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The role of spokes on energy and transport of ions in magnetron sputtering discharges

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Energy distributions of ions in magnetron discharges and ion transport away from the target (cathode) are still not fully understood. In this talk we will provide new insights on this topic. Our measurements suggest that the energy and spatial distributions of ions are related to the phenomenon of spokes. In magnetron discharges, azimuthally non-uniform plasma structures are referred to as spokes. Spokes travel in the dense plasma region above the erosion area of the target. They are observed for most discharge conditions (i.e., pressures and discharge currents) and operation modes of the magnetron, i.e., classical DC magnetron sputtering and high power impulse magnetron sputtering (HiPIMS) [1,2]. In this work, the role of spokes on the energy and transport of ions was investigated by a combined mass and energy analyzer. The instrument was operated in a time-averaged and time-resolved manner. In the time-averaged regime, we recorded the ion energy distribution functions (IEDFs) of single and double-charged ions [3], while in the time-resolved regime we recorded a stream (i.e., time sequence) of individual ions arriving at the instrument's detector. Results of time-resolved experiments demonstrate a strong correlation between the periodicities of ion signal and the rotation of a spoke. From this and previous experiments [4,5] we can conclude that IEDFs of working gas ions are mainly related to the electric field of the spoke, while IEDFs of sputtered ions are affected both by the energy distribution of sputtered atoms and the electric field of a spoke.

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Primary author: Dr PANJAN, Matjaz (Jozef Stefan Institute)

Co-author: Prof. ANDERS, Andre (Leibniz Institute of Surface Engineering)

Presenter: Dr PANJAN, Matjaz (Jozef Stefan Institute)

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