



MATERIALS AND PROCESSES

SURFACE-CONFORMAL POWDER COATING USING ALD AND CVD PROCESSES

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The Thin-Film Technologies Group of Fraunhofer IKTS has extended its expertise and service portfolio into the field of thin-film deposition on particles and powders. Using the available equipment and deposition technology, powder quantities of up to 100 g can now be coated using conformal ALD and CVD processes.

The recent research and development has focused on conformal functional layers on powder materials for applications for Li-ion batteries (LMNO – $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$ powder), as well as applications in hardmetal tool manufacturing. The group has developed novel ultrathin barrier layers and layer systems for LNMO powders and other hygroscopic and easily oxidizing materials, e.g. metal powders and hardmetal powders such as tungsten carbide (WC).

The first results for the coating of tungsten carbide powder with titanium nitride show that it is possible to produce coatings with excellent surface conformality using both ALD and CVD techniques (Figure 1). With a 10 to 50 nm thin TiN coating on tungsten carbide powder, new types of polycrystalline tungsten carbide based on polycrystalline WC particles can be produced for various applications in the tooling industry. As these hardmetals are being manufactured, a TiN barrier layer can prevent the molten cobalt from penetrating into the polycrystal and dissolving it. This results in extraordinarily high hardness and good fracture toughness. A broad range of TiN ALD- and CVD-coated powder is currently being investigated for their sintering processing behavior and material properties, such as hardness and rupture strength.

In a second project, LMNO powders for Li-ion batteries were coated with an extremely thin Al_2O_3 coating. This layer improves the interface with the electrolyte, which in combination with the high-voltage material LNMO prevents degradation of the electrolyte. The aim is to benefit both the battery cell's cycle stability and performance. The coated powders are currently being characterized and show promising results.

When coating powders with low density or low weight, the coating process was frequently marred by high powder losses. By optimizing the ALD pulse sequences and the reactor geometry, it is now possible to achieve a powder yield of more than 95 % for Al_2O_3 coatings in the layer thickness range of 1 to 20 nm. The agglomeration of the particles could also be avoided through rotation (Figure 3).

- 1 Tungsten carbide powder coated conformally with TiN.
- 2 Al_2O_3 -coated LMNO powder.
- 3 LNMO powder in the drum reactor. After processing, the powder character is retained without particle agglomeration.