Characterization of magnetron sputtering discharges used for the formation of metallic nanoparticles

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The aim of our current experiments is to study the formation and transport of metallic nanoparticles (NPs) in conditions of DC magnetron discharges. Tungsten cathodes were used as sources of sputtered atoms/clusters, which are the very first NP precursors. The Argon pressure was varied between 20 to 40 Pa, a pressure range larger than that used for deposition. A grounded disc was placed 10 cm below the cathode (top of the device). The discharge current was fixed at 0.3 A or 0.5 A. NPs were collected on substrates placed in the center of the grounded disc.

In such configuration, the magnetic field lines and strength were measured using a Hall probe. A cylindrical Langmuir probe allowed establishing a 2D map of the electron density and temperature between the cathode and the grounded disc. The evolution of these plasma parameters was correlated to the magnetic geometry and the forces applied to NPs can be deduced for typical sizes.

The NP sizes were investigated with electron microscopy (SEM, TEM), the atomic structures and compositions with HR-TEM and EDS mapping. The produced W-NPs have a typical structure (monocrystal) showing that they have grown by deposition during their transport across the plasma. The core of these particles exhibits the beta-W crystalline phase. Oxide shells indicate likely oxidation after the chamber venting. Growth laws have been established as a function of the argon pressure (20 Pa to 50 Pa) for two discharge currents (0.3, 0.5 A) and as a function of the plasma duration for a given pressure. These results are discussed as a function of the discharge geometry as well as the discharge parameters. In a near future, the laser light scattering technics will be used to correlate the NP transport from the cathode region towards the substrates.