Experimental study of homogeneous nucleation from the antimony supersaturated vapor

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Keywords: homogeneous nucleation, antimony, surface tension
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Thermodynamic properties of an interface can be completely determined by the surface tension. Recently, it became clear that the surface tension σ of nanoscale droplets might significantly differ from that for the flat surface. Therefore, both to understand and to predict processes such as homogeneous nucleation, the solubility of nanoparticles and similar ones, it is necessary to determine the value of the surface tension of nanoscale droplets. In the case of critical nucleus, which are typical nanoscale droplets, this can be done by the evaluation from the experimentally measured rate of the nucleation from supersaturated vapor (Vosel, 2012).

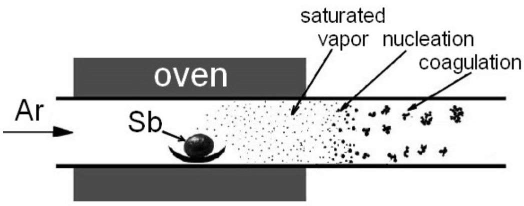

Figure 1. Experimental setup.

This work is devoted to the experimental study of homogeneous nucleation from Sb vapor in a laminar flow diffusion chamber (Fig. 1). The flow diffusion chamber consisted of a quartz tube with an outer heater. A piece of Sb was put inside the heated zone to generate the saturated vapor. Argon flux was supplied to the inlet of the tube. At the outlet of the heated zone the temperature decreased resulting in the vapor supersaturation and nucleation. The particle size and number concentration at the outlet of chamber were measured by the automatic diffusion battery coupled with a condensation nucleus counter.

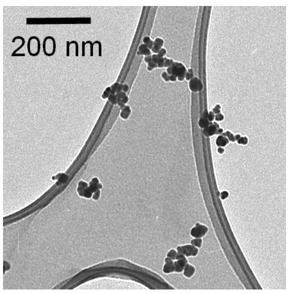

Figure 2. TEM image of Sb nanoparticles.

The morphology of the outlet particles was studied using JEOL-JEM 100SX TEM. The aggregates consisting of small primary particles originated from critical nuclei were observed (Fig. 2). The aggregate size, concentration and fractal dimension were studied as a function of heating temperature as well as size and number of the primary particles per aggregate.

“The supersaturation cut-off” method was used to find the approximate dimensions of the nucleation zone (Fig. 3). The metal grid was put inside the tube perpendicularly to the flow. The decrease in the outlet particles concentration was observed while changing the position of the grid within the nucleation zone. Therefore, the approximate nucleation volume was estimated.

The number of particles formed in the nucleation zone can be determined using the outlet aerosol concentration and mean number of the primary particles per aggregate. As in our conditions temperature inside the oven was below the melting temperature of antimony, coalescence doesn't take place. Thus, it's possible to determine the quantity of critical nuclei in nucleation zone with high precision.

Based on the experimental results nucleation parameters have been obtained. At nucleation temperature of 350 K the typical nucleation rate was found to be $1.7 \cdot 10^{10}$ $cm^{-3}s^{-1}$.

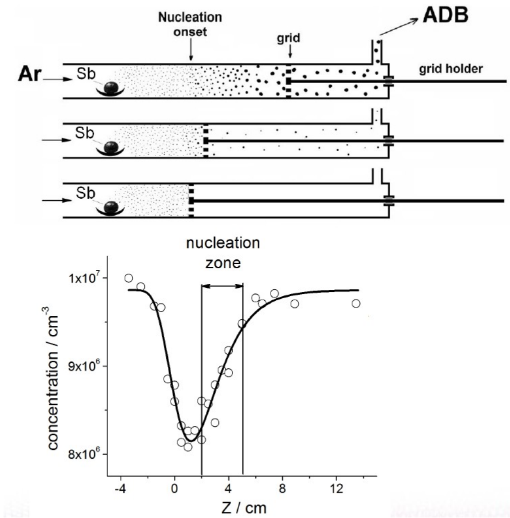

Figure 3. Experimental setup for the "supersaturation cut-off" method and the outlet particle concentration vs. the grid position.

This work was supported by RFBR (project №11-08-01204-a).

Vosel S.V., Onischuk A.A., Purtov P.A., Tolstikova T.G., (2012) *Aerosols Handbook: Measurement, Dosimetry, and Health Effects*, CRC Press.