QUASICRYSTALLINE MATERIALS AS THERMAL BARRIER AND HOT CORROSION RESISTANT COATINGS

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Abstract

Although the recently discovered quasicrystalline materials (QCs) are metallic in nature, they posses properties similar to those of ceramic materials such as low thermal and electrical conductivities and high hardness. These materials exhibit five and seven fold rotational symmetries which were forbidden according to the rules of classical crystallography. In particular, those that have high thermal stability, and high melting points are good candidates to be employed as thermal barrier coatings (TBCs) and since their main constituent is Al, they are at the same time resistant to high temperature oxidation and hot corrosion. The potential applications of $Al_{71}Co_{13}Fe_8Cr_8$ as a TBC and hot corrosion resistant coating for components of aeronautical and power generation turbines have been explored in our laboratories and the preliminary results are shown in this presentation. $Al_{71}Co_{13}Fe_8Cr_8$ is a QC approximant alloy of hexagonal symmetry but with properties similar to those of pure QCs, stable at 1000º C and with a thermal conductivity similar to that of yttria stabilised zirconia (YSZ), the most commonly used material for TBCs. This material was therefore chosen to be deposited as a coating by low pressure plasma spray to examine its properties as a TBC.

Powders of $Al_{71}Co_{13}Fe_8Cr_8$ were plasma sprayed under low pressure on IN100 (a Ni base superalloy) and very adhesive coatings with minimal porosity were obtained after a series of optimisation rounds. The "as deposited" coatings were characterised by XRD, SEM and TEM and the results indicated that the deposited material retained the same microstructure and phase composition of the bulk material. However, when IN100 coated samples were subjected to 950ºC, interdiffusion between coating an substrate took place resulting in the loss of the QC approximant phase. Mainly, Al from the QC coating diffused inwards forming a nickel aluminide layer (β-NiAl) while some Ni from the substrate diffused outwards forming a layer of composition $Al_{50}Ni_{30}Co_{10}Fe_4Cr_6$ mainly in the cubic phase. To eliminate or retard the interdiffusion process, a series of diffusion barrier coatings were applied between the substrate and the coating. The chosen diffusion barriers were a dispersion of Y_2O_3 in NiAl applied by low pressure plasma spray, a dispersion of Y_2O_3 in $Al_{71}Co_{13}Fe_8Cr_8$ also applied by low pressure plasma spray and a diffusion aluminide coating applied by pack cementation. The results obtained after applying a 950ºC heat treatment to said coating systems under inert atmosphere indicated that some of the studied layers were quite efficient in retarding the interdiffusion process. Optimisation of the most promising sistems is underway.

Cyclic oxidation testing of coated samples with and without diffusion barriers were carried out at 950º C and the results indicated a very high resistance to high temperature oxidation even in the absence of diffusion barriers. Hot corrosion testing at 900ºC (type 1) also indicated excellent behaviour especially when compared with commercially applied chromium aluminides coatings (pack cementation).

Although $Al_{71}Co_{13}Fe_8Cr_8$ can not be employed as a TBC at temperatures higher than 950º C due to its intrinsic thermal stability, the results showed that QC materials applied over diffusion barries show promise as potential TBC coatings. Their use would eliminate the need of the current utilised systems MCrAlY-YSZ with metal-ceramic interfaces in which failure occurs due to spallation caused by stresses generated by thermal shock and thermally grown oxides. Moreover, QCs can be used as high temperature oxidation and hot corrosion coatings even without diffusion barriers. Other potential applications of these QC coatings are as protective coatings for the wet seal of separator plates from corrosion in molten carbonate fuel cells and for stream engine components from steam oxidation at temperatures of 650ºC.