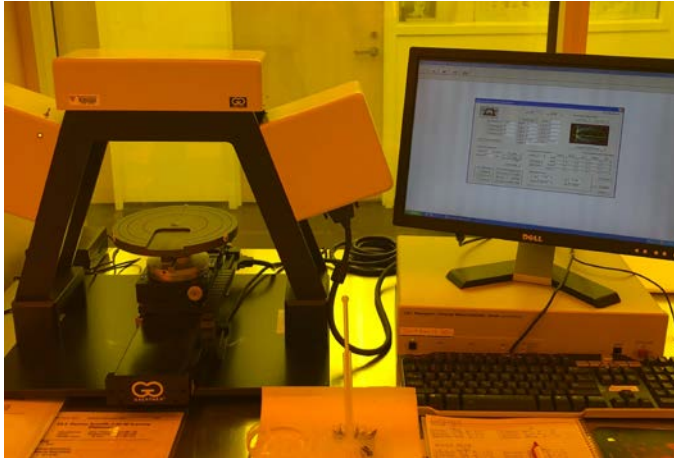


Atomic Layer Deposition

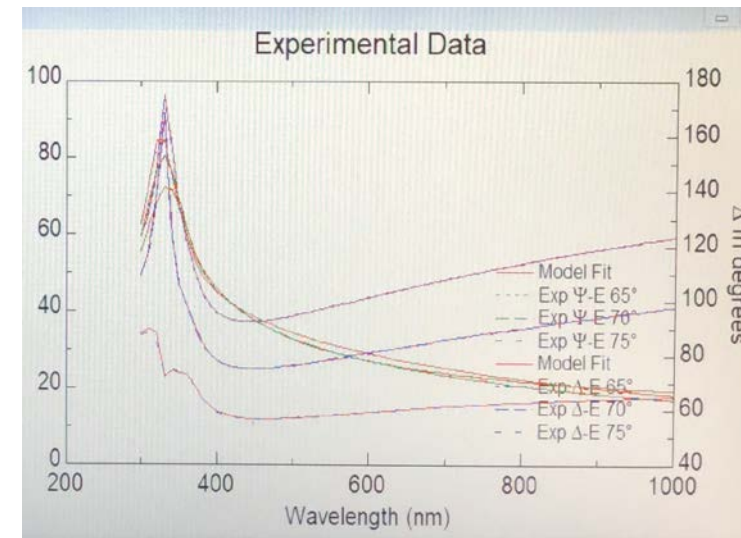
- ALD 1 and ALD 4 usage
- Low to mid range temperature range (100 -250 C)
- Single atomic monolayers
- High Uniformity
- Extreme Conformality
- Slow deposition rates
- Alternates gas pulses



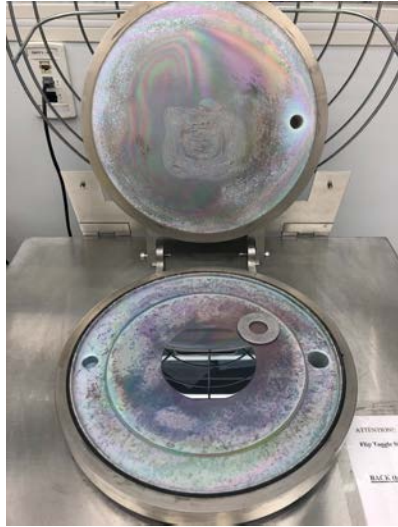
Ellipsometry



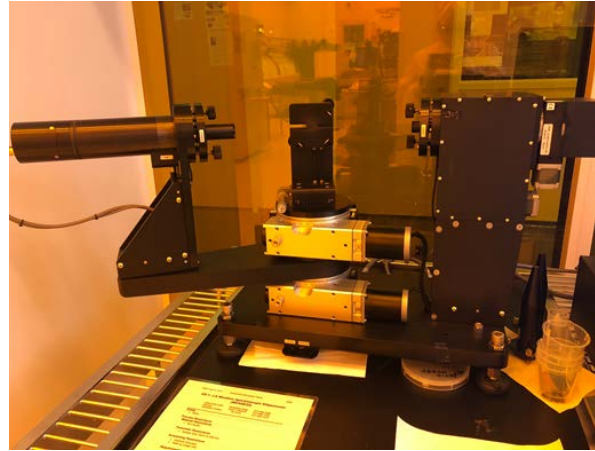
- Measures changes in light polarization to determine the samples material properties.
 - 1) Film thickness
 - 2) Optical Constants
- Data analysis
- Mean squared error (MSE), is used to quantify differences between curves.



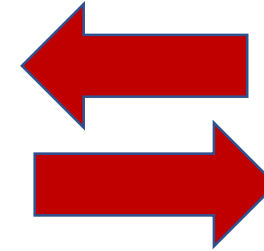
Work Flow



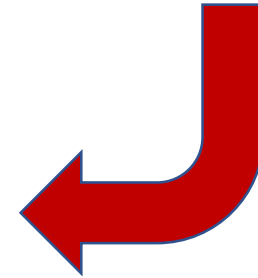
ALD



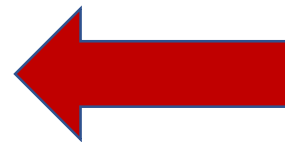
Ellipsometry



Wet Bench



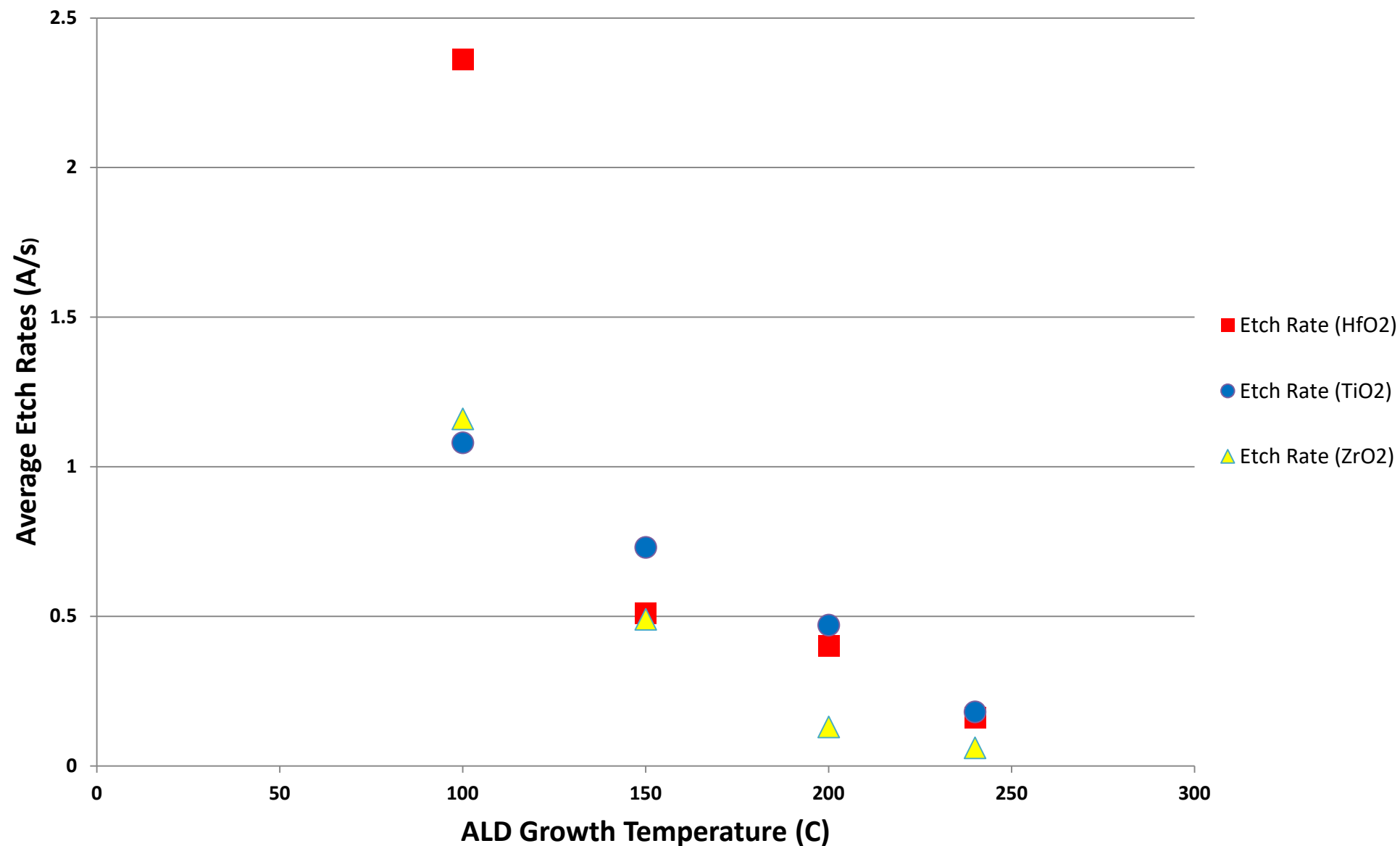
eGain Probe



FTIR

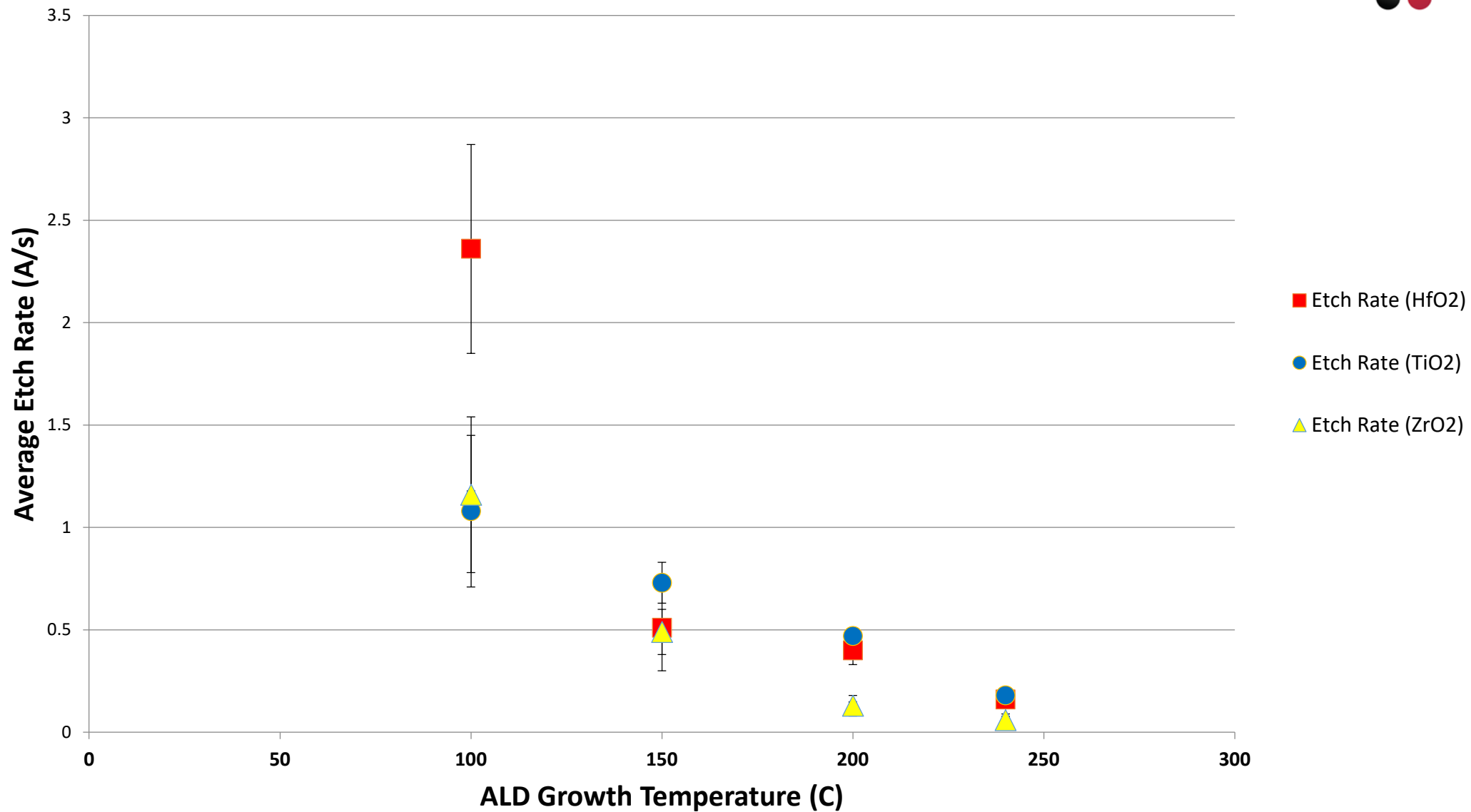


Wet Etch Rates in 100:1 HF



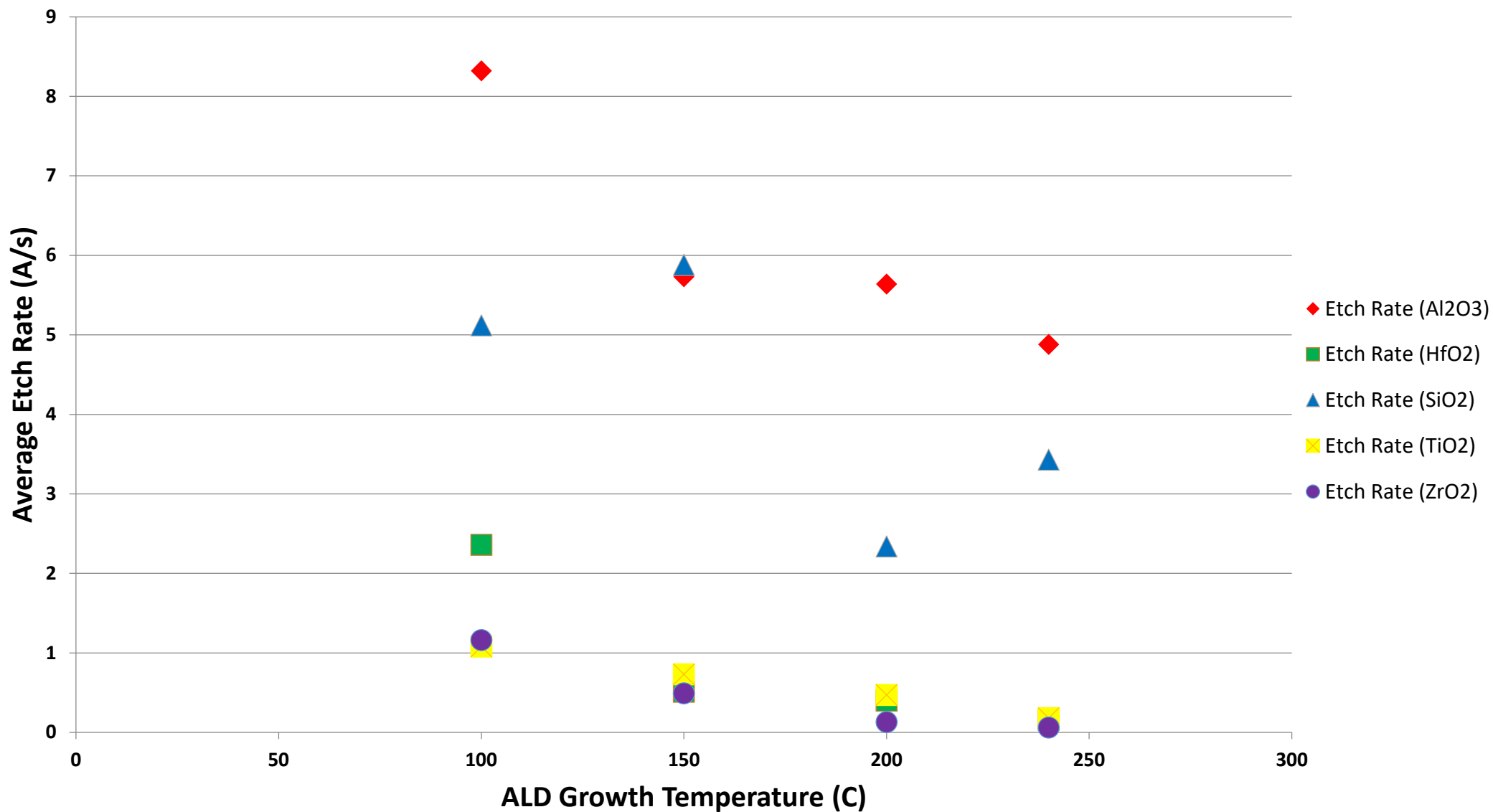


Wet Etch Rates in 100:1 HF



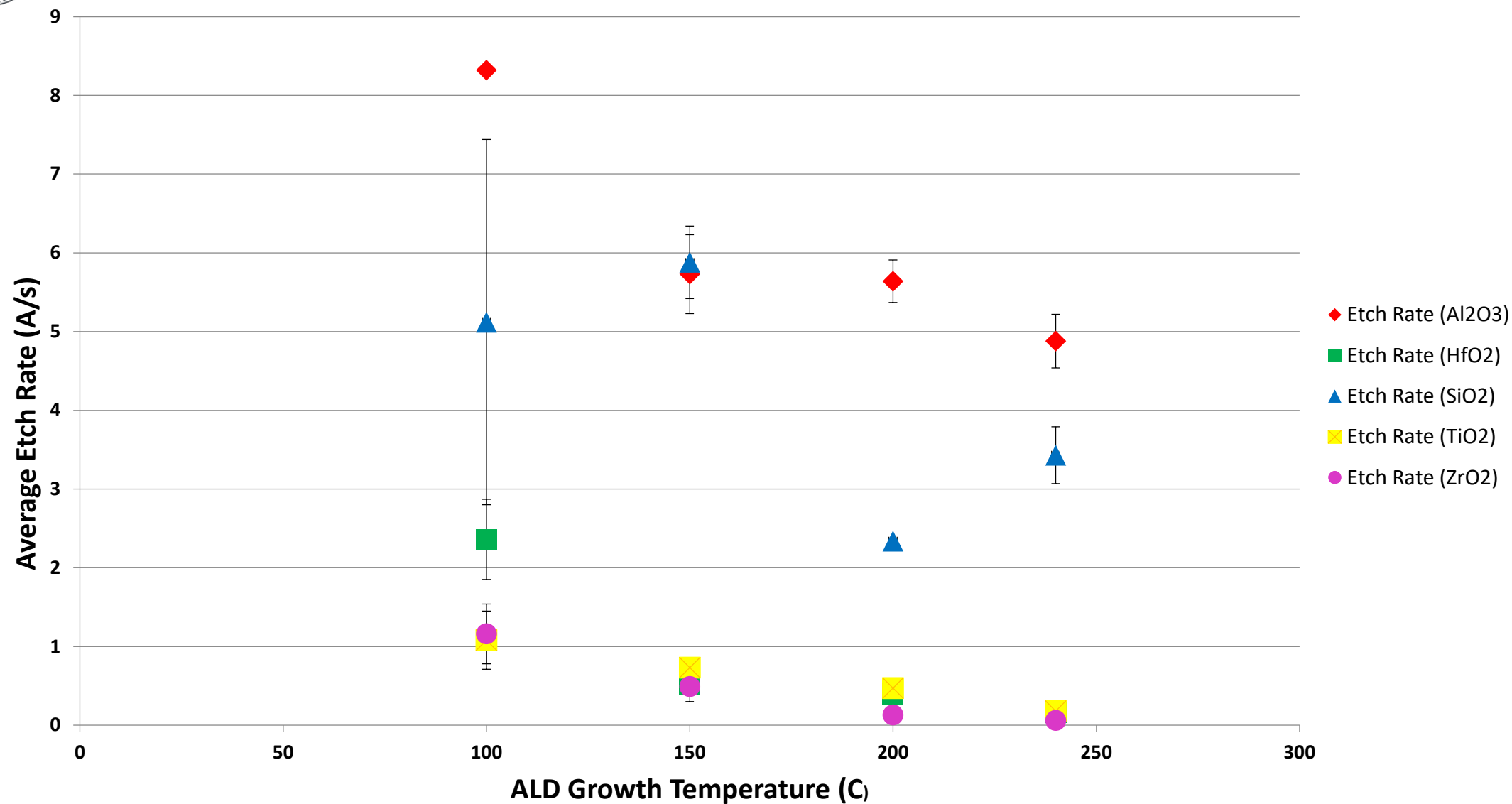


Wet Etch Rates in 100:1 HF



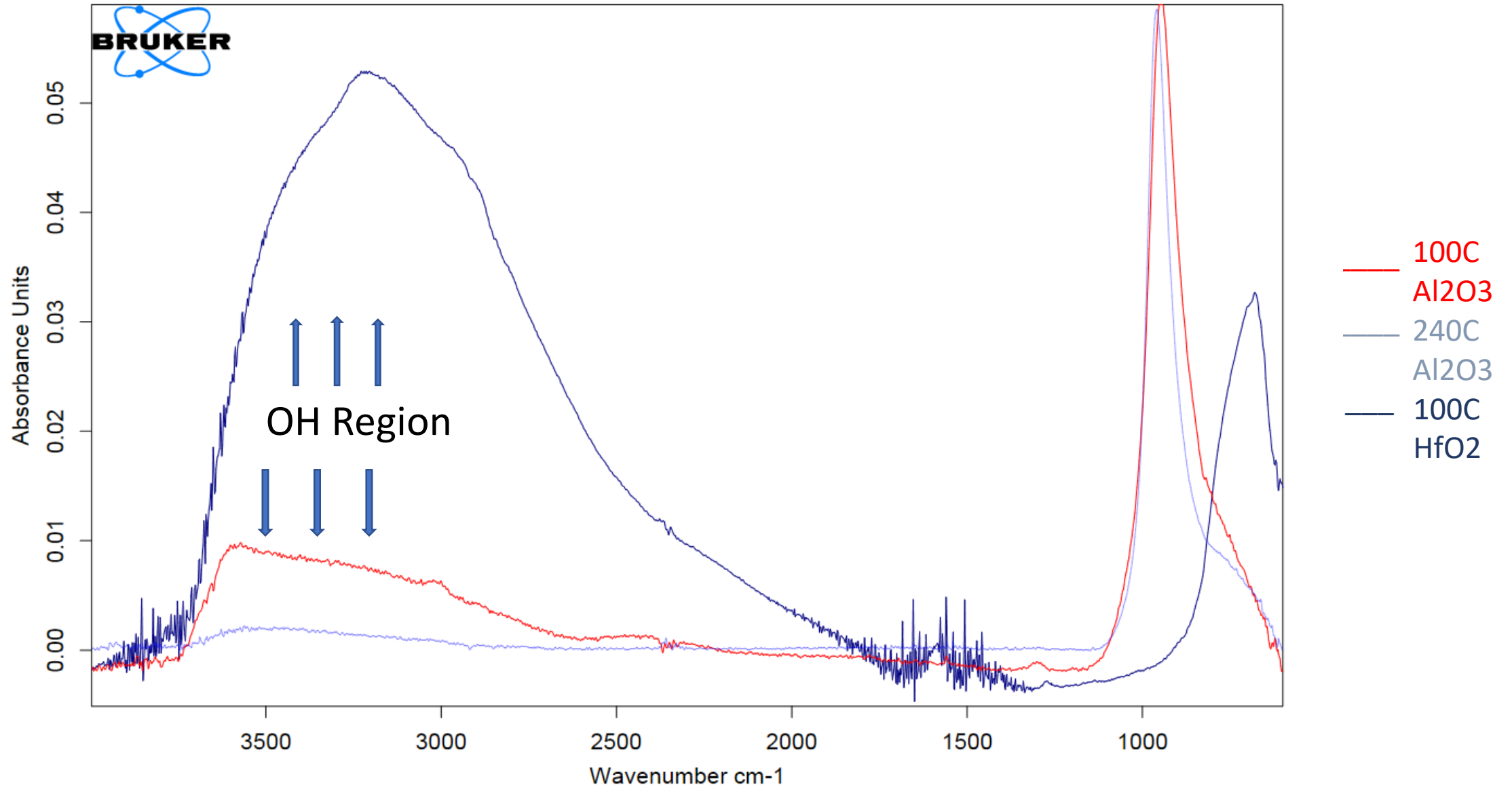


Wet Etch Rates in 100:1 HF





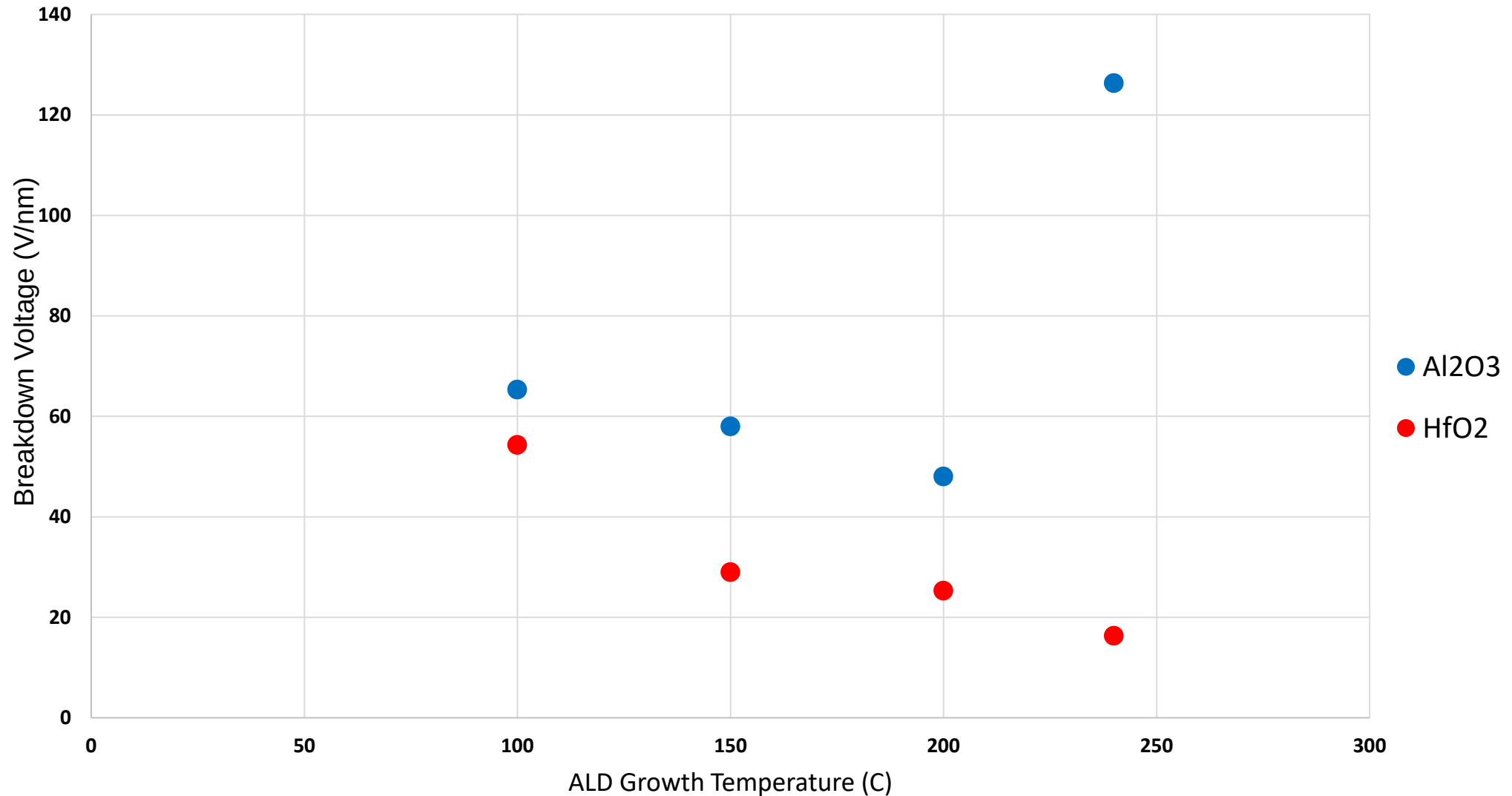
FTIR Absorption Spectrum of Al₂O₃ and HfO₂ vs Deposition Temp.





Electrical Characteristics

Breakdown vs Deposition Temperature





Ongoing Work



- Exploring the behavior of etched films with regard to breakdown.
- Confirming the correlation of OH content with etch rate variation
 - Using repeated samples
 - Atom Probe Tomography
- Looking at the behavior of nanolaminates.

Thank You