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High-temperature stability and oxidation resistance of amorphous coatings based on nitrides

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A crucial factor of many industrial sectors is ability to operate at high temperatures in various, more or less, aggressive environments. For that reason, new advanced high-temperature materials with heat-resistant capabilities are being extensively developed. An efficient way how to achieve an excellent oxidation resistance of coatings protecting the surface of base materials at high temperatures is a suppression of their crystallization, i.e., the formation of an amorphous grain-boundary-free structure with high-temperature stability.
Recently, two families of novel amorphous coatings, accomplishing these demands, have been developed in our laboratories. The first family is based on amorphous Me-Si-N composites (Me=Ta, Zr, Ti, Mo, W, Al) with a high (≥ 20 at.%) Si content. The second one is based on a purely amorphous quaternary Si-B-C-N system with strong covalent bonds. The coatings were deposited by reactive magnetron sputtering in argon-nitrogen gas mixtures with optimized process parameters. Oxidation resistance and thermal stability were investigated using high-resolution thermogravimetry, differential scanning calorimetry, X-ray diffraction and electron microscopy. The amorphous Me-Si-N coatings achieve a very high oxidation resistance (~1300°C) in air and thermal stability of the amorphous structure (~1450°C) in argon in case that the nitrogen content in the coatings reaches the saturated value being higher than would correspond to the stoichiometric value for the Si_3N_4 and MeN phases. Another crucial factor is also the stability (no volatility) of the Me oxide growing during oxidation of the Me-Si-N coatings in air. The amorphous Si-B-C-N coatings exhibit an excellent oxidation resistance (~1500°C) in air and thermal stability of the amorphous structure (~1600°C) in argon in case that the higher Si/C concentration ratio, optimized incorporation of boron and sufficiently high the concentration ratio N/(Si+B+C)≥1 is achieved in the Si-B-C-N coatings.

Keywords
Me-Si-N
Si-B-C-N
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thermal stability
magnetron sputtering