CERAMIC COATINGS
WHY CERAMIC COATINGS?

 Metals have many advantages as structural materials compared to ceramics
  ➢ Easier shaping (smaller tolerances also for more complex shapes)
  ➢ Higher damage tolerance → ductility
  ➢ Lower manufacturing costs

 Ceramics have in general better corrosion, wear and thermal resistance as well as a lower thermal and electrical conductivity

 Ceramic coatings on metallic substrates → Parts combining the structural advantages of the metals with the surface properties of ceramics
CERAMIC COATINGS BY THERMAL SPRAYING

Atmospheric Plasma Spraying (APS)

- A suitable gas (e.g. Ar, N₂) is ionized by an electric arc generating a plasma
- The ceramic powder is introduced into the hot plasma (10,000-20,000 °C) where it melts within 0.5 ms
- A gas stream carries the molten ceramic particles with high speeds
- Standard APS coatings: Al₂O₃, Al₂O₃/TiO₂, Cr₂O₃ und YSZ (Yttria-stabilized Zirconia)
- Typical coating thickness → 100-400 µm

High Velocity Oxy-Fuel (HVOF)

- A fuel gas (e.g. Ethylene, Hydrogen) is continuously burnt with oxygen generating temperatures up to 3000 °C
- The ceramic powder is fed into the resulting flame where it melts
- The combustion causes a pressure increase inside the torch, generating a gas stream with high kinetic energy (supersonic speed)
- Standard HVOF coatings: Al₂O₃ und Cr₂O₃
- Typical coating thickness → 100-200 µm
**MICROSTRUCTURE AND ADHESION**

- The molten particles collide with the substrate at high speed, causing them to flatten, forming the so-called splats.

- The splats resolidify, building a lamellar and usually porous microstructure (porosity: APS > 5% / HVOF < 5%).

- The porosity reduces the stresses caused by thermal expansion mismatches between substrate and coating.

- HVOF → higher density (lower porosity) → smoother surfaces.

- Coatings with a strong adhesion (> 30 MPa tensile adhesion) due to mechanical interlocking → a substrate with a rough surface is required (sandblasting).

- A metallic bond-coat (NiCr, NiAl) improves the adhesion.
Thermal spraying generates coatings with open porosity → fluids can reach the substrate

The open porosity can be sealed by infiltration with a low viscous, liquid material (sealer)

The liquid sealer is converted into a solid (cross-linking), usually by a thermal treatment and/or catalyst

Organic and inorganic sealers as well as nanocomposites are available

Sealing reduces the surface roughness and influences the coating properties

- Improves the electrical insulation
- Changes the wettability
- Anti-sticking properties
APPLICATIONS OF CERAMIC COATINGS

Repair and recycling of heated godets

- Godets for the textile industry must perform under high chemical, thermal and mechanical stresses
- APS ceramic coatings protect the metal body against corrosion and wear
- Despite the high wear resistance, the ceramic coatings will eventually wear off after a long service time
- The remaining ceramic coating can be removed by sandblasting and the expensive metal body reused
- The dimensions of worn metal bodies can be corrected by a metallic coating (NiCr) applied by wire arc spraying
- After that, a new ceramic coating is applied onto the surface of the godets
APPLICATONS OF CERAMIC COATINGS

Insulated Bearings

- Electrical current causes electro-erosion of bearings
- Ceramic coatings can be used to insulate the metal parts
- Demanding coating properties
- Coatings based on Al$_2$O$_3$, usually Al$_2$O$_3$/TiO$_2$
- Coatings with breakdown voltage up to 3 kV
APPLICATIONS OF CERAMIC COATINGS

LED-Cooling systems

- Ceramic coatings for electrical insulation of the cooling bodies
- Coatings of Al₂O₃/TiO₂
- Thinner coatings (60 µm) allow a good thermal transport