

Characterization of transport of neutral and ionized species in reactive HiPIMS process

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The aim of this study is to control in real time the deposition of thin films realized by means of a plasma reactor. The thin films are obtained by the HiPIMS (high power impulse magnetron sputtering [1]) plasma process since it is the only physical process currently able to ensure optimal compliance of the coatings on complex 3D substrates. The influence of the experimental parameters of the discharge must be correlated with the properties of the deposits, including thickness and crystallinity. To control this process, we use two plasma diagnostics: optical emission spectroscopy and mass spectrometry.

Measurements of optical emission spectroscopy (OES) have been also realized to obtain the composition of the plasma. The influence of pressure, distance from the target, surfacing power, time of discharge and gas mixture is studied. For validation of the correlation between thickness and OES measurements on the neutral Ti, two series were performed. The first correlation, depending on the t_D discharge time, between the thickness (determined by profilometry and scanning electron microscope SEM) and the intensity of the emission line of the neutral titanium Ti at 365 nm divided by the average current during the discharge $\langle I \rangle_{t_D}$ to take into account the variation in the density of the electrons that creates the spontaneous emission of plasma. The second correlation, based on the percentage of O₂ in the Ar/O₂ mixture, between the thickness and the intensity of the Ti-neutral emission line at 365 nm divided by the average current during discharge.

We also study the influence of the temperature on the substrates between 0 and 500°C on the crystallinity of TiO₂-type deposits in DC (direct current) [2] and HiPIMS processes [3]. The ions generated in HiPIMS mode should provide good crystallinity at lower temperatures than in DC mode.

[1] A. Anders, *Tutorial : Reactive high power impulse magnetron sputtering (r-hipims)*, Applied Physics Review **121** (2017).

[2] Wei Zhou et al : Low temperature deposition of nanocrystalline TiO₂ films: enhancement of nanocrystal formation by energetic particle bombardment J. Phys. D: Appl. Phys. 40 219 (2007)

[3] S.Konstantinidis et.al, *Titanium oxide thin films deposited by high-power impulse magnetron sputtering*, Thin Solid Films **515** (2006).