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Plasma Physics of Sputtering Magnetrons Revisited

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Sputtering magnetrons are widely used to make thin films and are generally considered a mature technology. Over the last years it has become known that magnetrons show surprisingly rich physics based on plasma instabilities. Without these instabilities, magnetrons would generally not work. Key to a magnetron's operation is the generation a magnetically enhanced glow discharge plasma with closed electron drift. The energy needed to produce plasma, i.e. to ionize atoms of the process gas and those sputtered or outgassed from the target, is delivered by sufficiently energetic "hot" electrons. Key to a functioning magnetron is thus the electron heating mechanism and the presence of atoms to be ionized, which in the case of HiPIMS, may primarily come from the target, not the background gas. Both electron heating and atom density are generally not uniform. Recent theoretical [1], spectroscopic [2], and probe data [3] prove that most of the electrons' energy comes from the presheath, and is provided by localized electric fields concentrated at the edge of "ionization zones" or "spokes" [4, 5]. This is closely related to self-organization and turbulence as visualized in interesting images of magnetron plasmas.

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[1] C. Huo, D. Lundin, M.A. Raadu, A. Anders, J.T. Gudmundsson, N. Brenning, *Plasma Sources Sci. Technol.* 22 (2013) 045005.

[2] J. Andersson, P. Ni, A. Anders, *Appl. Phys. Lett.* 103 (2013) 054104.

[3] M. Panjan, A. Anders, *J. Appl. Phys.* 121 (2017) 063302.

[4] A. Anders, *Appl. Phys. Lett.* 105 (2014) 244104.

[5] A. Anders, Y. Yang, *J. Appl. Phys.* 123 (2018) 043302.

Keywords

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