Motivation

The sol-gel techniques are relatively low-cost, the reaction conditions are mild, and more-over the composition and structure of coatings can be easily controlled.

Sol-gel processing of alumina provides films with different microstructure [1-3]. Zhang et al. [1] report that the wear life of sol-gel generated Al2O3 coatings is very short if the coating has no appropriate microstructure. They observe fine abrasive particles can form with ongoing wear. Some sol-gel alumina coatings showed slight plastic deformation according Zhang et al. [1]. Such coatings showed a longer wear life.

It is known, that surface topography plays an essential role in tribology. Laser impact is one possible method to create periodic surface topographies. Kunz et al. [2] describe laser-induced periodic surface structuring (LIPSS) gained rapidly increased interest in recent years. Not only wear behaviour, but wettability, optical properties or implementation of functional features to generate smart effects can be reached by reliable surface structuring of materials.

Experimental methods

Sol-gel coatings were deposited by dip coating on stainless steel 1.4403 (X1CrNiMo19-11) samples. As precursor a solution of aluminium-tri-sec-butoxide Al(OCH(CH3)C2H5)3 (99.9%, Sigma-Aldrich) in methoxyethanol (99.8%, Sigma-Aldrich) was selected.

Following drying, the samples were heat treated in vacuum oven (0.002-0.008 mbar). Two different top temperatures were chosen, 900°C or 1100°C.

As precursor a solution of aluminium-tri-sec-butoxide Al(OCH(CH3)C2H5)3 (99.9%, Sigma-Aldrich) in methoxyethanol (99.8%, Sigma-Aldrich) was selected.

Laser treatment were used for generating the surface structure. The femtosecond laser Pharos 15-1000-PP of the company Light Conversion, Lithuania is a single-unit integrated laser system combining millijoule pulse energies and high average power.

Pharo laser system at the Laser institute Mittweida, Company Light Conversion

As precursor a solution of aluminium-tri-sec-butoxide Al(OCH(CH3)C2H5)3 for sol-gel synthesis of ceramic layers in stainless steel 1.4403

Alumina precursor Al(OCH(CH3)C2H5)3 for sol-gel synthesis of ceramic layers in stainless steel 1.4403

Scanning electron microscopy

Stereomicroscopy

Aluminum Oxide Gel

Sol-Gel Al2O3 900°C

Sol-Gel Al2O3 1100°C

Raman shift [cm⁻¹]

Intensity

Intensity

Results

Biomimetic Al(OCH(CH₃)C₂H₅)₃ sol-gel coatings: Structuring by femtosecond Laser

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Motivation

For laser structuring of the coated surface, the femtosecond laser Pharos 15-1000-PP of the company Light Conversion, Lithuania is a single-unit integrated laser system combining millijoule pulse energies and high average power.

For laser structuring of the coated surface, pulse duration was 220 fs, repetition rate 220 Hz and laser beam radius 11.5 µm in focus. Two different top temperatures were chosen, 900°C or 1100°C.

Stereomicroscopy

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Scanning electron microscopy

Scanning electron microscopy

Scanning electron microscopy

Scanning electron microscopy

Scanning electron microscopy

Scanning electron microscopy

Scanning electron microscopy

Conclusions

- Successful tests of biomimetic laser dimpling of Al2O3 sol-gel coating according the natural model of "Crab shovel".
- Oxide interlayer increases with heat treatment temperature intensively.
- Laser impact effects different heat treated zones with evaporation, melting and densification/ sintering of metallic or ceramic materials.

References