The global (volume averaged) model

- A global model (Gudmundsson, 2008) is applied to study a reactive high power impulse magnetron sputtering (HiPIMS) N$_2$/Ar discharge.
- The discharge consists of (Thorsteinsson and Gudmundsson, 2009a,b):
  - Electrons, Maxwellian-like energy distribution ($0.0259 - 10$ eV).
  - Vibrational levels of the ground state nitrogen molecule N$_2$ ($\nu = 0 - 6$) ($0 - 1.68$ eV).
  - Metastable nitrogen molecule N$_2$ (3P$_{2}$) ($6.17$ eV).
  - Nitrogen atoms N($^3$P$_0$), N($^3$P$_2$) ($2.38$ eV) and N($^3$P$_1$) ($2.58$ eV).
  - Nitrogen ions N$_2^+$ ($15.6$ eV) and N$_3^+$ ($14.5$ eV).
  - Argon atoms Ar($^3$P$_2$), Ar($^3$P$_1$) ($11.6$ eV), Ar$^+$ ($11.7$ eV), excited argon atoms 4p states Ar$^*$ ($11.2$ eV).
  - Argon ions Ar$^*$ ($15.8$ eV).
  - Titanium atoms Ti($^4$P$_0$) and titanium ions Ti$^+$ ($6.83$ eV).

Results and discussion

- The chamber is assumed to be made of stainless steel, cylindrical with $R = 15$ cm and $L = 15$ cm and the target is made of titanium of radius $R_0 = 15$ cm.
- The discharge pressure is $10$ mTorr and the total gas flow is $Q = 42$ sccm which is $95\%$ argon ($Q_A = 40$ sccm, $Q_N = 2$ sccm) and the gas temperature is assumed to be $T_g = 430$ K.

Figure 1: The temporal evolution of the sputtering yield $\gamma_{sput,X}$ of the absorbed power $P_{abs}$ and the target voltage $V_T$.

- Sputtering of metal atoms from the target by bombardment of positive ions with the rate coefficient $k_{sput,X} = \frac{W^2}{m}R_T^2\gamma_{sput,X}$ (1).
- The sputtering yield is dependent on the ion energy, so the temporal evolution of the target voltage $V_T$ must be known.
- We use experimentally obtained current-voltage characteristics for the power $P_{abs}$ and the target voltage $V_T$ that were measured for a pure Ar HiPIMS discharge (Gudmundsson et al., 2002).

Figure 2: The temporal evolution of the ionized metal fraction $n_{p,i}(t)$, $n_{p,g}(t)$, and the fraction of ionized metal flux at the substrate $F_{p,i}/(F_{N+} + F_{Ti+})$ at and around the tenth pulse period.

- The power is assumed to be deposited uniformly to a reduced volume $V_T$ below the target that is cylindrical in shape and assumed to have the dimensions $R_0 = 15$ cm and $L_0 = 7.5$ cm.
- The pulse length is roughly $100$ µs (FWHM of about $32$ µs) and the repetition frequency is $500$ Hz (i.e. a period of $T = 2$ ms).
- The fraction of ionized metal flux at the substrate is significantly larger than the ionized metal fraction when the power is on but significantly smaller when it is off.

Conclusions

- A global model was supported by the Icelandic Research Fund and the University of Iceland Research Fund.

Acknowledgments

This work was partially supported by the Icelandic Research Fund and the University of Iceland Research Fund.

References

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