

## Phase Structure, laser pulse heating and short-time high-temperature oxidation behavior of sputtered Ta coating for gun bore application

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**Abstract** In weaponry systems, guns and barrels play a significant role by guiding ultrahigh-temperature projectiles through narrow cylindrical tube with the high length-to-diameter ratios. During firing, the chemical ammunition substances explode and produce large amounts of gases, leading to oxidation, carbonization and high-temperature erosion for the Fe-based gun bore. Therefore, protective coating is greatly necessary to prolong the service life of the gun bore against this thermal–chemical–mechanical erosion. Tantalum coating, deposited by magnetron sputtering technology, is a promising candidate for Cr substitute for gun bore applications. In this paper, phase structure of sputtered Ta coating in the negative glow space was explored. The structure for whole coating/substrate system was substrate → physically gas-absorbed Fe surface → oxygen-enriched TaO<sub>x</sub> layer → amorphous Ta → α and β dual phases → single α phase. After the laser pulse heating, microstructure of Ta coating showed intact, only a few cracks emerged after 100 laser pulses, indicating thin heat affected zone and thick Fe/Ta inter-connected zone without large-area martensitic transformation. As to electrodeposited Cr coating for comparison, repeated thermal stresses produced many extra micro-cracks, substrate oxidation and martensitic transformation areas, subsequently leading to crack propagations and final bulk delamination. Moreover, the short-time oxidation behaviour of sputtered Ta coating was studied at 850 °C. With the representative columnar structure and quantitative grain boundaries, a rapid oxygen diffusion rate caused no initial Ta<sub>2</sub>O<sub>5</sub> to form at the surface. The gaps between columns provided spaces for bulk expansion, resulting in almost no opening cracks and delaminations. However, Ta oxidation experienced a Ta<sub>2</sub>O<sub>5</sub> crystallization course from its amorphous state, leading to in situ temperature surging at the crystallization sites. Then, avalanche delamination behavior happened

together with its surrounding coating, and those became independent individuals and finally pulverized after 120-s oxidation.

**Keywords** sputter Ta, phase structure, pulse laser heating, high-temperature oxidation, phase explosion, pulverization

## References

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