High Temperature Oxidation Behavior of TiAl Coated by Al-Cr Alloy in Molten Salt

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Introduction

TiAl inter-metallic compound is may be one of the next turbine blade materials of internal combustion engine. However the corrosion resistance of TiAl is not enough in a high temperature area. To improve the oxidation resistance in high temperature, we proposed electroplating of Al-Cr alloy on TiAl in a molten salt as a surface treatment of TiAl. In this study, relation between electrodeposition potential and content of the electrodeposit were investigated. TiAl with the electrodeposit of Al-Cr alloy was kept in 100hr high temperature environment at 1173K and the oxidation resistivity was evaluated comparing with TiAl without the deposit.

Experiment

61molAlCl_3-26mol%NaCl-13mol%KCl mixture salt was melted at 423K. TiAl plates made by ark-melt in Ar gas were used as test electrodes. Pure Al wire and plate were used as a counter electrode and a reference electrode respectively. $CrCl_2$ powder was dissolved into the molten salt as Cr content. Al-Cr alloy deposit was electrodeposited in potential of -0.1, -0.2, -0.3, or -0.4V (vs. Al/Al^{3+}) with 1C cm^{-2} electricity. Oxidation test was made for 100h in air at 1173K for TiAl with electrodeposit of Al-Cr alloy formed at –0.1V. The specimen of after the oxidation was investigated by SEM, XRD and EPMA.

Results and Discussion

Compositions of electrodeposits are identified to Al and Al_8Cr_5 by XRD results. Cr concentration of the electrodeposit Al-Cr alloy at potential of -0.1, -0.2, -0.3, and –0.4V are 43, 23, 18, and 15% respectively. Cross-sectional microstructure of TiAl coated by Al-43at%Cr alloy after oxidation are shown in Fig. 1 in which TiAl without the coating is also shown. The oxide layer of TiAl without coating consists of TiO_2, Al_2O_3 and mixture of TiO_2 and Al_2O_3. The total thickness of the oxide layer is 100 μm. In this oxide layer Al_2O_3 layer does not play a role of protection layer, since the layer is not fine and not uniformity. Oxidation penetrates into the inner part, probably due Ti ions or oxygen can transfer the Al_2O_3 layer easily. On the other hand, fine oxide layer 2-3 μm thick forms continuously on the Al-43at.%Cr alloy electrodeposit coated on TiAl after oxidation(b). Cr_2Al layer works as an effective protective layer of Ti ions. The diffusion coefficient of Ti ion may be very small in this layer. Thickness of oxide layer is 1/30 compare with the case of TiAl without coating (a). Therefore we can conclude that TiAl coated by the Al-Cr alloy exhibits excellent corrosion resistance in high temperature oxidation.

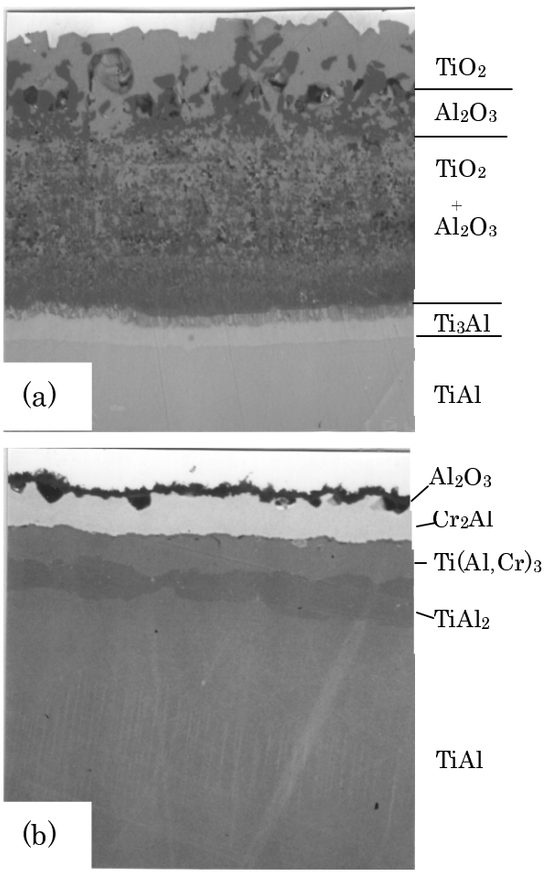

Fig.1 Cross-Sectional microstructure of TiAl(a) and Al-43at.%Cr alloy electroplated TiAl(b) after oxidation at 1173K for 100h.