# Dense ceramic coatings manufactured with the Aerosol-Deposition-Method (ADM) at the Department of Functional Materials

Manufacturing of ceramic components or coatings requires usually high sintering temperatures above 1000°C. Joining of ceramic coatings with lower-melting materials such as metals, glass and polymers is difficult. Furthermore, many functional and structural ceramics can hardly be processed to dense devices without decomposition. Therefore it is challenging to produce, e.g., electroceramics or microelectronic components.

By utilizing the Aerosol-Deposition-Method (ADM) it is possible to produce dense ceramic coatings completely without any high-temperature process directly from an initial bulk powder on almost any substrate material.

A powder aerosol is generated and transported by a pressure difference to a vacuum chamber. By means of a nozzle, the aerosol is accelerated to several 100 m/s. The aerosol beam hits the substrate material and dense films are formed (see Fig. 1). Resulting coatings can be achieved in a thickness range between 1 and 300 µm with good adhesion to the substrate. Without any subsequent sintering step, the stability and mechanical properties of these coatings are comparable to the initial powder.

As an issue of research, the exact mechanism of film formation has not yet been clarified. It is assumed that the high kinetic energy of the sub-micrometer particles makes them breaking by impaction on the substrate resulting in nanometer fragments (see Fig. 2). As a first step, an anchoring layer is created on the substrate surface on which subsequently a coating forms. The coatings get compacted by continuous bombardment of impacting particles (so called Room Temperature Impact Consolidation). The thickness of the coating can be varied simply by variation of the deposition time.

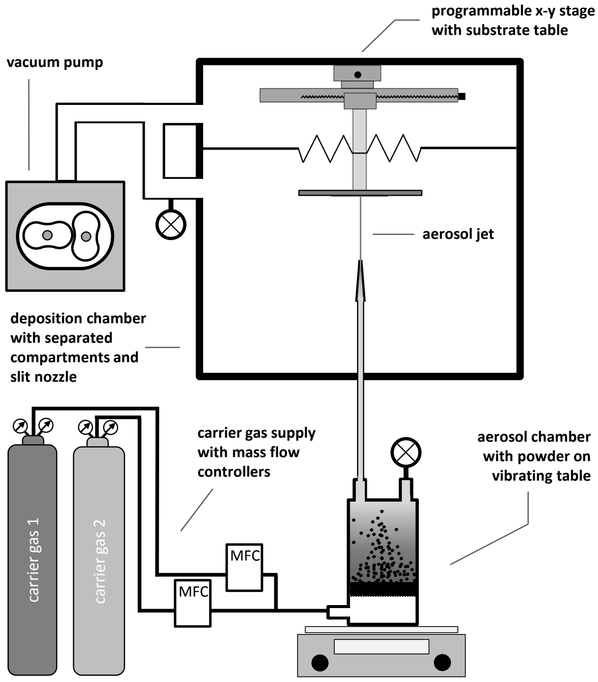


**Fig. 1**: Schematic drawing of an aerosol deposition device with aerosol generator, deposition chamber and vacuum pump.

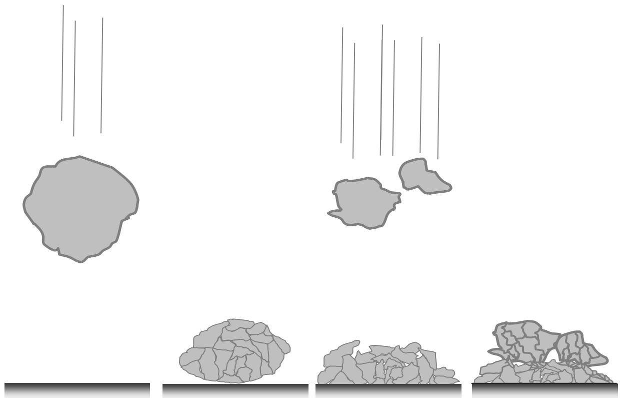

**Fig. 2**: Mechanism of particle breaking and consolidation

At the Department of Functional Materials, we combine gained knowledge about materials (material classes, functional properties, powder synthesis and preparation) and the process technology (process control, nozzle design, aerosol generation and transport) in the improvement and optimization of the deposition results. The key facts of our work are research on the fundamentals for successful deposition behavior as well as the mechanical and functional properties of coatings and last but not least their applications.



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Up to now we achieved successful deposition for a variety of materials such as passive ceramics (e.g. $Al_2O_3$ [1], $TiO_2$ [2]), oxygen-ion conductors (e.g. YSZ, bismuth vanadate [3]), thermoelectric materials (e.g. bismuth telluride, copper delafossites) and further functional ceramics like silicide or PZT. For the application as gas sensors, aerosol deposited $SrTi_{0.7}Fe_{0.3}O_{3-\delta}$ [2] and $BaFe_{0,7}Ta_{0,3}O_{3-\delta}$ [3] show promising sensing properties. As substrate material, ceramics, steel, glass, silicon, screen printed structures or even polymers have been shown to be applicable. A remarkable feature of these coatings is their very dense structure (see Fig. 3).

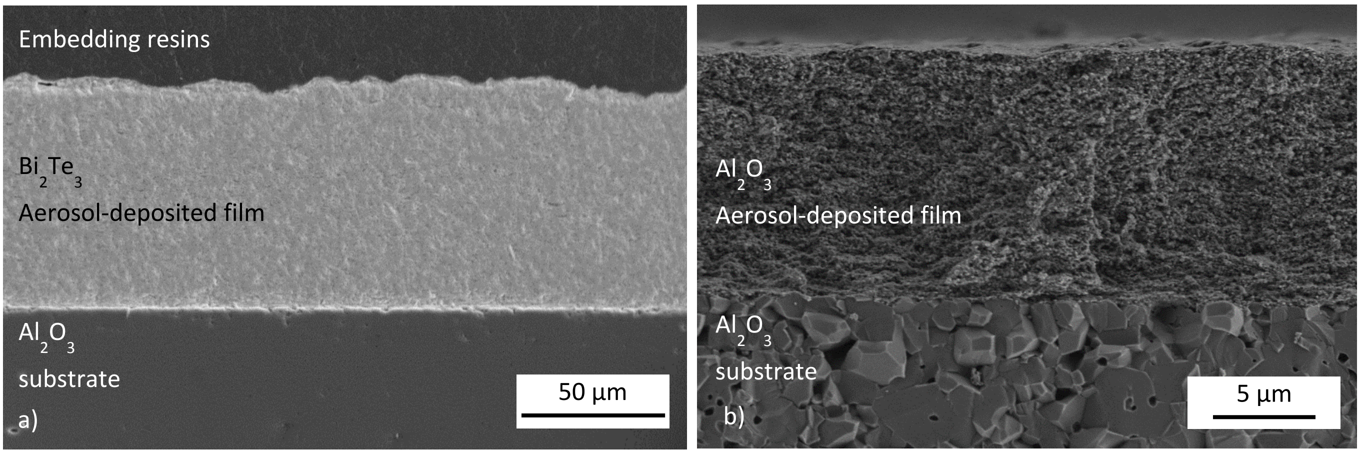


**Fig. 3**: a) Micrograph of polished cross section of an 80 µm thick ADM coating of $Bi_2Te_3$ on a $Al_2O_3$ substrate; b) Fracture pattern of a 8 µm thick as deposited $Al_2O_3$-cotaing on $Al_2O_3$ substrate [1].

A novel approach in AD processing is the simultaneous deposition of several powders (Co-deposition) and the following calcination of the initial materials to a coating with completely new functional properties. An application example is the co-deposition of $Bi_2O_3$ and $V_2O_5$ as AD film to form the ion conductor $BiVO_4$ after a thermal post-treatment [5].

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