Post-treatment of wear protection layer

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INTRODUCTION: The aim of the proprietary plasma-sprayed wear protective layer is to extend the life of titanium surfaces which are subject to abrasion wear. The rather limited wear-resistance of titanium parts could be compensated by a hard ceramic plasma-sprayed coating, in particular on sliding surfaces [1]. Therefore, a novel multi-component Al_2O_3/TiO_2 powder mixture as starting material is injected in the plasma flame, where the particles melt. On the flight to the sandblasted implant surface, the droplets start to cool down before they impact the substrate with high kinetic energy. There they immediately solidify under high cooling rates forming the multi-component surface coating. This thermal quenching is the reason for the formation of not fully ceramized, non-stoichiometric, partially electrically conductive, oxygen-deficient, crystalline phases and for the appearance of pores and micro cracks [2]. We identified under what conditions these phases form and how they can be subsequently transformed.

METHODS: Vickers HV1 hardness (Zwick-Roell, Germany), SEM (TM3030, Hitachi) and XRD measurements (Bruker Phaser D2 diffractometer, in Bragg-Brentano geometry) were done on polished, anodized and heat-treated single and mixed Al_2O_3/TiO_2 coatings (Fig. 1). High-resolution Synchrotron X-ray micro-computed tomographic SXRµCT measurement were performed with 1 mm^2 cut strips from post-treated samples to inspect the coating and the interface between the coating and the Ti grade 5-substrate.

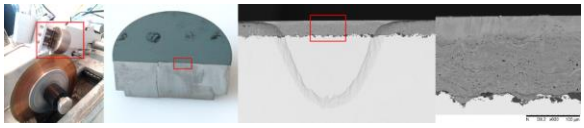

Fig. 1: Cross-section preparation with diamond saw and ion-milling for SEM investigations.

RESULTS: While anodization showed only little effect, the hardness significantly increased after thermal oxidation (Fig. 2a). Crystallographic analysis showed a clear change in the phase composition. Oxidation of non-stoichiometric phases and reduction of high temperature phases was observed in the thermally treated samples (Fig. 2b). XRD indicates that thermal treatment induces transformation into rutile. This also explains the increase in hardness after post-treatment.

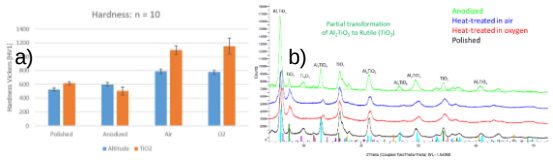

Fig. 2: a) HV1- and b) XRD-measurement after different post-treatments.

With SXRµCT several features were found at the interface and in the coating (Fig. 3): 1) A rippled interface, having a coating-substrate interlayer with thickness ~40 µm, 2) an agglomeration of pores near the interface, 3) smaller pores in the coating, 4) different grey levels inside coatings due to different intensity measured. The variation in intensity in distinct volumes can be caused by different phases present inside the coatings.

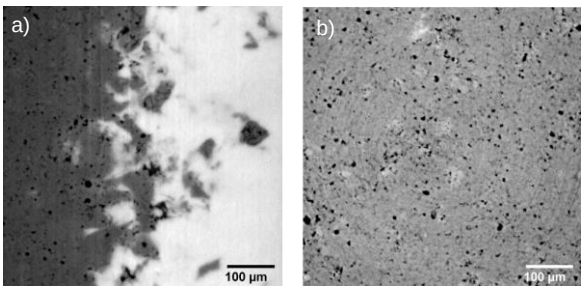

Fig. 3: a) Reconstructed SXRµCT images of the substrate-Al_2O_3 coating interface. b) Reconstructed cross-section through the Al_2O_3 coating.

DISCUSSION & CONCLUSION: Appropriate heat treatments seem to have a positive influence on the multi-component Al_2O_3/TiO_2 wear protection layer in terms of mechanical, structural, crystallographic and tribological properties.

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