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Non-reactively sputtered ultra-high temperature Hf-C and Ta-C coatings

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Abstract

Transition metal carbides are known for their exceptional thermal stability and mechanical properties, notably governed by the carbon content and the prevalent vacancies on the non-metallic sublattice. However, when using reactive deposition techniques, the formation of amorphous C-containing phases is often observed. Here, we show that non-reactive magnetron sputtering of $HfC_{0.89}$ or $TaC_{0.97}$ targets lead to fully crystalline coatings. Their C content depends on the target-to-substrate alignment and globally increases from $HfC_{0.66}$ to $HfC_{0.76}$ and from $TaC_{0.69}$ to $TaC_{0.75}$ with increasing bias potential from floating to -100 V, respectively, when using a substrate temperature T_{sub} of 500 °C. Increasing T_{sub} to 700 °C leads to variations from $TaC_{0.71}$ to $TaC_{0.81}$.

All HfC_y films are single-phase face-centered cubic, whereas the TaC_y films also contain small fractions of the hexagonal Ta_2C phase. The highest hardness and indentation modulus among all coatings studied is obtained for $TaC_{0.75}$ with H = 41.9±0.3 GPa and E = 466.8±15 GPa.

Ab initio calculations predict an easy formation of vacancies on the C-sublattice, especially in

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