The influence of ion flux and ion energy in Thin Film applications

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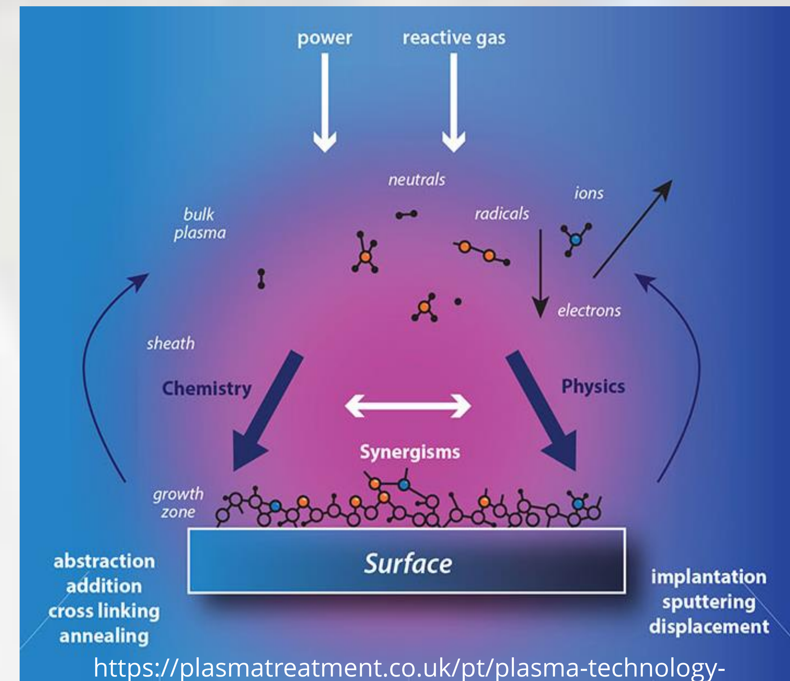
Introduction

- Interactions of energetic ions at a substrate play a major role in thin-film plasma processing.
- Ion energy and flux can be controlled by process parameters such as
  - ✓ chamber design
  - ✓ plasma gas mixture
  - ✓ gas pressure
  - ✓ power coupled into the plasma
  - ✓ substrate-biasing techniques etc.

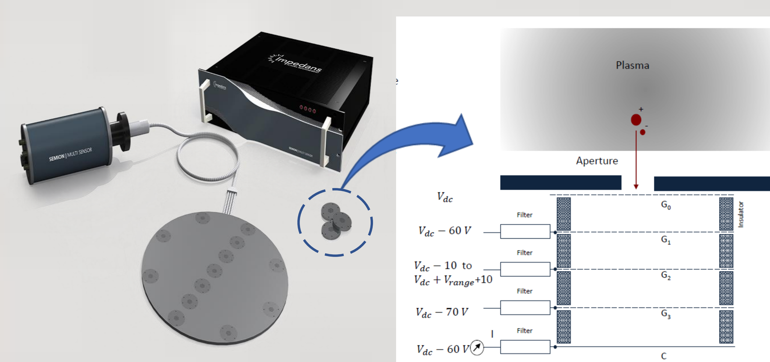


The ability to quantify the flux, energy of ions and ion-neutral fraction becomes crucial to optimize industrial plasma-assisted processes.

Methodology

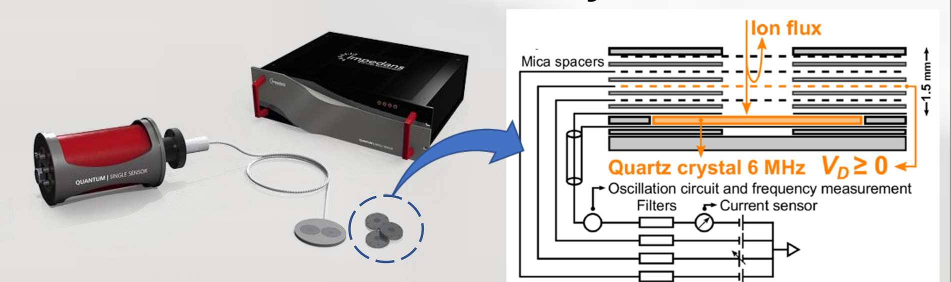
Substrate level measurement [1, 2]
Suitable for DC, CW RF biasing & pulsed RF biasing (sensor deployed on the grounded pedestal)

A. Semion Multi Sensor RFEA



Parameters Measured
- ✓ Ion energy distribution function (IEDF)
- ✓ Number of sensors: 1 – 13
- ✓ Average energy & ion flux
- ✓ Vdc

B. Quantum System

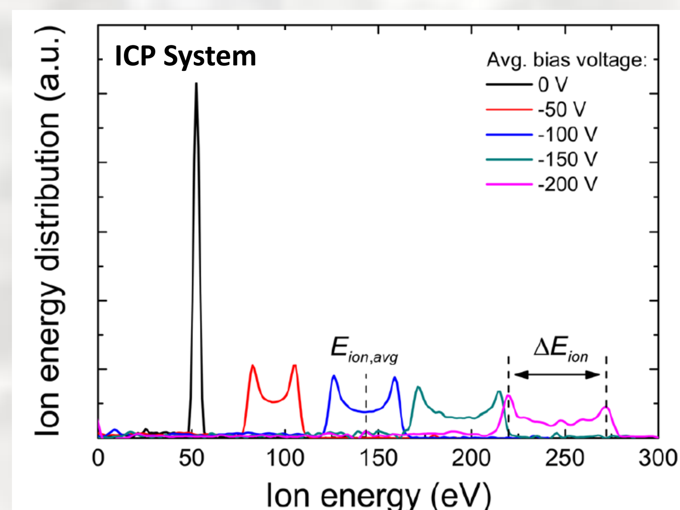


Parameters Measured
- ✓ Ion energy distribution function (IEDF)
- ✓ Number of sensors: 1
- ✓ Average energy & ion flux
- ✓ V_{dc}
- ✓ Ion-Neutral Fraction
- ✓ Deposition rates of ions and neutrals

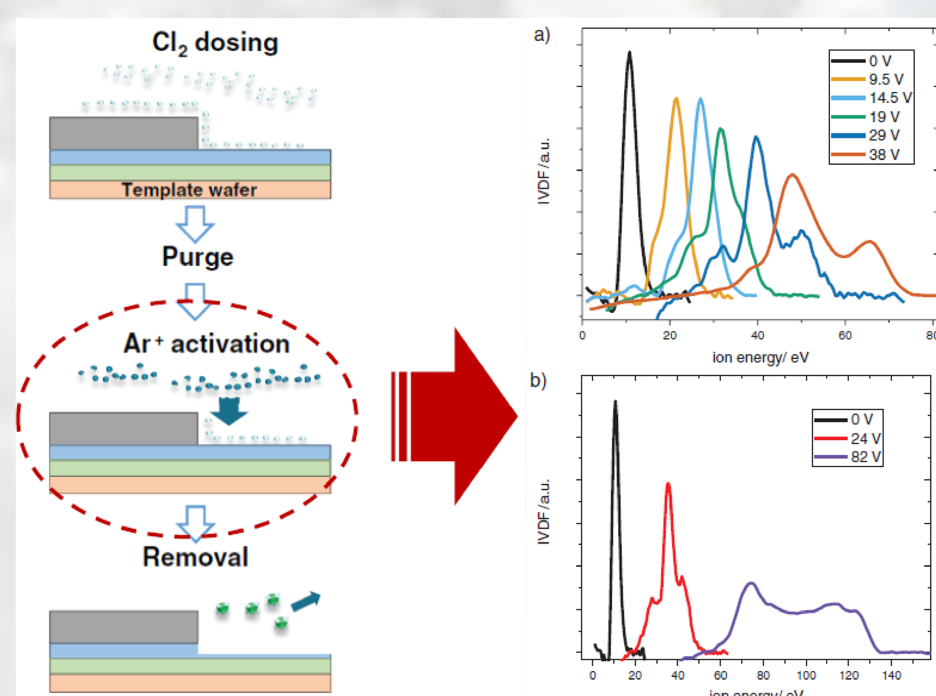
Results

A. Measurement of IEDF/IVDF (Semion)

Control of the ion energy during plasma-assisted ALD [3]

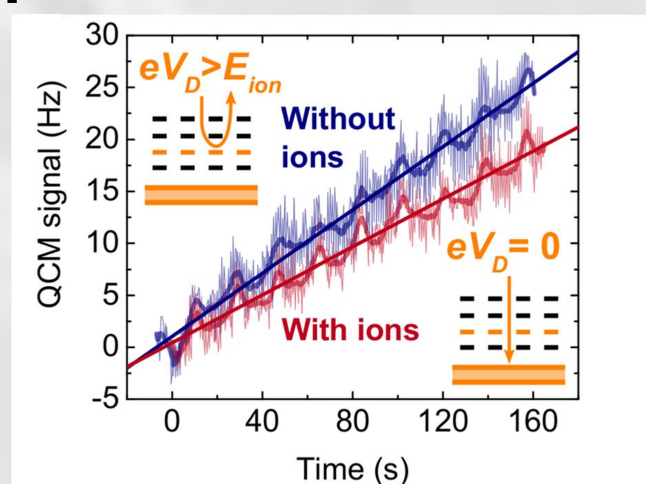


Estimation of bias power impact on critical Argon plasma activation step in ALE [4]

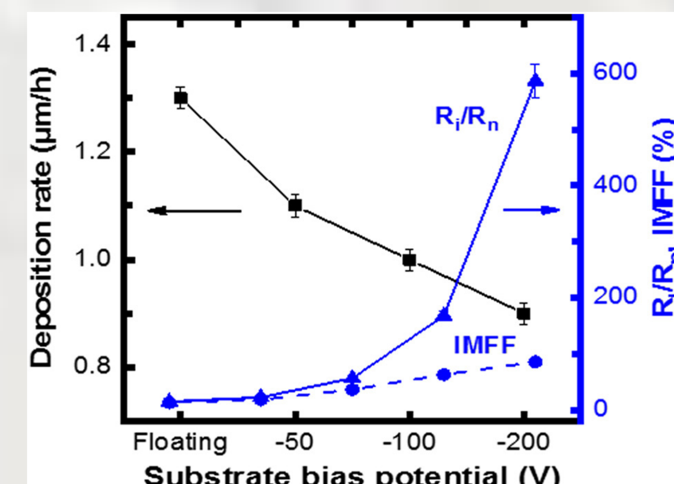


B. Measurement of deposition rates and Ion: Neutral fraction (Quantum)

Evidence for low-energy ions influencing plasma-assisted atomic layer deposition of SiO_2 [5]



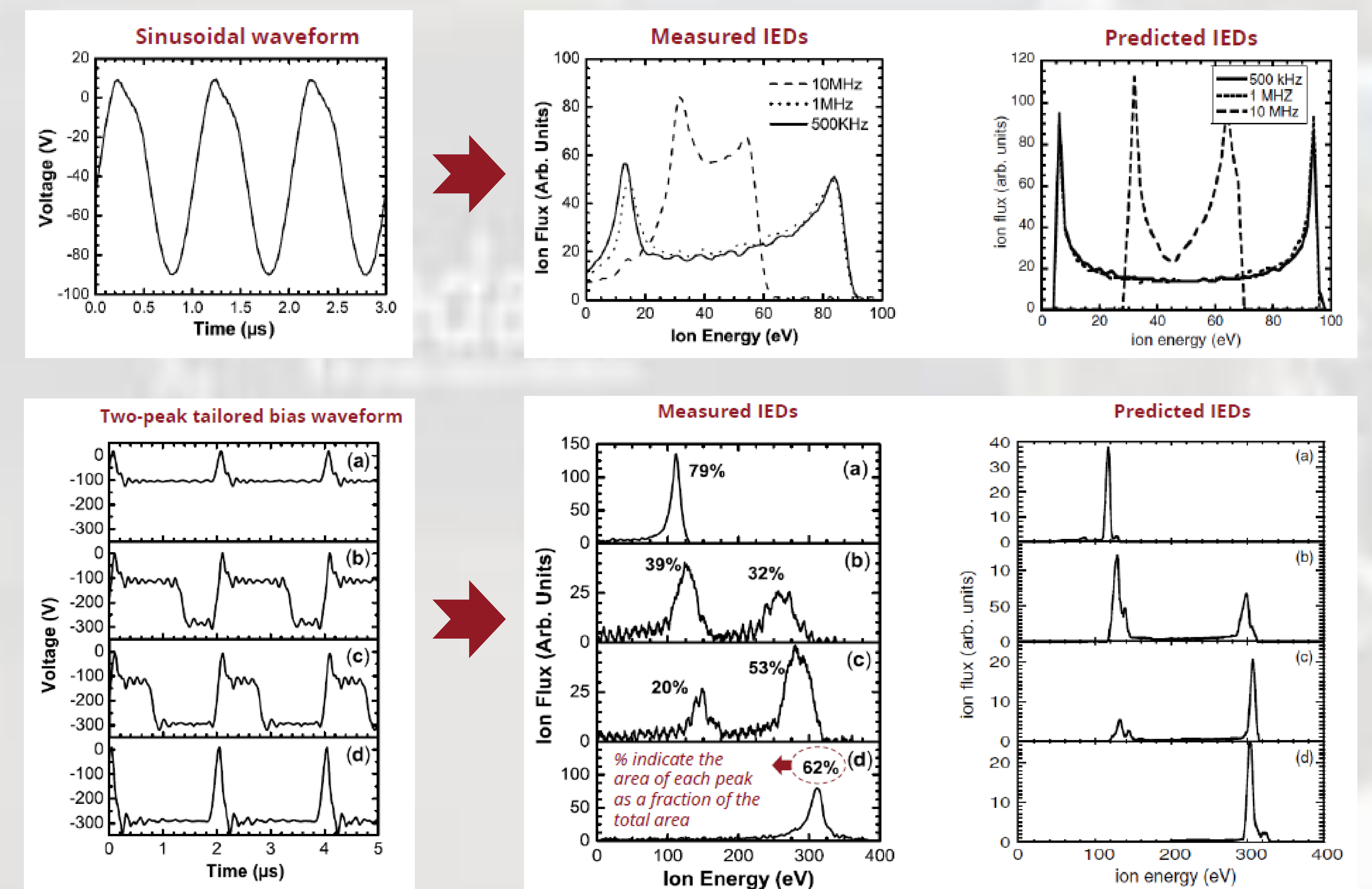
Effects of HiPIMS discharges and annealing on Cr-Al-C thin films [6]



Discussion

Comparison between the predicted and experimentally observed IEDs at an rf-biased electrode in a helicon plasma system

Tailored ion energy distributions at an rf-biased plasma electrode [7]



- Excellent agreement between predicted and experimentally observed IEDs.
- These results confirms that arbitrary IEDs may be produced by manipulating the shape of the bias voltage waveform in the collisionless sheath regime.

Conclusion

SEMION Benefits

- » **Characterize** the uniformity of a new process or chamber design
- » **Verify** plasma models
- » **Generate marketing material** for new tool releases
- » **Correlate** ion energy/ion flux with key process parameters

QUANTUM Benefits

- » **Verify** plasma models of deposition rates at the substrate surface, in rf plasmas
- » **Enhance** deposition rates by establishing the drivers of the ionized flux fraction
- » **Reduce** chamber down time for DOEs

References

References

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