AN AUGER ELECTRON SPECTROSCOPIC ANALYSIS OF SURFACE SEGREGATION IN TITANIUM

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Titanium Aluminides are being considered for use in hydrogen fueled, hypersonic flight vehicles in spite of some distinct limitations, such as a lack of room temperature ductility, poor oxidation resistance, and susceptibility to hydride formation, because of their standing properties:high strength -to-weight ratio, high elastic modulus, and high temperature creep rupture strength. Although titanium aluminides having some critical problems for this applications, such as poor oxidation resistance and considerable embrittlement when they absorb hydrogen, maybe overcome by an aluminizing coating. We are faced with another problem, such as a Al_2O_3 spalling at oxide-metal interface [1]. In our previous reports [2,3], it has been shown that the variation of sulfur concentration as a function of temperature for the titanium,Ti-14Al-21Nb (α_2) and Ti-33Al-6Nb-1.4Ta(γ). The sulfur Auger peak increased dramatically at T>500℃ for the pure titanium and somewhat slower for the α_2 titanium aluminide (T>600℃), but since the titanium aluminide retained a rather significant oxygen level at high temperature, the detected sulfur never increased beyond 10% even at 1000℃. From above results we believe that impurity segregations in titanium and titanium aluminides are highly correlated with the Al_2O_3 spalling at oxide-metal interface. Therefore a detail study of the segregation of impurities, such as sulfur, carbon and oxygen, in high purity titanium are essential.

The experimental system was comprised of a standard ultrahigh vacuum (UHV) work chamber pumped by a Alcatel Drytel 30 roughing pump, ion pump, a titanium sublimation pump and turbo pump (base pressure was around 2 x 10^{-11} torr). The system was equipped with an Auger electron spectroscopy(AES), an ion scattering spectrometry(ISS), a seconary ion mass spectrometry(SIMS), a quadrupole mass spectrometer(QMS), and two differential ion guns and two electron guns. The sample (99.9998%) used in this work were cut in the shape of a 5 mm square and 2 mm thick. The titanium sample was mounted in platinum envelope. Behind the sample envelope contacted mechanically with the nichrome electrode for heating resistively by DC current and its temperatures were measured by a Pt/Pt-19%Rh thermocouple loaded by W spring for a good contact with back of the sample envelope.

In this report the kinetic behavior of surface segregation was studied during heat treatment of a polycrystalline titanium between 400°C and 750°C by using an Auger electron spectroscopic technique. When the specimen is heated above 400°C, the present as an impurity in the titanium segregation on the surface. The intensity changes of Auger electron signals of sulfur and titanium showed that the rate of the segregation in the temperature range studied. The rate of the segregation of sulfur stays constant until the surface is covered by monolayer at each temperature. The activation energy of surface in the initial stage of the segregation is 17 Kcal/mol. The sulfur is distributed uniformly on the surface. The Auger peak shape of titanium is constant when segregated sulfur is maximized at high temperature. This indicats that segregated sulfur on the titanium is not formed sulfide and scale spallation accurs due to sulfur segregation and weakening at the Al_2O_3-metal interface.

[1] A.G. Evans and R.M. Cannon, Stresses in Oxide Films and Relationship with Cracking and Spalling, in Oxidation of Metals and Associated Mass Transport, edited by M.A. Dayananda, S.J. Rothman and W.E. King, The Metallurgical Society (1986) p.135

[2] W.S. Lee, S.N. Sankaran, R.A. Outlaw and R.K. Clark, J. Electrochem. Soc., 137 (1990) 1194

[3] R.A. Outlaw, W.S. Lee, S.N. Sankaran, D. Wu and R.K. Clark, Scripta Metall., 25 (1991) 171