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In-situ monitoring of nanoparticle generation in plasma

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Nanoparticles (NPs) play an important role in the growing field of nanotechnology due to the unique properties associated with their small dimensions. Plasma based generation of NPs has been considered as an interesting approach for synthesis of NPs with tunable size distribution, morphology and chemical structure. Moreover, so-called gas aggregation sources (GAS), based on magnetron sputtering, have been utilized to obtain independent control of the size distribution and flux of the metallic NPs. However, the processes inside the GAS, leading to NP growth, are not fully understood yet due to the limited accessibility by most of the common analytical methods in vacuum and plasma environment.
In the work presented here, we report on the in-situ monitoring of the initial stages of metallic NP growth in a low temperature plasma by broadband transmission UV-Vis spectroscopy. We demonstrate that for several metals, due to strong particle plasmon resonance, NPs can be monitored by UV-Vis spectroscopy in-situ during their growth and transport in a GAS. Our results show that small NPs are already generated in the region close to the magnetron target surface and generally do not change their size much during transport through the gas aggregation volume. A strong broadening of the plasmon resonances, which results from a strong coupling between particles, in the vicinity of the magnetron indicates a high concentration of NPs in this region.
In addition to the fundamental studies on pure silver NPs, we also show that utilization of a bimetallic sputtering target leads to generation of alloy NPs (e.g. AgAu, AgPt) with in operando tunable composition by simply changing the sputtering conditions. Moreover, optical emission spectroscopy (OES) in combination with in-situ UV-Vis allows for “online” monitoring and tuning of the chemical composition of such NPs.

Keywords
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