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Thermal stability and mechanical properties of Ta-Hf-C coatings for ultra-high temperature applications

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A limiting factor in several industrial applications, e.g. combustion processes or milling operations, is the thermal stability of the applied coating materials. In the last decades the application of nitride based thin films lead to a tremendous increase of the applicable temperatures. Nevertheless, the exploration of new coating systems, exhibiting higher stabilities, is from scientific and industrial point of view inevitable. Transition metal carbides such as TaC or HfC are due to their ultra-high melting points promising candidates for such applications. Especially the combination of these two binaries leads to the ternary material system Ta(1-x)Hf(x)C(y), which currently exhibits the highest melting point among all materials. In addition, TaC as well as HfC prefer the face centered cubic crystal structure, which is highly attractive for coating materials synthesized by plasma assisted deposition systems.
Therefore, we study in detail the structure, morphology, thermal stability and mechanical properties of magnetron sputtered TaC, HfC, and Ta(1-x)Hf(x)C(y) thin films. All coatings deposited showed very dense, smooth, and fibrous like structures with very low amounts of amorphous carbon phase fractions, which is essential for outstanding thermal stability. Based on their single phase cubic structure, all coatings exhibit excellent mechanical properties with hardness and Young's moduli comparable to Ti(1-x)Al(x)N. In addition, increasing bias potentials during deposition leads to increased residual stresses up to 6 GPa. Various annealing treatments (vacuum annealing and differential scanning calorimetry) proved the excellent thermal stability up to 1600°C and higher for these coatings.

Keywords
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