

Post-plasma SiO_x Coatings of Metal and Metal Oxide Nanoparticles for Enhanced Thermal Stability and Tunable Photoactivity Applications

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An aerosol technique is presented, which allows the coating of particles with silicon oxide directly in the gas phase in a continuous Plasma Enhanced CVD process. It uses a non-thermal dielectric barrier discharge (DBD) plasma at atmospheric pressure making the method quite flexible in its integration into other processing steps. The precursor is not in contact with the DBD plasma itself, enabling a more stable process without the risk of changing the discharge behaviour. Tetraethyl orthosilicate (TEOS) is used since it reacts more slowly compared to other common precursors, which facilitates the control of the process.

In the presented contribution active species are generated with a DBD discharge to facilitate the reaction. Since the mixing of the gas flowing through the discharge with the precursor/particle flow takes place after the discharge, many reactive but short-living species from the discharge do not participate in the reaction. Ozone and nitrogen oxides are the main species found in the post-plasma of nitrogen and air mixtures and are as such the important species for this reaction.

As shown in figure 1 a difference in the coating thickness measured with a SMPS and with a TEM was observed when spherical particles were coated. This and a liquid-like form of the coatings coupled with a cluster formation of aerosol particles suggest an intermediate vapour that condenses on the aerosol prior to the formation of the solid SiO_x coating in a sol-gel reaction. The results also show that a reaction time of at least a few minutes between mixing of the precursor and the plasma species and the sampling is required for these ambient conditions. The reaction time of 1.4 min in figure 1 (left) is too short to completely convert the liquid film into a solid coating, so that the solid coating thickness is here independent of the concentration. In contrast, the reaction time has a significant impact on both the liquid and solid coating thickness for a given precursor concentration as shown in figure 1 (right). The control of both the reaction time and precursor concentration allows a variation of the coating thickness on spherical particles as well as on agglomerates. On agglomerates the coating can be controlled to cover nearly only the interparticle spaces between branches.

Results for different particle materials are presented that confirm the proof of concept of this process for the homogeneous coating of nanoparticles. Examples are shown in figure 2 with coated CuO, TiO₂ and Pt particles.

The process could be used for the thermal stabilization of agglomerates or the control of photoactivity. For both examples first experiments showed promising results.

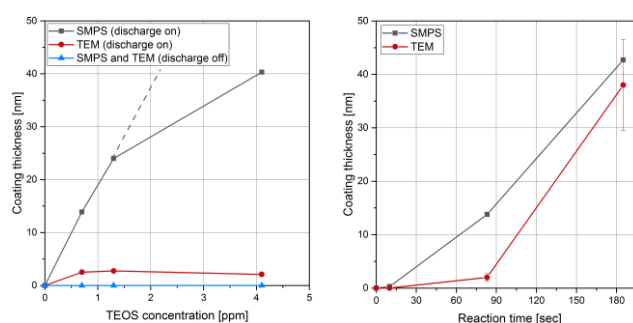


Figure 1. Comparison between coating thickness measured with SMPS and TEM for different precursor concentrations (reaction time of 1.4 min) (left) and for different reaction times (TEOS concentration of 0.7 ppmv) (right).

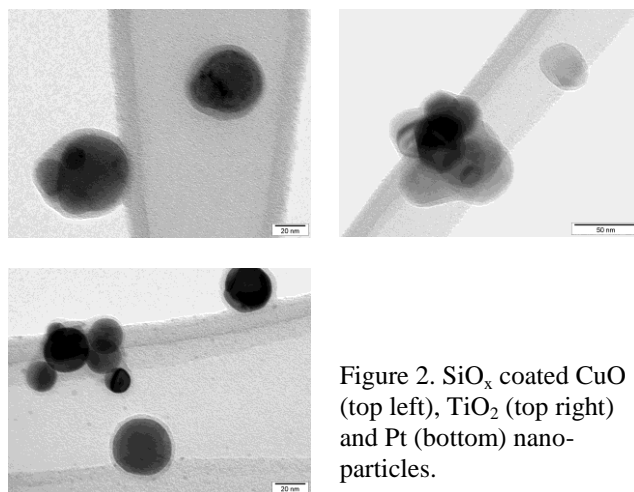


Figure 2. SiO_x coated CuO (top left), TiO₂ (top right) and Pt (bottom) nanoparticles.

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