Summary on Discussion Session "Non-soot LII"

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Motivation

There is a wide variety of gas-borne non-carbon particulates of interest that require the development of possibilities for determining their properties. These include:

- Atmospheric aerosols (which are expected to be unstable at LII conditions)
- Manufactured nanoparticles (metals and metal oxides) where
  (a) it is important to gain fundamental understanding of reaction processes. Here, it is of interest to measure particle sizes and particle volume fraction both *in situ* to observe spatial / temporal variation in particle size and to develop a model understanding of the underlying complex processes.
  (b) Because synthesis is of commercial interest, process control (inline, potentially via sampling: faster than conventional methods) is a second topic of interest
  (c) For health and safety the detection of nanoparticles in the (workplace) atmosphere is of interest
- Welding fumes generate unwanted nanoparticles at the workplace
- Additionally, the investigation of LII provides information for basic sciences to further understand particle–gas-phase interaction

Challenges

In contrast to LII on carbonaceous materials, there is a very small number of investigations for non-soot materials reported in literature. Therefore, there is a

- Severe lack in fundamental information including
    - Optical properties of many materials
    - Thermal accommodation coefficients
    - Evaporating species (that potentially lead to additional emission once electronically excited)
    - Sources for interfering signal (Raman, Plasma emission, ...) when increasing fluence
    - There are additional fundamental challenges for:
- Elemental materials (Fe, Si, Cu, Mo, ...)
    - Many materials have comparably low boiling points which leads to weak LII signal which makes LII potentially hard to detect in high-temperature environments
    - Low melting points and other phase transitions occur in the temperature range that is reached during the LII process. These might (a) change the optical properties and (b) contribute to the heating and cooling behavior because of the contribution of the latent heat during phase transitions. As a further complication, it is not clear if these processes

happen under thermodynamic control or are kinetically controlled on the time-scale of interest

- Oxidic material
    - High-temperature chemistry (i.e., loss of oxygen) happens at high temperature. Therefore, additional heat-loss paths (with the implicit question of they are happening under kinetic or thermodynamic control) are opening up
    - Many oxidic materials show low absorption in the NIR and visible (e.g., SiO_2, TiO_2)

Advantages

In comparison to soot, non-soot materials also provide advantages.

- The particle morphology usually simpler compared to soot and therefore, the “maturity issues” observed for soot are less important.
- During the synthesis of tailored materials, the reaction conditions are usually well controlled. Therefore, there is a much better chance to determine the boundary conditions (such as gas-phase temperature, size-distribution and aggregation). These conditions even provide the possibility to generate isolated particles under well-defined conditions that can be used for fundamental investigations of the interaction between heated particles and their environment

Recommendations for future work

- Investigate optical properties based on a fundamental physics understanding
- Theoretically investigate accommodation coefficients for various materials commonly used in nanoparticle synthesis and research
- Carry out LII in well-defined nanomaterials (such as particles with narrow size distribution from various materials) to validate the above mentioned theoretical aspects