Fraunhofer IWS Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

QUALITY ASSESSMENT OF THERMALLY SPRAYED COATINGS

Non-destructive testing

Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS
Winterbergstraße 28, 01277 Dresden, Germany

Fax +49 351 83391-3300
www.iws.fraunhofer.de

Contact:
Dr. Filofteia-Laura Toma
Phone +49 351 83391-3191
filofteia-laura.toma@iws.fraunhofer.de

Task

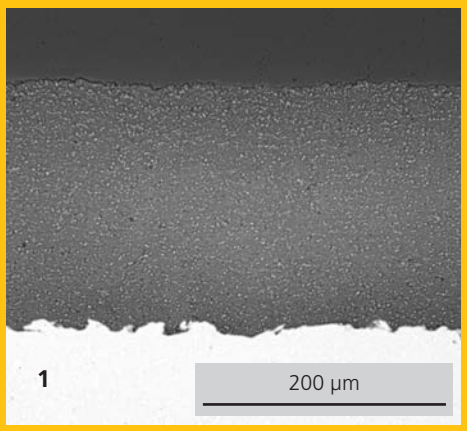
Thermal spraying is a very effective technology to apply protective and functional coatings of varying composition and properties on components. Although modern thermal spraying technologies can spray nearly dense coatings, microdefects and residual porosity cannot be avoided. Depending on the application, a certain amount of pores may be useful, but in most cases porosity degrades the integrity of the coatings and reduces their mechanical strength.

Thus, it is desirable to have a fast and non-destructive test method for the quality control of the mechanical integrity of thermally sprayed coatings.

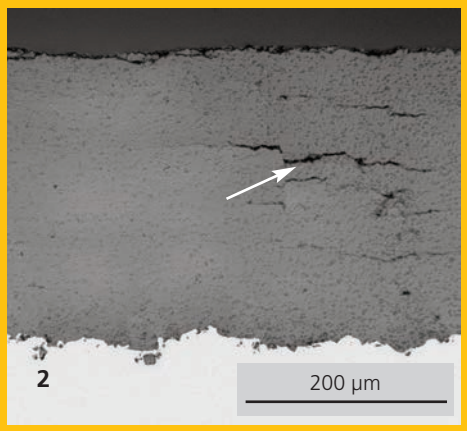
Solution

The Young's modulus is not only one of the important mechanical properties of thermally sprayed coatings but also a sensitive indicator of the coating's microstructural defects.

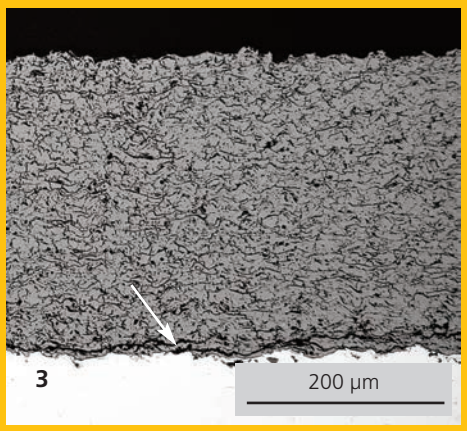
Its measurement can be done with the technique LAwave® making use of surface acoustic waves. This laser induced wave is an elastic vibration with small amplitude propagating along the surface. Therefore, the test does not influence the material structure. Measuring the propagation velocity of the wave, depending on frequency, enables the elastic modulus of the coating to be determined.



Suspension sprayed dense Al_2O_3 coating, E = 101 GPa



Suspension sprayed Al_2O_3 coating with lateral cracks, E = 46 GPa



Cr_2O_3 coating with adhesion problems, deposited by APS

Results

Laser acoustic surface waves have been successfully used for the Young's modulus determination of thermally sprayed ceramic and hardmetal coatings as well as multilayered systems. This fast and non-destructive test evaluates a larger volume of the material than the micro-indentation test, so all microstructural defects contained in this volume are detected.

The material volume to be tested has a dimension of at least 5 mm x 5 mm in square. The penetration depth is depending on the wave length, but reaches the substrate for all typical coating thicknesses.

Application examples

Cracks detection

The dramatic effect of cracks on the Young's modulus is demonstrated in Figure 1 and 2. They show metallographic cross sections of two suspension sprayed Al_2O_3 coatings. Whereas, the sample in Figure 1 has a dense structure, the sample of Figure 2 shows lateral cracks. These cracks have reduced the Young's modulus measured with LAwave® from 101 GPa to 46 GPa.

Detection of adhesion problems

The LAwave® measurement on the APS Cr_2O_3 coating shown in Figure 3 resulted in a Young's modulus of 23 GPa (a value about 50 GPa was expected).

A second calculation was made using a different routine: the coating was divided in two areas. E = 4 GPa was calculated for the range of 10 µm thickness next to the interface, while for the remaining thickness of 290 µm E = 52 GPa was determined. This led to the conclusion that there should exist a defect close to the interface later confirmed via cross-section analysis.

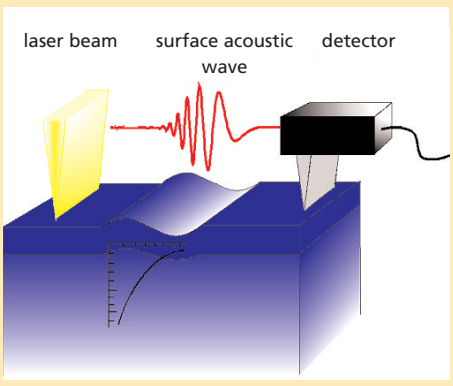
Advantages of LAwave®

- non-destructive
- fast and reliable
- measurement and evaluation of multilayered systems
- portability
- evaluation of a larger material volume

Young's modulus for coatings determined by LAwave® measurements, produced by different thermal spraying technologies

Atmospheric Plasma Spraying (APS), High Velocity Oxy-Fuel Spraying (HVOF), Suspension Thermal Spraying (Suspension)

coating material	spray process	Young's modulus GPa
Al_2O_3	APS	68 ± 1
Al_2O_3	HVOF	113 ± 2
Al_2O_3	Suspension	101 ± 6
TiO_2	APS	76 ± 1
TiO_2	HVOF	111 ± 1
TiO_2	Suspension	88 ± 4



Schematic representation of the laser acoustic test