Acta Microscopica, Vol. 8 Supplement A October 1999
Proc. XVII Congress of the Brazilian Society for Microscopy and Microanalysis and X Congress of the Brazilian Society for Cell Biology

MICROSTRUCTURE OF Al-Fe-Nb-Si PREPARED BY MECHANICAL ALLOYING AND VACUUM HOT PRESSING

Coelho, Rodrigo Estevam [1]; Zampieron, João Vicente [2] & Ambrozio Filho, Francisco [3]

Ipen- Instituto de Pesquisas Energéticas e Nucleares
Cidade Universitária "Armando de Sales Oliveira"- Travessa R, 400
CEP 05508-900 - São Paulo - SP - Brazil
(1)Fax (011) 816-9370 - email: recoelho@net.ipen.br
(2)Fax (011) 816-9370 - email: jovizam@hotmail.com
(3)Fax (011) 816-9370 - email: fambrosi@net.ipen.br

Mechanical alloying (MA) is a high-energy ball milling process developed by INCO in 1960's however it has attained commercial standard in the 1980's. MA is important to stabilize the balance between cold welding and fracturing. The intermediate phases and intermetallic compounds have been synthesized from the pure components in several alloy systems. The present work shows the solid state interaction among Al, Fe, Nb, and Si element by MA. The initial composition $Al_{90.8}$-$Fe_{6.2}$-$Nb_{1.0}$-$Si_{2.0}$ (at. %) powder mixture was milled and was submitted to double vacuum hot pressing. Mechanical alloying was performed using an attrition ball-mill under a nitrogen atmosphere. The processing parameters were impeller velocity (1400 rpm), ball diameter (7mm), rate ball / weight (9:1), milling time (10 hours). Then the powder was degased for 3.5 hours at 350 ° C and compacted in billet with pressure of 750 MPa. The green billet with 96 % theoretical density was compacted at 350 ° C with pressure of 940 MPa. Microstructures of the powder and the compacted material were studied by scanning electron microscopy (SEM) and energy dispersive spectrometry (EDS). The X-ray diffraction was used to identify the intermetallic phases. The density of the compacted sample was measured by Archimed's method. Vickers hardness (HV_{100}) at room temperature of the compacted material was obtained from 10 indentation measurements. Figure 1 shows the external morphology of mechanically alloyed $Al_{90.8}$-$Fe_{6.2}$-$Nb_{1.0}$-$Si_{2.0}$ (at. %) powder after 10 hours of milling. Note that the particles are welded and fractured and it can be appreciated the spherical and irregular shape. The backscattered electron image of the compacted material, in parallel to the hot pressing plane, can be seen in Figure 2. The microstructure of compacted material, which was mapped by (EDS). The elements Fe, Nb and Si distributed in the Al matrix were observed. By X-ray Cu $K\alpha_1$ analysis of the compacted $Al_{90.8}$-$Fe_{6.2}$-$Nb_{1.0}$-$Si_{2.0}$ (at. %) sample the Al_3FeSi, $Al_{13}Fe_4$ and Al_3Nb crystalline phases were identified. The line intensity decreases and enlarges as compared with Al, Fe, Nb and Si X-ray diffraction. It is evident that the material structure was mechanically deformed, facilitating the formation of intermetallic phase. The line intensity of the Si element disappears, indicating that it was in complete solid solution. The hardness (HV_{100}) and density of as compacted material are summarized in Table I.

The present paper concludes that mechanical alloying of Al with Fe, Nb and Si powders results in a fine distribution of these elements embedded in the Al matrix. During vacuum hot pressing at 350 ° C occurs formation of intermetallic phases at a submicrometer scale. The alloy presents an excellent hardness. The elevated hardness is due to the presence of a high content of intermetallic phases.

Table I - Hardness and density of $Al_{90.8}$-$Fe_{6.2}$-$Nb_{1.0}$-$Si_{2.0}$ (at. %) as compacted material.

Hardness (HV_{100})	Density		
	Green	Compacted	Theoretical
267	2.925	2.985	3.047

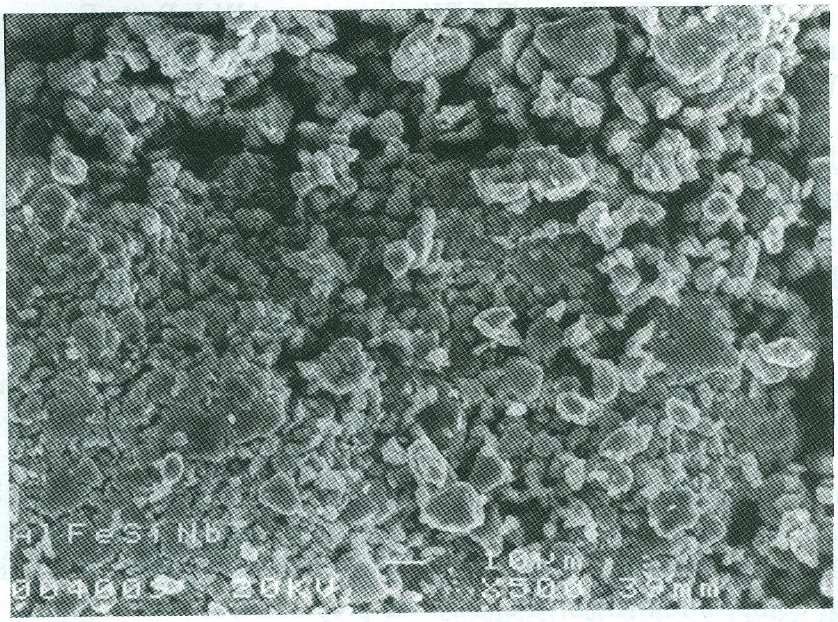

Figure 1- SEM image of the mechanical alloying $Al_{90.8}$-$Fe_{6.2}$-$Nb_{1.0}$-$Si_{2.0}$ (at. %) powder after 10 hours of milling at 1400rpm.

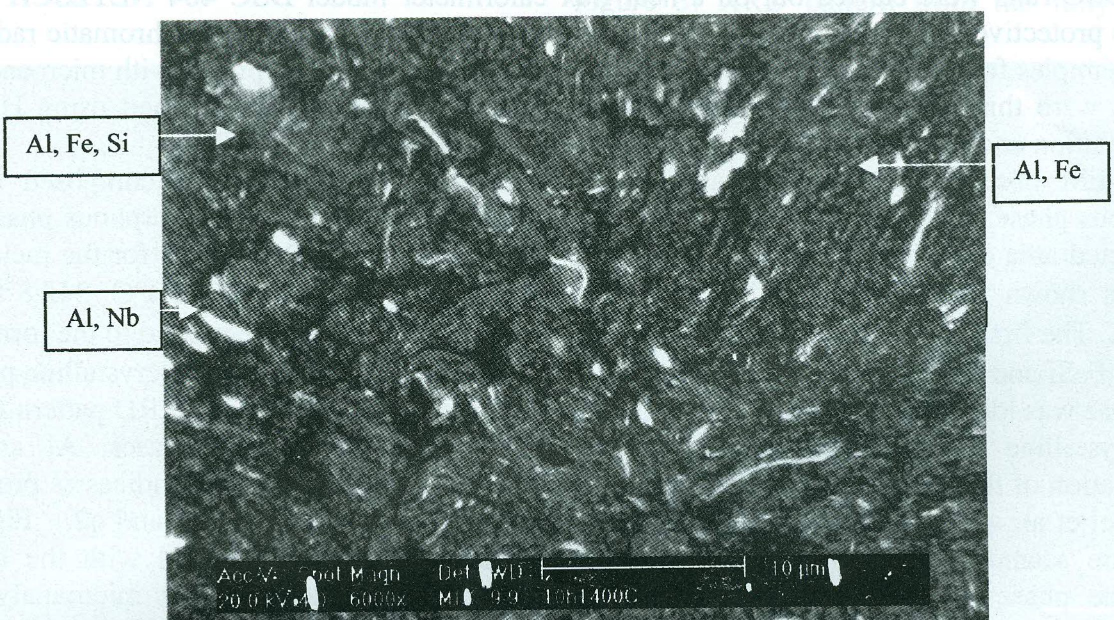

Figure 2 - The backscattered electron image of the compacted material, mapping by (EDS) the elements Fe, Nb and Si distributed in the Al matrix.