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Synthesis of NiCoAl powder alloy for aeronautical coatings

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Coating techniques have been used as processes to increase and improve life and performance of aeronautical and aerospace components. Some of these techniques involve metallic and ceramic materials in the form of liquid droplets or semi-molten or solid particles, which are deposited on structural materials to create a surface coating for use as a thermal insulation, clearance control, oxidation/hot corrosion, and/or wear coating.

Mechanical alloying is a promising technique to manufacture alloyed powders which may be used as coatings in other alloys. Milling process has an important effect over the morphology of milled products. The intrinsic mechanical characteristics of powders as well as their volumetric fractions affect the surface characteristics.

In this work, NiCoAl powders were mechanically alloyed and subsequently used as a spray coating on an Inconel 718 substrate. Raw materials and as-alloyed powders were analyzed by SEM. Figures 1a and 1b-d show a mixture of powder particles of pure initial materials and a homogeneous morphology after alloying process, respectively. This is achieved with the continuous competition between plastic deformation, agglomeration and size reduction. The chemical composition of the as-mechanically alloyed (MA'ed) samples, based on results of EDS-SEM analyses, confirmed that the chemical composition of individual MA'ed powders is very similar to those of the starting elemental powders. Although this technique is limited to being semiquantitative, it was used to show that the chemical composition of the alloys were nearly equiatomic. It is possible to assume a good chemical homogeneity of the powder alloy with a variation of ±3% even on those ones obtained during lower alloying times.

At the beginning of the mechanical alloying process, the powders are still soft enough to be agglomerated and a phenomenon of refinement and tightening of particles is undertaken as time passed, which is an indication of the equilibrium state of the process. The sample with 10 h of mechanical alloying presents a mean particle size of 11.77 µm, while samples with 20 and 30 h exhibits a mean particle size of 15.85 and 21.53 µm, respectively. A reduction of the particle size is expected with longer times of alloying [1], but in this work an opposite effect was observed, probably due to the powder ductility.

It has been reported that Ni-Co-Al alloys with addition of other elements like Ta and B generate a state of superplasticity, decreasing the precipitation of brittle phases in the grain boundaries [2]. Equiatomic composition promotes the increment of entropy and favors the formation of FCC and/or BCC solid solution phases (figure 2) instead of the formation of brittle intermetallic compounds [3-4]; this feature could result in an improved ductility of the alloys and their metallic coatings.

During mechanical alloying process, the particles formed by the cold welding of smaller particles have a typical lamellar microstructure (figure 3a). After sintering the coated sample, it was observed that the internal pores of the particles were reduced and the lamellar microstructure tended to disappear, leading to the formation of two distinguishable phases (figure 3b): a dark area having a chemical composition close to the equiatomic ratio, and a bright area having a low aluminum content.

From figure 4, it can be noted that phase changes occur at 450°C and 820°C.

[1] G. Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, 1997.
[2] T. Omori, S. Abe, Y. Tanaka, D.Y. Lee, K. Ishida, R. Kainuma, Scripta Mater. 69 (2013) 812–815.
[3] B.S. Li, Y.P. Wang, M.X. Ren, C. Yang, H.Z. Fu, Mater. Sci. Eng. A 498 (2008) 482-486.
[4] A. Li, X. Zhang, Acta Metall. Sin. 22 (2009) 219–224 (Engl. Lett.).

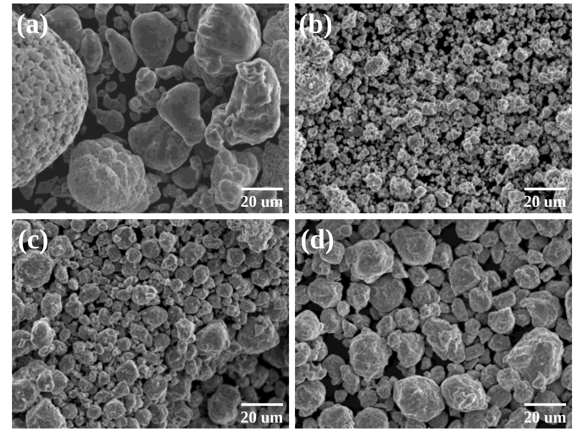

Figure 1. SEM micrographs of the MA'ed NiCoAl powder alloy. (a) Starting powder mixture and alloyed powders for: (b) 10 h, (c) 20 h and (d) 30 h.

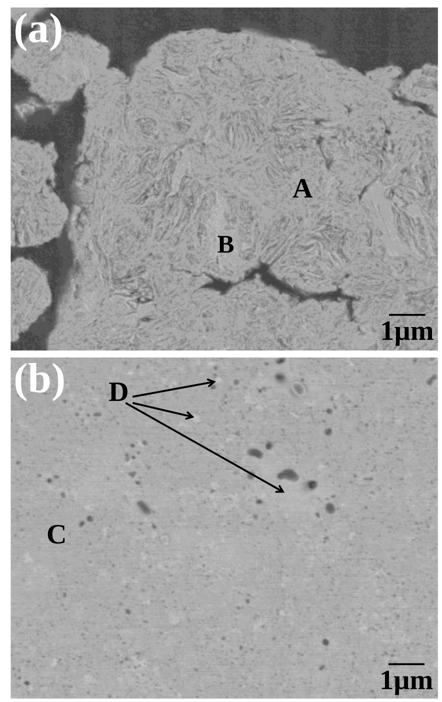

Figure 3. SEM micrographs of NiCoAl samples: (a) cross-section of powder milled for 10 h and (b) coating sintered at 1200°C.

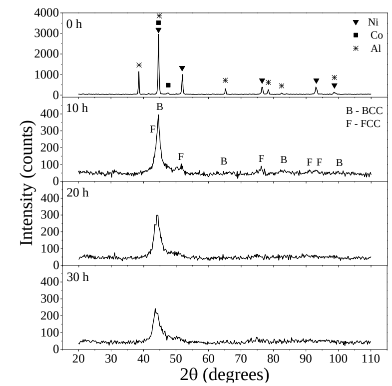

Figure 2. Structural evolution as a function of alloying time.

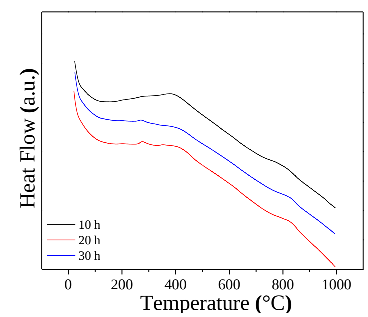

Figure 4. Profiles of TGA thermal analysis of NiCoAl at a heating rate of 5°C/min.