

MICROSTRUCTURAL CHARACTERIZATION OF THE Cu-NbC ALLOY BY ELECTRON MICROSCOPY

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Composites materials consisting of pure copper strengthened with 0,5 and 1% by volume of NbC were prepared in order to determine the influence of this reinforcing ceramic particles on the mechanical and electrical properties. Atomized powders of pure copper were milled with NbC particles in a planetary mill to achieve a homogeneous mixture. Different milling time and rotation speed were used. The resulting powders were consolidated by hot pressing under 90MPa for 2h at 650°C to obtain a fine microstructure. After hot pressing, consolidated samples were microstructural characterized by X-Ray Diffraction (X-RD) and high resolution scanning electron microscopy (SEM-EDS). Hot consolidation process produced fully density MMCs materials with a satisfactory mechanical properties and electrical conductivity between 46 and 75 % IACS. Microscopic observation of non-etched samples revealed an homogenous distribution in the copper matrix of NbC particles with a size lower than 5 μm , also included some very fine nanoparticles rich on Cr, C and Fe, finer than 5 nm included in the grain interiors and in subgrain boundary, as is shown in figure 1 and figure 2.

During MA process, the surface of the powder particles picks up iron and chromium due to wear with milling balls and jags walls. On the other hand, as the milling process was performed under protective atmosphere of argon, the oxygen and carbon contamination probably resulted from the spontaneous reaction between the powder and the PCA used.

The effect of milling intensity(rotation speed) on the microstructure and electrical conductivity has been related to the pick up of iron, chromium, carbon and oxygen, with Fe-Cr oxycarbides and F_3C particles precipitated during hot consolidation.

Scanning electron microscopy revealed that the strength of consolidated metal matrix composites Cu-niobium ceramics is consistent with estimates based on Hall-Petch strengthening mechanisms. Semiquantitative analysis determined by EDS spectrum of bigger precipitates with size around 100nm, revealed the presence only of Niobium and C in the core(white) and Fe, Cr, O and C in the outer zone(black) as is shown in figure 1.

A recrystallization process takes place during hot consolidation at 650°C. Furthermore, as solubility of Cr and Fe in copper is very low, in these region enriched with iron and chromium during the milling process, precipitation of second phase iron-chromium rich particles is produced, which can block dislocation slip.

Table 1 shows the results of the mechanical and electrical conductivities properties of the Cu-NbC alloys manufactured. The hardness behavior exhibited an increase in most of the alloys in according with milling time and speed. On the other hand electrical conductivities decreased with milling intensity significantly. The increase in the tensile stress compared with the reported data for pure wrought Cu was related with the presence of niobium carbides and Fe-Cr-C-O precipitates.

TABLE 1 Mechanical and Electrical Properties of Cu-NbC Mechanical Alloyed

<i>Alloy Cu-NbC (10:1) load ratio</i>	<i>Fe (%) Impurities</i>	<i>Milling Time (h)</i>	<i>Rotation speed (rpm)</i>	<i>Hardness (HR_B)</i>	<i>Tensile Strength (MPa)</i>	<i>Electrical Conductivity (%IACS)</i>
<i>Cu-0,5%NbC</i>	<i>0,5</i>	<i>8</i>	<i>153</i>	<i>67</i>	<i>-</i>	<i>76</i>
<i>Cu-1%NbC</i>	<i>0,6</i>	<i>8</i>	<i>153</i>	<i>70</i>	<i>255</i>	<i>70</i>
<i>Cu-0,5%NbC</i>	<i>0,5</i>	<i>24</i>	<i>153</i>	<i>75</i>	<i>245</i>	<i>68</i>
<i>Cu-1%NbC</i>	<i>1,1</i>	<i>24</i>	<i>153</i>	<i>82</i>	<i>300</i>	<i>65</i>
<i>Cu-0,5%NbC</i>	<i>1,9</i>	<i>8</i>	<i>300</i>	<i>98</i>	<i>322</i>	<i>63</i>
<i>Cu-1%NbC</i>	<i>2,0</i>	<i>8</i>	<i>300</i>	<i>102</i>	<i>340</i>	<i>52</i>
<i>Cu-0,5%NbC</i>	<i>2,4</i>	<i>24</i>	<i>300</i>	<i>100</i>	<i>350</i>	<i>58</i>
<i>Cu-1%NbC</i>	<i>3,4</i>	<i>24</i>	<i>300</i>	<i>29HR_C</i>	<i>450</i>	<i>46</i>
<i>Wrought pure Cu HR and annealed</i>		<i>-</i>		<i>28</i>	<i>216</i>	<i>101</i>

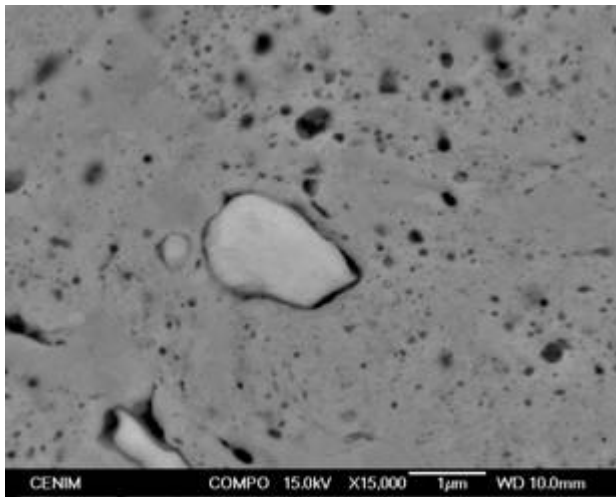


FIGURE 1

FIGURE 1 x15.000
BEI image of Cu-0,5%NbC alloy, 24h milled at 153 rpm. NbC particles(white) with a size lower than 5 μm.
Niobium and C in the core and Fe, Cr, O and C in the outer zone(black)

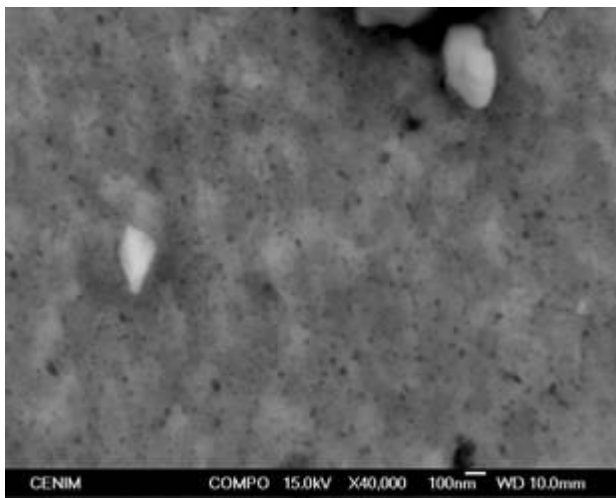


FIGURE 2

FIGURE 2 x40.000
BEI image of Cu-1%NbC alloy, 8h milled at 300rpm. Nanometric iron-chromium rich particles(black) precipitated as second phases, well as fine oxide particles prevented the grain growth during consolidation. NbC particles(white) with a size lower than 300nm.

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