Room temperature Aerosol Deposition for dense ceramic coatings - functional principle and potential applications

**Motivation**
The aerosol deposition (AD) method is a novel spray coating process for ceramic materials. With AD it is possible to obtain dense ceramic coatings at high deposition rates (several µm/min) directly from ceramic powders. Working at room temperature, it makes ceramic coating technology accessible to temperature sensitive substrate materials and applications. This paper gives an introduction to the functional principle of AD as well as some applications. A variety of other applications have been successfully deposited at the Department of Functional Materials, as shown exemplarily below.

**Mechanism of film formation**
Since the process happens on small scales, the mechanism for particle deposition and layer formation is difficult to analyse and has not been completely clarified yet.

- Simulations of particle impact show local appearance of elevated temperature along with high strain in the contact area between particle and substrate [1].
- Local strain in the particle exceeds the fracture toughness and leads to breaking of ceramic particle into small crystallite fragments in the nm range [1].
- Continuous particle bombardment contributes to the film consolidation and growth by densification and compaction of the deposited particles [2].

**AD coatings and applications**
Numerous materials such as Al₂O₃, TiO₂, Bi₂Te₃, BFT, PZT, YSZ, STF [3] etc. have been successfully deposited at the Functional Materials Department. Examples are shown below. Bi₂V₂O₈⁺a for oxygen ion conduction. BaFe₁₋₅Ta₂O₇⁺a for sensing applications. Bi₂Te₃ for thermoelectric applications. Al₂O₃ as insulator (high resistivity) or protection layer (high hardness, inert).

**Functional principle and setup of an AD apparatus**
Ceramic particles are transported by a pressure difference into a vacuum chamber. Accelerated by a nozzle, the particles impact on a substrate and form a dense layer.

- Vibration of gas flow through the ceramic powder generates a fluidized bed.
- Carrier gas transports particles out of the aerosol chamber.
- High throughput booster pump creates a vacuum < 1 mbar in the deposition chamber.
- The pressure drop and nozzle accelerates aerosolized particles to several 100 m/s [1].
- Impact of the particles on the substrate forms a dense layer.
- X-y stage used for substrate holder allows for variable area coverage.

**Parameters of influence**
- Carrier gas (e.g. air, O₂, N₂)
- Carrier gas flow
- Particle size (0.1 < dₜ₅ < 5 µm)
- Nozzle design
- Stand-off distance

**Conclusion/Outlook**
Aerosol/spray techniques can play an important role as a continuous deposition process. Since AD is a rather new method for ceramics, research in process fundamentals will be an important factor for broadening this technique to different materials and applications. Key research areas include better aerosol generation, understanding the deposition mechanism(s) and comparing resultant AD films to those from other techniques.

References