Synthesis of single digit nanoparticles with a dielectric barrier discharge at atmospheric pressure

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Applications of non-agglomerated, single digit nanoparticles in the gas phase are of particular interest. Many syntheses methods have difficult operating conditions e.g. low pressure or high mass flows, to generate non-agglomerated, single digit nanoparticles.
In this work a particle synthesis method with a dielectric barrier discharge (DBD) reactor will be investigated. This DBD reactor works at low temperature and ambient pressure. Figure 1 shows a plate DBD reactor that was used for the experiments.

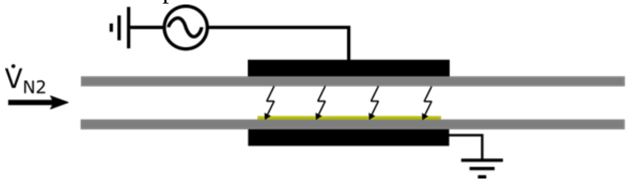

Figure 1. Sketch of a plate DBD reactor.

An AC voltage was applied between the two metal electrodes. Each of the electrodes is covered by a ceramic plate (dielectric). Because of the dielectric, a filamentary discharge was initiated. Every filament evaporates the surface that it hits during the discharge. The evaporated surface condenses again and primary particles are formed by homogeneous nucleation and are able to grow by coagulation [1]. One dielectric can be exchanged with a metal plate, so that the produced particles consist of the used metal.

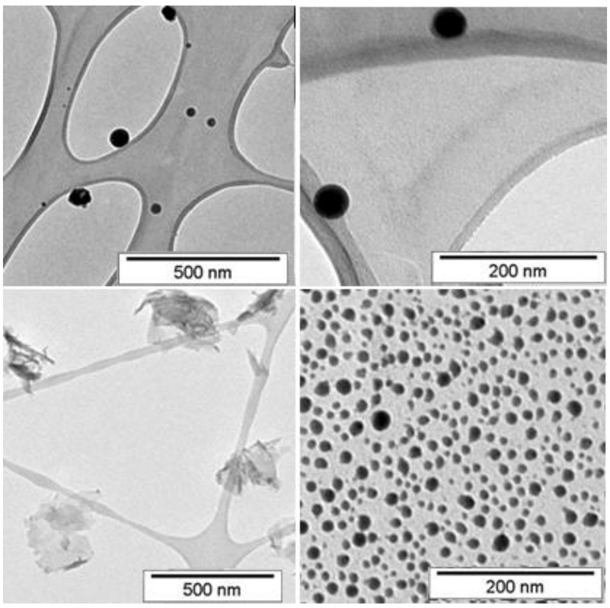

Figure 2. Synthesis of nanoparticles with different suspensions. Top left: Zn, top right: Sn, bottom left: C, bottom right: S.

Furthermore, it is possible to coat one of the dielectrics with a metal suspension (e.g. Zinc particles bigger 2 µm in isopropanol). Hence, synthesis of nanoparticles dependent on the coating material, as shown in figure 2, is possible. Even nonmetal suspensions, like sulfur, allow particle production.

There are several methods to adjust the particle size distribution of the synthesized particles. The energy per filament is higher for bigger gaps between the electrodes. Therefore, the particle size is increasing with higher discharge energy [2]. Furthermore, the gas mass flow and the type of gas are parameters that also influence the filamentary discharge. Figure 3 illustrates the dependence of the particle size distribution on the discharge power.

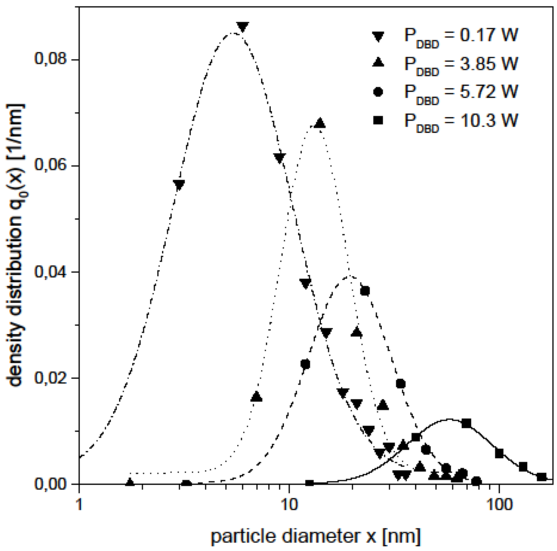

Figure 3. Comparison of several density distributions in dependence on the discharge power that was measured with a Lissajous figure.

[1] Borra, J.-P., N. Jidenko, J. Hou and A. Weber (2015) *J. Aerosol Sci.* **79**, 109 – 125.

[2] Borra, J.-P., N. Jidenko, C. Dutouquet, O. Aguerre J. Hou and A. Weber (2011) *Eur. Phys. J. Appl. Phys.* **56**, 24019-p1 - 24019-p7.