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Design and development of refractory metal intermetallic composites, refractory high entropy and refractory complex concentrated alloys

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Metallic ultra-high temperature materials (UHTMs) that could replace Ni-based superalloys in a “beyond Nickel superalloys era” could be refractory metal (RM) intermetallic composites (RMICs), RM high entropy alloys (RHEAs) or RM complex concentrated alloys (RCCAs). In aerofoil applications in aero-engines, the new materials will be used as part of an ultra-high temperature material system comprising a metallic UHTM substrate plus an environmental coating system. The metallic substrate should have “adequate” resistance to oxidation and interstitial contamination, and the environmental coating should also “protect” the substrate from interstitial contamination. It is important to know how individual phases in a metallic UHTM are contaminated. Such knowledge is essential for the design, development, and in-service life of the material. Current research is focussing on substrate metallic UHTMs, in particular on A2 solid solution RHEAs or RCCAs, or (i) on multiphase RHEAs and RCCAs with A2+B2 two-phase microstructure, or (ii) on RMICs, RHEAs and RCCAs with microstructures that consist of intermetallics such as silicides, aluminides, Laves phases and A15 compounds with/without A2 solid solution(s). Research focussing on material systems for a “beyond Nickel superalloys era”, though essential, is still in its infancy. The constituent phases in the aforementioned multiphase metallic UHTMs can be “conventional” or high entropy (HE) or complex concentrated/compositionally complex (CC). In other words, HE and/or CC phases can co-exist with “conventional” phases and vice versa in these materials. Furthermore, depending on their location in the microstructure, the said phases can be contaminated with interstitials, some more severely than others, in particular A2 solid solution(s). The presentation will discuss the design of metallic ultra-high temperature systems and challenges for the metallurgical/materials science communities. The use of “alloy design landscapes” will be considered, and processing-microstructure-property relationships will be used to highlight the development of metallic UHTMs. New data for processing, microstructures, and properties of contaminated interstitials and uncontaminated phases will be presented and discussed. Emphasis will be given on the use of Nb in these materials, as the speaker considers Nb to be the “Brazilian element”.