

Characterization of a Ni-Co-Cr-Al bond coat produced by mechanical alloying

E. Prieto-García, G. Valle-Corona, A. Martínez-Villafañe, I. Estrada-Guel, M. Herrera-Ramírez and R. Martínez-Sánchez

Advances in gas turbine technology for power generation [1] and for aeroengine applications [2] place an increasing demand of high temperature Ni-base superalloys, used for turbine blades. Bond coat (BC) is probably the most important component in thermal barrier coating (TBC) systems. Its chemistry composition and microstructure have an important influence over the durability of the system through the structure and morphology of the thermally grown oxide (TGO), which grows as the BC is oxidized. The function of these coatings is to provide a stable phase for the adhesion of the ceramic layer of thermal insulation [3].

In the present study one type of BC was prepared using two different treatments. Elemental powders of Ni, Co, Cr and Al (with purity higher than 99.5%) were used as raw materials, and processed by means of mechanical alloying (MA). Composition of BC was set at $\text{Ni}_{60}\text{Co}_{10}\text{Cr}_{20}\text{Al}_{10}$ (at. %). Milling process was carried out in a Simoloyer mill, using methanol as a process control agent, the milling time was set to 10h. The ball-to-powder ratio was

~20:1. The milled powders were deposited on top of Inconel 718 by Air Plasma Spraying (APS) technique. The specimens were sectioned and separate in two groups: one group (G1) was subjected to oxidation in presence of air at 1000°C with different processing times (1, 2, 3 and 10h). The other group (G2) was placed in a vacuum quartz ampoule and maintained under an argon atmosphere (1000°C)

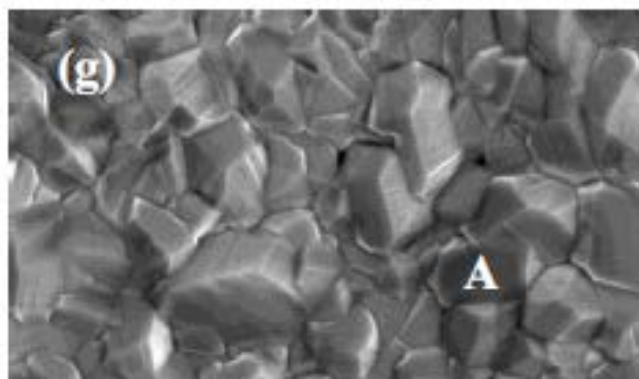
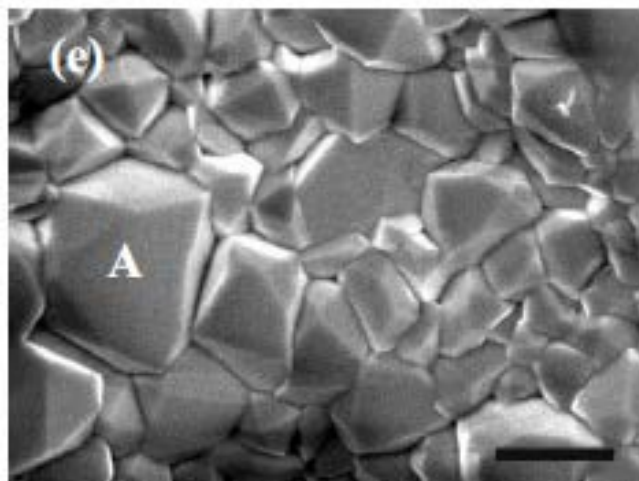
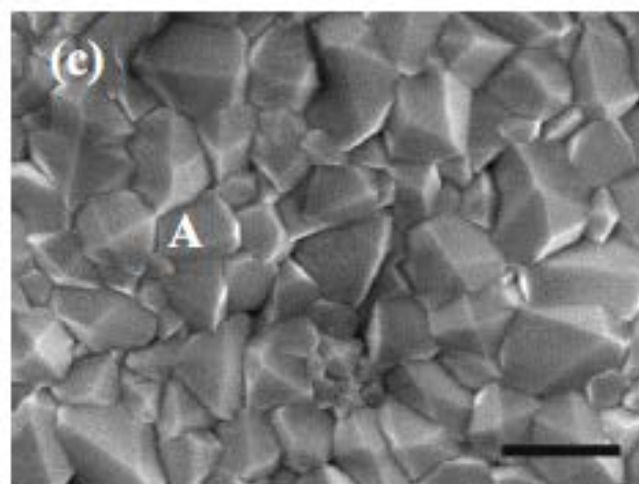
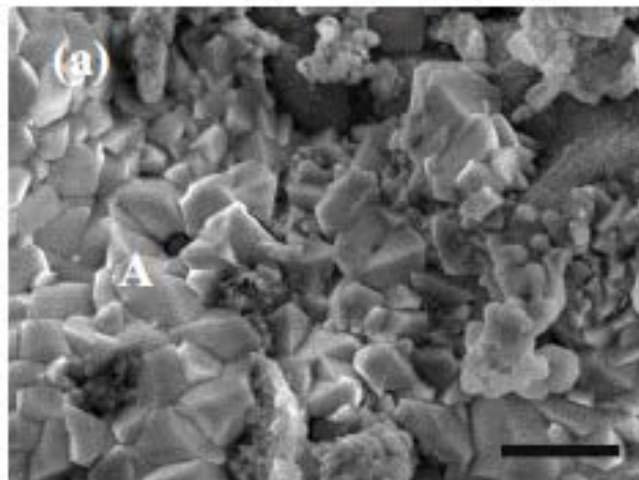
during a period of 3h and cooled to room temperature. After heat treatment the specimens were subjected to an oxidation process under similar conditions used with the first group of samples. Microstructural characterization was done using conventional techniques: X-rays diffraction and microscopy with a SEM model JSM-5800LV.

The Fig. 1 shows the characteristic surface microstructure of prepared systems. According to the EDS analyses in (a), (c), (e) and (g) samples, the zone A corresponds to a double oxide with the formula: $(\text{Ni,Co})\text{O}$. However this oxide does not appear in a single step, has been reported that NiO is the first oxide formed on Ni-20Cr sample upon heating to 1000°C [4]. Also, presence of low Cr and Al contents leads the formation of this phase with internal oxides of Al and Cr [5]. The figures show an increase of abundance of this phase as the time of oxidation raise, in other words, the oxide formed on the surface grows. In Fig. (e) and (g) the oxide formed on the surface of further processed samples is similar. Meanwhile the images of samples showed in Figs. (b), (d), (f) and (h) present a Cr_2O_3 -rich phase (denoted as zone B). The growth of oxide on the surface was lower than samples without pre-treatment. Thus, the heat treatment prior to oxidation helps the formation of Cr_2O_3 phase. The Fig. 2 shows the XRD patterns of the systems after oxidation and with the pre-treatment process before oxidation. In the Fig. 2a is showed the oxide layer formed by the reaction of Ni solid solution with oxygen and was identified by XRD as $(\text{Ni,Co})\text{O}$. On the other hand, XRD studies showed in Fig. 2b expose that oxide formed in the surface corresponds to Cr_2O_3 phase.

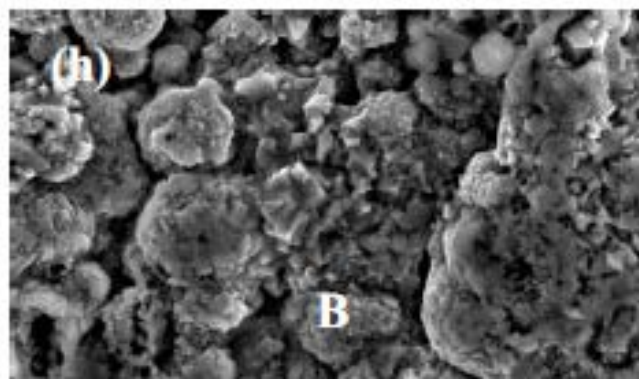
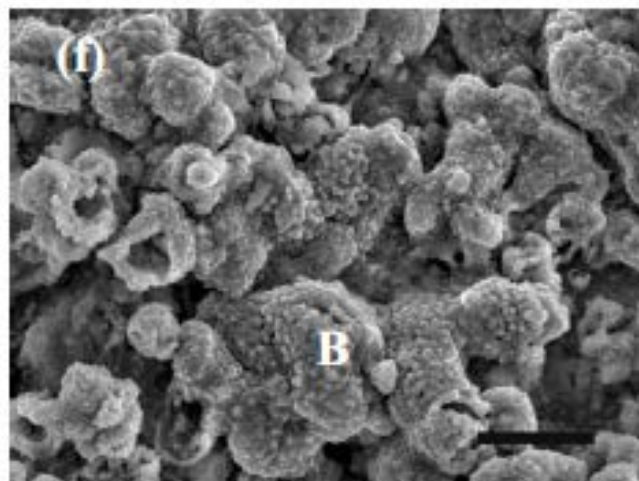
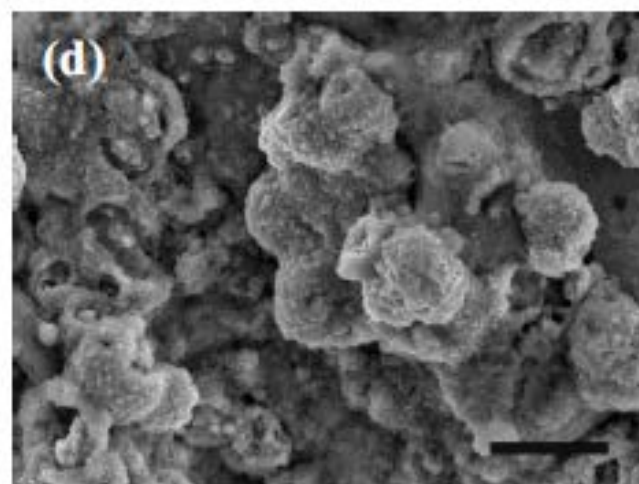
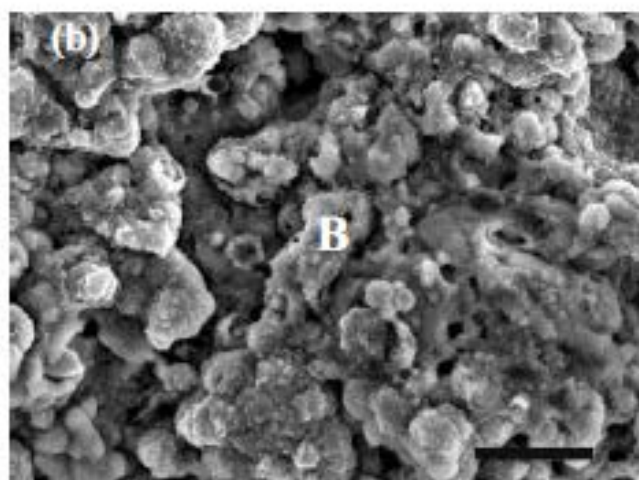
Table 1. Chemical composition

System	Composition
G1-Ni₆₀Co₁₀Cr₂₀Al₁₀ (a), (c), (e) and (g)	Zone A: (Ni,Co)O
G2-Ni₆₀Co₁₀Cr₂₀Al₁₀ (b), (d), (f) and (h)	Zone B: Cr ₂ O ₃

G1-Ni₆₀Co₁₀Cr₂₀Al₁₀



G2 Ni₆₀Co₁₀Cr₂₀Al₁₀



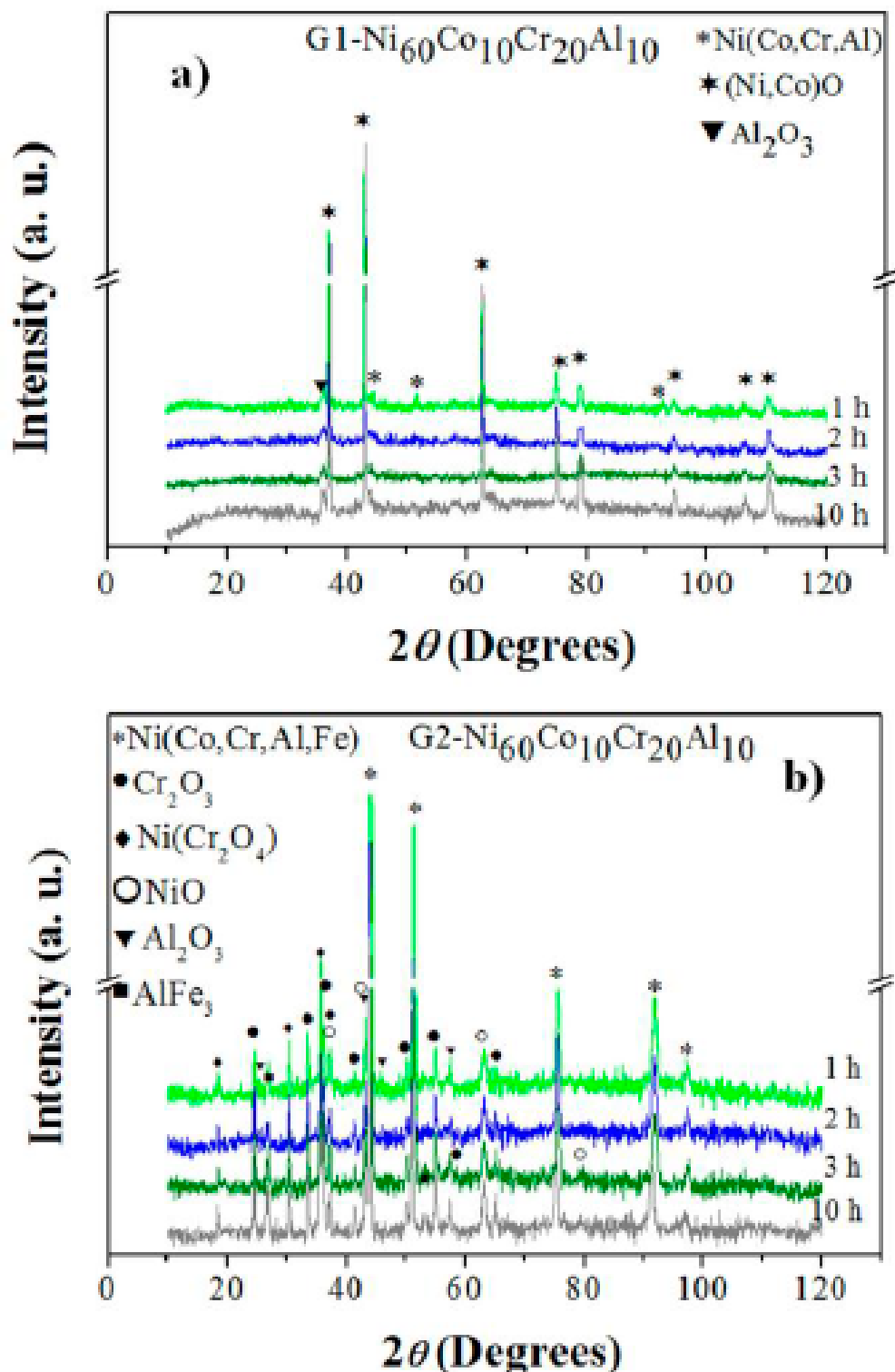


Fig. 2. XRD spectra of the APS-st- $\text{Ni}_{60}\text{Co}_{10}\text{Cr}_{20}\text{Al}_{10}$ bond coats after oxidation and A- $\text{Ni}_{60}\text{Co}_{10}\text{Cr}_{20}\text{Al}_{10}$ bond coats with heat-treatment before oxidation.

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- [6] Thanks to E. Torres-Moye, K. Campos Venegas and W. Antunez-Flores, for their technical