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Development of refractory metal-based CCAs with improved mechanical properties

Refractory Compositionally Complex Alloys (CCAs) can be considered as promising materials for high temperature applications because of their high melting point and outstanding high temperature strength. Our recent experimental studies on the equimolar refractory metal-based alloy system Nb/Ta-Mo-Cr-Ti-Al have revealed that these materials possess a beneficial combination of mechanical properties and corrosion protectiveness. While the alloy Nb-Mo-Cr-Ti-Al consists of a disordered body centred cubic (BCC) phase and a small amount of the Laves phase, the microstructure of the alloy Ta-Mo-Cr-Ti-Al exhibits the ordered B2 and several Laves phases in addition to the BCC crystal structure. At present, the common drawback of these alloys is their low ductility at room temperature. The prime aim of the present proposal is, thus, the development of refractory CCAs based on the Nb/Ta-Mo-Cr-Ti-Al system with improved low-temperature ductility and high temperature strength while keeping the oxidation resistance on the high level observed for the alloy Ta-Mo-Cr-Ti-Al. To achieve these goals, following strategies will be pursued: (i) the formation of the brittle Laves phase will be suppressed by lowering the Cr and/or Nb concentration, (ii) a highly creep resistant two phase microstructure (BCC/B2) with a substantial amount of the strengthening phase B2 will be established by varying the Nb/Ta ratio and (iii) a sufficiently high ductility at room temperature shall be provided by addition of the potentially ductilizing element Re. In order to realize these strategies, different kinds of mechanical tests will be carried out: (a) tensile and (b) notched-bar impact test to proof RT ductility at various loading rates, (c) temperature-dependent four-point bend tests to determine the brittle-toductile transition temperature (BDTT) and (d) creep tests to verify the efficiency of second phase strengthening. In addition, microstructural investigations as well as oxidation studies will be conducted in order to establish sound correlations between the alloy chemical composition, its microstructure and the resulting mechanical and oxidative properties. This will guide our strategy for developing novel oxidation resistant refractory CCAs for high temperature structural applications.