SYNCHROTRON RADIATION STUDY ON THE OXIDATION BEHAVIOUR OF NEW TI ALLOYS

M. F. López and F. J. Palomares
Instituto de Ciencia de Materiales de Madrid, CSIC, Cantoblanco, E-28049 Madrid, Spain

L. Soriano, M. Sánchez- Agudo, G. G. Fuentes and A. Gutiérrez
Departamento de Física Aplicada, Insituto de Materiales Nicolás Cabrera, Universidad Autónoma de Madrid, Cantoblanco, E-28049 Madrid, Spain

J. A. Jiménez
Centro Nacional de Investigaciones Metalúrgicas, CSIC, Avda. Gregorio del Amo 8, E-28040 Madrid, Spain

Titanium alloys are very interesting because they have one of the highest strength/weight ratio among the metallic materials. The spontaneous formation of a protective native oxide layer on its surface, named passive layer, leads to a high corrosion resistance which makes these alloys good materials for different technological applications [1,2]. However, for some applications, the protection against the environment can be improved by generating an oxide layer by heat treatment.

The aim of the present work is to investigate the oxidation behaviour of three Ti alloys, Ti-13Nb-13Zr, Ti-15Zr-4Nb and Ti-7Nb-6Al, using soft X-ray absorption spectroscopy (XAS). The main contributions to the chemical composition of the oxide layers formed on these alloys at room and at high temperature were determined.

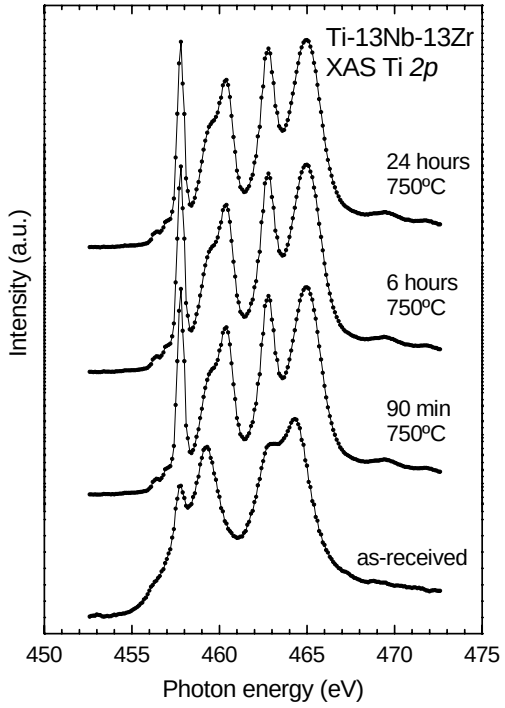

Fig. 1: Ti *2p* XAS spectra of Ti-13Nb-13Zr.

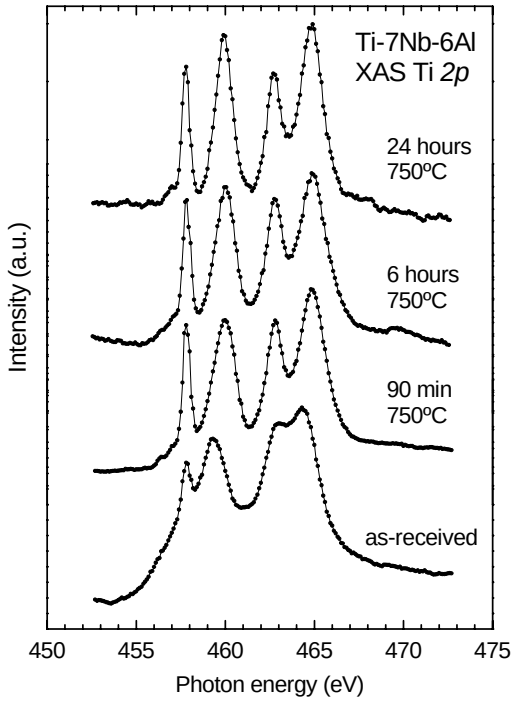

Fig. 2: Ti *2p* XAS spectra of Ti-7Nb-6Al.

In order to study the oxidation behaviour of Ti-13Nb-13Zr, Ti-15Zr-4Nb and Ti-7Nb-6Al (wt %), some samples were isothermally heated at 750ºC in air for three different exposure times, 90 min, 6 hours and 24 hours. XAS measurements were carried out at the VLS-PGM soft x-ray monochromator at BESSY. XAS spectra were obtained by recording the total yield of electrons from the samples surfaces, i.e., in TEY mode. The base pressure in the UHV-chamber during the measurements was better than 2×10^{-10} mbar.

The Ti *2p* XAS spectra of the Ti-13Nb-13Zr and Ti-7Nb-6Al alloys are represented in Figs. 1 and 2, respectively. For Ti-13Nb-13Zr, the spectral shapes of all heat-treated samples are very similar to that of TiO_2, as can be deduced by comparison with previous works [3]. The Ti-15Zr-4Nb alloy exhibits a similar behaviour against oxidation in air to that of the Ti-13Nb-13Zr alloy. For Ti-7Nb-6Al, all heat-treated alloy spectra are very similar, but their shape is different to that of TiNbZr alloys. A comparison of these spectra with those of previous works, leads to the conclusion that they correspond to Al_2TiO_5 [4]. Both as-received spectra are, however, very similar and correspond to the native oxide.

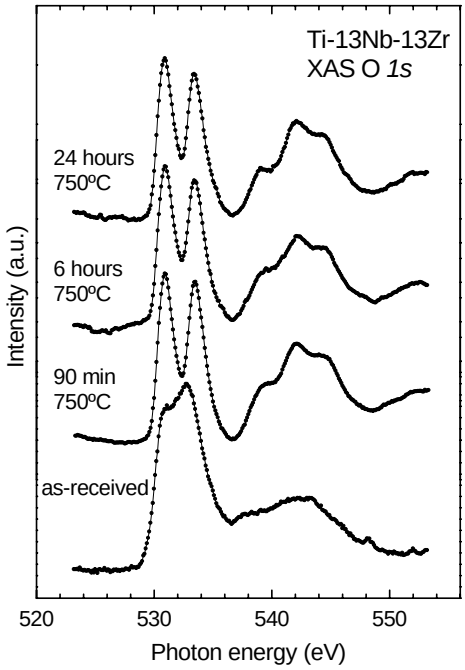

Fig. 3: O *1s* XAS spectra of Ti-13Nb-13Zr.

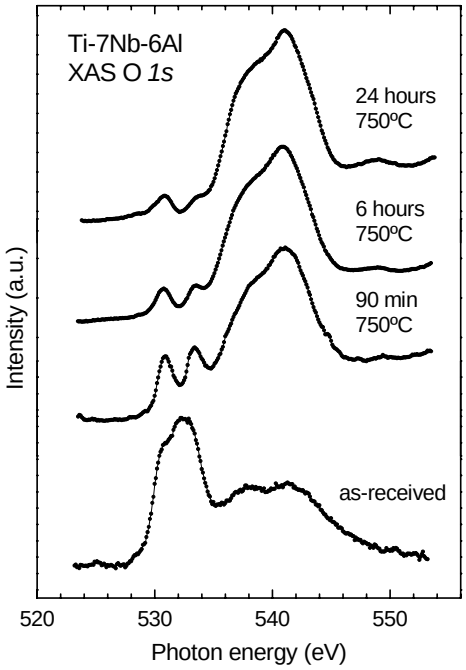

Fig. 4: O *1s* XAS spectra of Ti-7Nb-6Al.

Figs. 3 and 4 show the O *1s* XAS spectra of Ti-13-Nb-13Zr and Ti-7Nb-6Al, respectively. All Ti-13Nb-13Zr oxidized samples exhibit the typical O *1s* spectrum of rutile TiO_2, in agreement with the Ti *2p* spectra showed previously. In contrast, for the oxidized Ti-7Nb-6Al samples a broad feature at ≈ 540 eV is observed. By comparing the spectral shape of the oxidized samples with that of previous works, it can be concluded that this broad structure corresponds to Al_2O_3. The intensity of this feature increases by increasing the treatment time. These results suggest that the early state of oxidation promotes the formation of an Al_2TiO_5 layer on the material, as deduced from the Ti *2p* XAS spectra. As the exposure time increases, an Al_2O_3 layer grows on the previous oxide becoming thicker for longer oxidation times. Thus, the presence of Al in Ti-7Nb-6Al leads to a different oxidation tendency. The oxidation process of TiNbZr alloys promotes the TiO_2 formation contrary to Ti7Nb6Al alloys where Al_2TiO_5 and Al_2O_3 were formed.

This work was supported by the spanish CAM (07N-0050-1999), the MCYT of Spain (BFM2000-0023) and the EU-HPRI-CT-1999-00028.

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