Seminar

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Institute for Plasma Research

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Title: Development of Aluminide coating on Ni based super-alloys

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Time: 11:00 AM

Venue: Join the talk online:
https://meet.google.com/dxo-yqjn-ntw

Abstract

Nickel-based superalloys are extensively used in various industries, including aircraft, marine, chemical, thermal, and nuclear power plants. However, the performance and lifespan of components made from these superalloys can be limited by challenges such as corrosion and high-temperature oxidation. One specific application affected by these issues is the Joule Heated Ceramic Melter (JCHM), utilized for the vitrification and immobilization of high-level radioactive waste in nuclear fission power plants. The vitrification process faces significant problems, including premature degradation of the melter pot and electrode material, as well as corrosion-induced clogging of pour spouts. To address these challenges, plasma-assisted diffusion treatments can play a vital role. It has been widely reported that alpha alumina (α-Al_2O_3) along with diffusion layer of aluminides have shown promising results to mitigate such issues for other alloys. However, such treatment regarding the application of plasma-assisted aluminide coatings for Ni based super alloys is scarcely reported.

This study emphasises on the development of nickel aluminide coatings along with stable alumina produced by hot dip aluminizing and plasma assisted heat treatment. The treatment includes thermal exposure at 900°C/5h in oxygen plasma environment at -520V. The processed samples were then characterized to investigate the effect of heat-treatment on microstructures and bulk material. X-ray diffraction (XRD) studies revealed the presence of Al_2O_3 layer followed by NiAl and FeAl phases in the inter diffusion region. These phases and their microstructures have been investigated with both, optical and scanning electron microscopy. Electron microscopy of the samples indicated distinguished intermetallic precipitates and supports the XRD data. Moreover, the morphology revealed that the samples treated with plasma exhibited a tendency towards the formation of stable α-Al_2O_3, whereas thermally treated samples displayed the presence of theta (θ) alumina. The presence of oxygen species of plasma environment promotes the formation of α-Al_2O_3 from θ- Al_2O_3. In addition, elemental depth analysis via energy dispersive spectroscopy (EDS) further confirmed the elemental distribution of phases. To understand the impact of plasma-assisted diffusion heat treatment on the alloy's microstructure and properties, a thermal heat treatment in muffle furnace at 900 °C/5h is also carried out and compared with plasma treated samples. The Vickers micro-hardness results were ranging from 724 $HV_{0.1}$ to 945 $HV_{0.1}$ which are in agreement with the phases reported and discussed in this study. The future work involves mechanical property evaluation and corrosion tests against molten borosilicate glass. This will provide valuable insights into the feasibility and effectiveness of this technique for improving the performance and longevity of components used in the JCHM and other similar applications.
