In-situ determination of gas-to-particle reaction generated nanoscaled particles

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One method to determine particle size distributions of nanoscaled particles relies on the simultaneous detection of the time resolved laser-induced incandescence signal (LII) at two different wavelengths. Due to the absorption of a short highly-intensive laser pulse the particles are heated up far above the ambient gas temperature. After the laser pulse the particles are cooling down due to heat transfer, radiation and evaporation. The time-resolved LII-signal describes the temporal evolution of the enhanced thermal radiation. With respect to Planck's law the particle temperature decay can exactly be calculated from the ratio of the time resolved LII-signals at two different wavelengths.

The experimental determination of the particle temperature is based on a developed optical system which separates the induced LII-signal into two wavelength regimes. Two interference filters with a centre wavelength of 650 nm and 450 nm, respectively, filter the separated light beams before they enter a Streak-camera. This is a highly temporally (max. 4 ps) and spatially (~ 35µm) resolving detection system for light intensity measurements. The possibility to detect the time-resolved LII-signal simultaneous with one detection system is one of the advantages of this measuring technique. An improved LII-model with prior validated parameters was used to determine particle-size distributions from measured LII-signals using non-linear multidimensional regression. Knowing the particle temperature for every moment of the cooling phase due to the simultaneous detection of the time resolved LII-signal at two wavelengths it is not necessary to consider the absorption term in the LII model. Thus, there is no need to explain the very well known difference in the maximum particle temperature between the numerical simulated and measured temporal temperature evolution due to uncertainties in the absorption model. In consequence the total uncertainties in the LII-model are less and in comparison to the conventional single-colour method the determined particle size distributions of the two colour method are more correct. The two colour method is a possibility to determine particle size distributions without knowing the optical properties as far as the refractive index is not depending on the wavelength in the regime of 450 nm to 650 nm. Therefore, the knowledge of the refractive index is dispensable and this technique could be adapted to various materials. Determinations of particle size distributions of manganese and iron oxide particles confirmed the applicability of this measuring technique for nanoscaled oxide particles.

One single frequency-doubled Nd:YAG laser pulse was used to determine highly spatially resolved particle-size distributions in the measured volume during gas-phase synthesis of nanoscaled particles. The influence of process parameters on particle formation and growth and therefore on the size distribution could be recognized immediately. A structural characterisation of aerosols with locally different particle size distributions is feasible. Therefore, a possible application for this measuring technique is the usage for air pollution control tasks. Furthermore, it assists to design processes of combustion devices with lower particle emissions or gas-to-particle conversion reactors for the synthesis of nanoscaled particles.

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