Investigation of Titanium as a Surrogate Material for Magnetron Sputtered Beryllium

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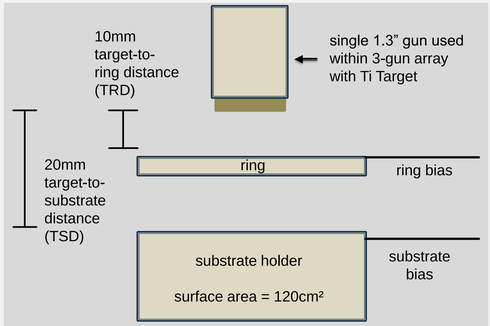
- The current chamber setup presents significant challenges for the deposition of Be. Hardware failures occur often and fixing them causes significant time delays and risk of contamination of capsules. Simplifying the process is, therefore, highly desirable, and utilizing HIPIMS is one way of achieving and improving this goal.
- Research and development of Be ablators is impeded because of its toxicity. Thus, we use a non-toxic surrogate material with similar growth characteristics, comparable sputter yield, and reactivity.
- Here we investigate the use of Ti as a Be surrogate material. This work focuses on effects of direct current magnetron sputtering and high-power impulse magnetron sputtering parameters on I-V characteristics of the gun, ring, and substrate.

Characterizing Deposition Setup

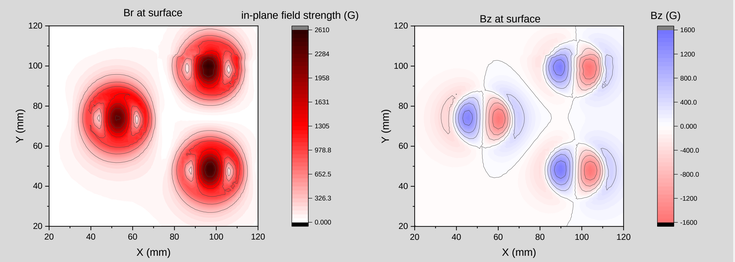
Deposition Conditions with 3 Biased Electrodes



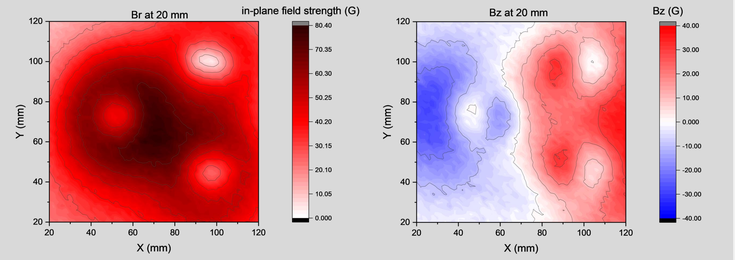
Side-view diagram of experimental setup

Photograph of 3-gun array

Mapping the Magnetic Field - 3-Gun Array Produces Asymmetrical Field



Magnetic field components at surface of 3-gun array

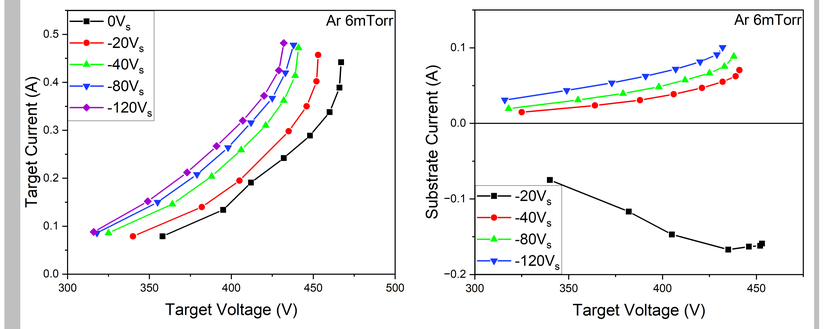


Magnetic field components 20mm away from surface of 3-gun array. Asymmetry of Bz particularly pronounced.

- Pan containing capsules is placed at 20mm TSD under typical deposition conditions.
  - — At this distance capsules will experience differing plasma properties dependent on their position in the xy plane and which of the 3 guns are used.
  - — A standard isolated MAK magnetron source has a cylindrically symmetric B field.

DC I-V Characteristics – No Ring Bias & Variable Substrate Bias

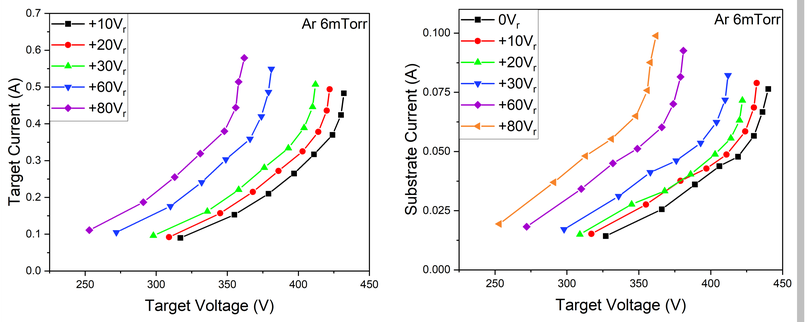
Increasingly Negative Substrate Bias Increases Target & Substrate Ion Current



Vs = Substrate Bias. I-V curves also display unusual inflection point at high target voltages

DC I-V Characteristics – Variable Ring Bias & -80V Substrate Bias

Increasingly Positive Ring Bias Increases Target & Substrate Ion Current Further

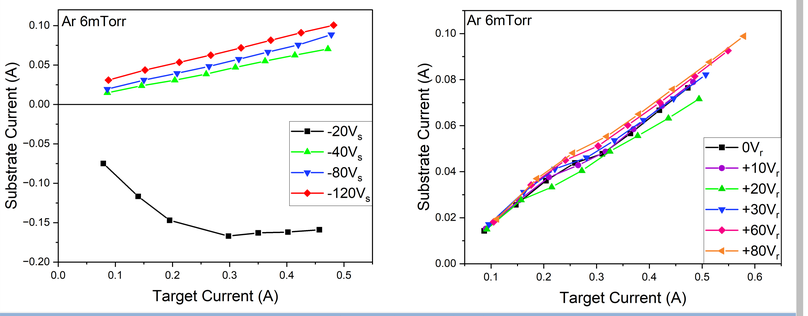


Vr = Ring Bias. Combination of substrate and ring bias has significant affects on target and substrate ion currents due to small TSD

- Due to the inflection points, the I-V curves are not described by the classic Westwood and Thornton models.

Increasing Target Current Generally Produces Linear Increase in Substrate Current

No Ring Bias & Variable Substrate Bias | Variable Ring Bias & -80V Substrate Bias



Vs = Substrate Bias, Vr = Ring Bias

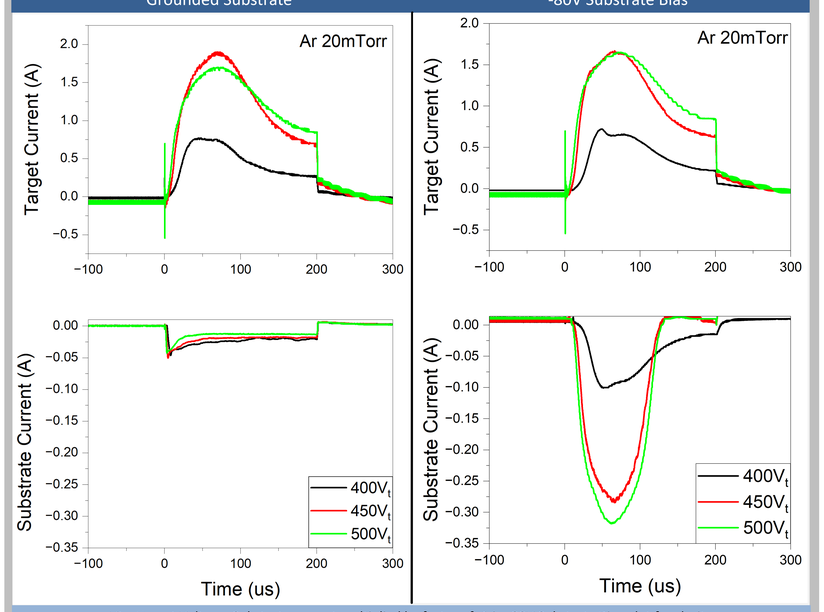
- -20V substrate bias with no ring bias acts as anode collecting.
- For all other substrate bias conditions, the substrate is an efficient ion collector

HIPIMS – No Ring Bias, Voltage Control Mode

- Unable to replicate low working pressure and voltage deposition conditions using HIPIMS.
  - — Plasma difficult to ignite < 20mTorr working pressure. 20mTorr used.
  - — Plasma difficult to ignite < 375V and very prone to arcing > 500V target voltage.
  - — Magnetron source only rated to 375W average target power.
  - — Voltage waveforms not affected by substrate bias – square wave.

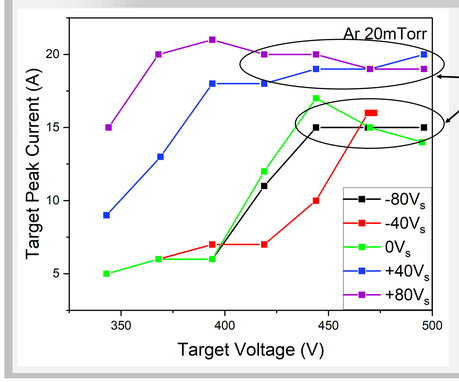
Current Waveforms - Substrate Bias Significantly Increases Substrate Ion Current

Grounded Substrate | -80V Substrate Bias



Vt = Target Voltage. Substrate current multiplied by factor of -1 in -80V Substrate Bias plot for clarity.

Substrate Bias Significantly Affects Target Peak Current



- Increasing target voltage causes target peak current to increase after which it plateaus thus reaching HIPIMS regime.
- Larger peak currents are observed for positive substrate bias values.
  - — This may be caused by creating additional ions by electrons accelerated from the plasma towards the substrate.

Future Work

- Studying the target-to-ring distance's effect on the substrate current and I-V characteristics of the magnetron discharge.
- Using plasma diagnostic tools to correlate I-V characteristics with plasma properties.
- Leveraging our new understanding to identify deposition parameters for beryllium coatings.

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