Plasma-Enhanced ALD on Particles and Powders

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Surface engineering of micro- and nanoparticles is of great importance in fields such as catalysis, energy and sensing. For many of these applications, particles are required with different bulk and surface properties. A popular technique to achieve this is to coat the particle surface with a nanometer thick layer. Only a few techniques have been explored for depositing such thin conformal coatings. Chemical vapor deposition (CVD) has been used extensively for this purpose, but suffers from some limitations, such as imperfect control over layer thickness and uniformity of the coating over all individual particles. In contrast, atomic layer deposition (ALD) is known as a reliable technique for covering complex 3D objects with ultrathin conformal coatings. However, to perform ALD on large quantities of powders, the individual particles need to be fluidized or agitated. Fluidized bed reactors are most often used for ALD on particles, but this reactor concept does not easily allow for plasma-enhanced ALD (PE-ALD), which is advantageous for e.g. coating on temperature-sensitive polymer particles and hard-to-treat substrates (such as Teflon) or deposition of metals and metal nitrides. Furthermore, PE-ALD is compatible with cheaper precursor chemistry.
In this work, a rotary reactor was used to agitate particles, enabling the deposition of conformal coatings by thermal and plasma-enhanced ALD. Particles ranging from nanometer size to millimeter size were successfully coated with layers of Al_2O_3, TiO_2, AlN and TiN [1]. X-ray photo-electron spectroscopy measurements confirmed the composition and purity of the coatings. Transmission electron spectroscopy finally showed that the individual particles were coated uniformly and conformally, for both thermal and plasma-enhanced ALD. However, the use of plasma has shown to be crucial for the deposition of e.g. low-resistive conformal TiN coatings.
[1] D. Longrie et al., Surface & Coating Technology 213, 183-191 (2013).

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