# High-Power Impulse Magnetron Sputtering (HiPIMS), from plasma analysis to thin film and nanoparticle synthesis.

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High-Power Impulse Magnetron Sputtering (HiPIMS) is a Physical Vapor Deposition (PVD) technique. During short - several tens of microseconds – plasma pulses, peak power densities as high as several kW/cm$^2$ can be reached (Fig 1). This is two orders of magnitude higher than values obtained during conventional Direct Current (DC) magnetron sputtering discharges. In this situation, metal atoms are sputtered from the target surface i.e., the cathode of the system, and ionized [1]. The kinetic energy of the ionized film-forming species can thus be tuned by applying an electric bias voltage onto the substrate during growth.

First, basic features of HiPIMS plasmas as well as important aspects of the plasma-surface interaction during film growth will be introduced as well as the latest technological developments like peak current regulation during reactive HiPIMS [2] and bipolar HiPIMS [3]. The Fig. 1 shows typical current and voltage versus time waveforms during DCMS, HiPIMS and BPH discharges respectively.

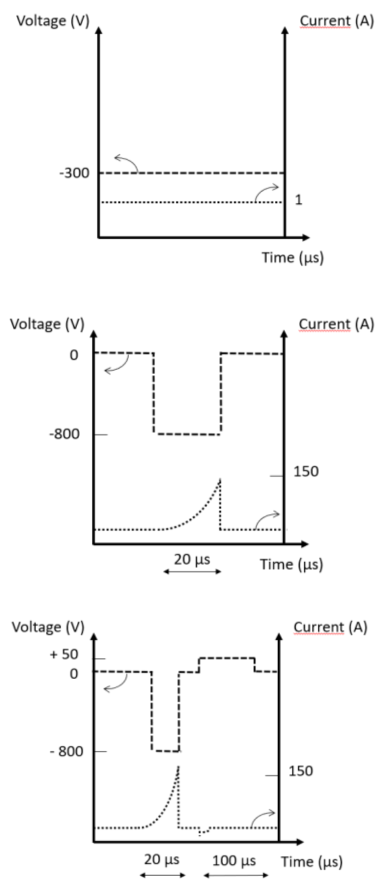


*Fig. 1: Schematic representation of current and voltage waveforms applied to a magnetron cathode to reach 300W in the case of a conventional DC discharge (top), HiPIMS plasma (middle) and Bipolar HiPIMS plasma (bottom).*

Plasma diagnostics data highlight the dynamical behavior of HiPIMS plasmas [4]. Moreover, energy flux measurements at the substrate location show that the energy deposition is dramatically increase because of the intense ion bombardment [5]. Ultimately, more degrees of freedom are available to design functional films, which are usually denser, smoother, and better crystalized film as compared to those grown by DCMS.

In the second part of the presentation, key results highlighting the relationship between the plasma characteristics and the film properties, mostly for titanium [6], zinc [7], and vanadium oxide [8] based coatings, will be presented. The synthesis of nanoparticles (Nps), as obtained when the solid substrate is replaced by a liquid (which sustains vacuum), will be introduced as well (Fig 2) [9]. Silver [10] and gold [9] NPs are larger produced by HiPIMS. Hence HiPIMS mimics the effect of annealing the NP solution.

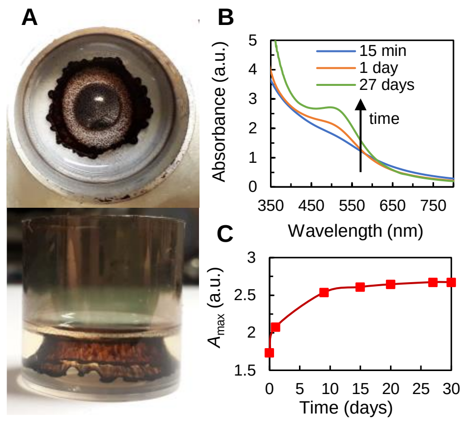


*Fig. 2: A sample produced by sputtering gold onto castor oil. (A) Photos of the sample after venting the vacuum chamber (B) UV-vis spectra of the solution obtained after stirring the sample. (C) Increase in absorbance at the maximum of SPR of Au NPs (505 nm) with time*

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