# High Power Impulse Magnetron Sputtering for the growth of functional metal oxide thin films

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High-Power Impulse Magnetron Sputtering (HiPIMS) is a plasma-based Physical Vapor Deposition (PVD) technique [1]. During short plasma pulses, which typically last several tens of microseconds, the electric power is delivered to the low-pressure (~1 Pa) plasma and peak power densities as high as several kW/cm$^2$ can be reached. This is roughly two orders of magnitude higher than values obtained during conventional Direct Current (DC) magnetron sputtering discharges.

During HiPIMS deposition experiments, metal atoms are sputtered from the target surface, i.e. the cathode of the system, and ionized. Each plasma pulse results in the production of a cloud of metal ions which condense on the surface of the sample to produce a thin film. In this situation, the trajectory and the kinetic energy of the ionized film-forming species can be controlled. In particular, ion bombardment of the growing film is intensified, and film properties are significantly modified as compared to thin films grown by DC magnetron sputtering. Because they are ionized, the kinetic energy of the film forming species can also be tuned by applying an electric bias voltage onto the substrate during growth.

Quite recently, Bipolar HiPIMS discharges (B-HiPIMS) have been implemented [ref]. A positive voltage pulse is applied after the negative pulse generated to sputter and ionize the metal atoms. Typical voltage and current waveforms are presented in Fig 1. Applying the positive voltage allows to accelerate the metal cations without the need of applying an external electric bias on the sample [2,3]. The kinetic energy of the film-forming species can thus be controlled by the positive pulse voltage. A comparison of the Ion Energy Distribution Function of titanium ions is shown in Fig 2 for a DCMS, HiPIMS and Bipolar HiPIMS discharge [4].

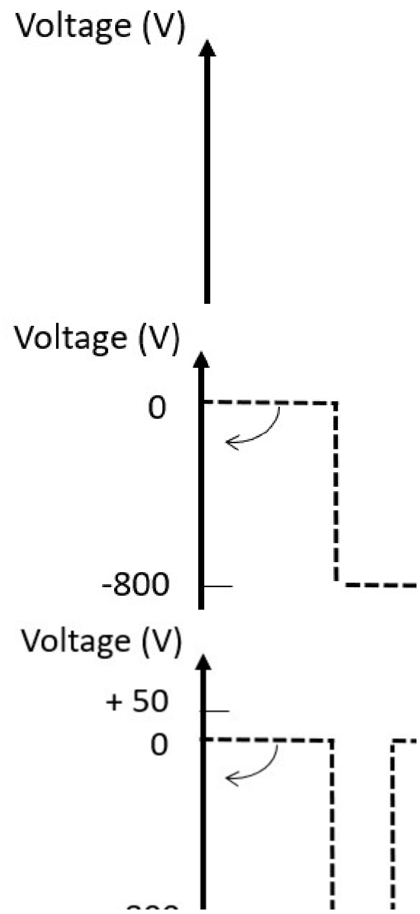


Fig. 1: Schematic representation of current and voltage waveforms applied to a magnetron cathode during a DC discharge (top), a HiPIMS plasma (middle) and a Bipolar HiPIMS plasma (bottom).

In the first part of this presentation, basic features of HiPIMS plasmas as well as important aspects of the plasma-surface interaction during film growth will be introduced and the latest technological developments presented. As an example, spatial distribution of particle densities during HiPIMS discharges will be presented [5] and energy flux values measured at the substrate location will be discussed (see [6] and references therein).

In the second part of the presentation, key results related to the synthesis of thin film materials such as titanium [7], zinc [8], and vanadium [9] oxides will be reviewed hence demonstrating the opportunities offered by the HiPIMS technology for the synthesis of functional metal oxide nanometer scale coatings.

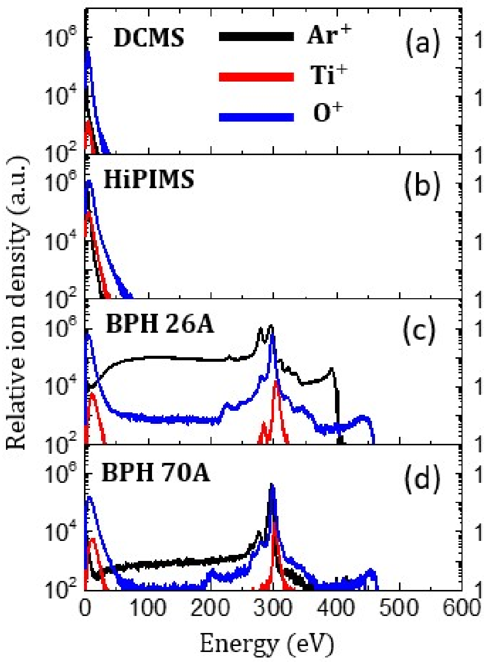


Fig. 2: The Ion Energy Distribution Functions (IEDF) measured at the substrate location by energy-resolved mass spectrometry. IEDFs of $Ar^+$, $O^+$ as well as of film – forming sputtered metal ions ($Ti^+$) are shown for four different magnetron discharges: a) DCMS, b) HiPIMS with a peak discharge current of 26Amp c)Bipolar HiPIMS (26A peak current) with +300V positive voltage applied and d) Bipolar HiPIMS (70A peak current) with +300V positive voltage applied

## References


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