3D conformal deposition of ceramic layers on complex metallic tools and injection molds via chemical vapor deposition

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Introduction
Chemical vapor deposition (CVD) is a well-known process to produce high quality thin coatings, such as films with specific properties to protect metallic tools and injection molds from wear and corrosion. However, it can be difficult to obtain a high-performance coating on complicated three-dimensional surfaces of some tools. It needs understanding of the solid material formation from a gaseous phase, containing complex volatile molecules; research of metalorganic precursors, which decompose at low temperatures (<500°C) and allow the deposition of conformal layers into narrow cracks and holes; and the detailed research of the 3D substrate materials to clarify the influence of the steel alloy on the adhesion of the layers. Selection of a suitable coating material is crucial for tool protection, for it needs a thermal expansion coefficient and mechanical properties which are similar to the substrate material. Yttria-stabilized zirconia (YSZ) is a highly anti-corrosive and wear resistant ceramic, that is used for coating of turbine blades as well as electrolyte layer material in solid oxide fuel cells. A mixture of acetylacetonates is used in an aerosol-assisted process at comparably low temperatures to avoid corrosion and mechanical failure of the steel substrate.

Deposition of YSZ Coating via MOCVD

Monolayer YSZ Films with SiO₂ Sealing

Multilayer fabrication for reduced film tensions

CVD Parameter Optimization

Optimization was carried out by measuring YSZ film thickness at different pressures, temperatures and carrier gas flows on several specimens placed along the reactor tube. From the film thickness measured via calotte grinding the average growth rate (AGR) in the reactor was calculated.

Injection Mold Modification

For measurement of film thickness inside of cavities, cracks and columns the injection molds provided by the companies participating in the project were modified to allow insertion of test bodies. These steel discs can therefore imitate the inner walls of the corresponding cavities (like the thread seen on the picture), which get coated throughout a conformal deposition of ceramic layer in the CVD process. After removing the steel disc, measurement of film thickness was possible via calotte grinding giving accurate visualization of the film distribution inside the cavity.

Partners

“Crack Coating” Device

Lowering temperature and pressure results in more regular film thickness distribution within the cavity.

References


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