Analysis by Optical Microscopy and X-ray Diffraction of Composite Cu-Cr-Ag-Al_2O_3 Synthesized Using Powder Metallurgy

Daniela Passarelo Moura da Fonseca[1*], Waldemar Alfredo Monteiro[1]

[1]Instituto de Pesquisas Energéticas e Nucleares, IPEN–CNEN/SP, São Paulo, Brazil
*danipassarelo@hotmail.com

The use of Nature's materials in favor of human beings has been present in its daily life for a long time, copper and its alloys have been used in function of the high thermal and electrical conductivity, good mechanical properties, resistance to corrosion, ease of fabrication and also by the high value of scrap [1]. Metal alloys can also be combined with other classes of materials in order to obtain new properties, superior to the original alloy, this union of two or more materials forms a composite [2]. The studied composite has a ternary metal alloy (copper, chromium and silver) as a matrix and a ceramic oxide (alumina) as the reinforcing phase. The addition of chromium, silver and small amounts of finely dispersed metal oxides in copper improves their mechanical properties and increases the operating temperature, causing little loss of conductivity. A possible application of this composite is in electrical contacts, electronic devices that break the passage of current in electrical circuits [1]. The objective of this study was the microstructural characterization by optical microscopy and X-ray diffraction of the composite Cu-Cr-Ag-Al_2O_3 processed by powder metallurgy. The samples used were fabricated in laboratory scale of 25 mm diameter, 3,5 mm $\geq h \geq$ 4,0 mm of height and 6,5 g of mass, with the following chemical compositions: (a) 85% Cu – 15% Al_2O_3; (b) 90% Cu – 5% Cr – 2% Ag – 3% Al_2O_3; (c) 90% Cu – 5% Cr – 5% Al_2O_3; (d) 90% Cu – 7% Cr – 3% Al_2O_3; (e) 85% Cu – 5% Cr – 5% Ag – 5% Al_2O_3; (f) 90% Cu – 5% Cr – 3% Ag – 2% Al_2O_3; (g) 90% Cu – 3% Cr – 7% Al_2O_3. In order to obtain the samples, the powders were weighed on a precision balance (according to each composition), mixed manually and cold-compacted in uniaxial press with 450 MPa pressure and sintered in an EDG furnace under 10^{-3} torr of mechanical vacuum and 650 °C in 6 h. The samples were prepared metallographically and observed in an optical microscope, the micrographs indicated coalescing of the copper particles and other metallic elements and formation of porosity (figure 1). The X-ray diffraction data were collected for samples (a) and (e) using graphite monochromator, copper tube, $25^o \leq 2\theta \geq 90^o$ and $\Delta 2\theta = 0{,}02$, from the diffractograms the mean crystallite size (D) and microdeformation (ϵ) were calculated using the Williamson-Hall graphical method where the approximate line has a linear coefficient equal to $1/D$ and the angular coefficient is equal to $4\epsilon/\lambda$ [3]. In both samples were identified the expected phases, in agreement with the composition, and an undesirable phase of copper oxide (figure 2). The Williamson-Hall method was not used for all phases because it requires the identification of at least three peaks. Optical micrographs indicated presence of porosity inside the structure and partial homogeneity, due to the non-dissolution of the elements involved in the metal alloy, it is necessary to do further special thermal treatments. In some samples, a third phase was recognized, whose composition demands microanalyses to be properly identified. Through the diffractograms it was possible to identify the phase of copper oxide possibly coming from the sintering stage, this phase is not desirable or this composite because it negatively influences its electrical and mechanical properties. The Williamson-Hall method obtained a straight line with good correlation and suitable values of mean crystallite size and microdeformation for the copper phase.

[1] ASM International. Specialty Handbook – Copper and Copper Alloys. 2001.
[2] ASKELAND, D.; PHULÉ, P. Ciência e Engenharia de Materiais – Uma introdução. São Paulo: Cengage Learning, 2008.
[3] SANTOS, R. L. P.; RIBEIRO, P. C.; VIEIRA, D. A.; SANTOS, P. T. A.; SASAKI, J. M.; COSTA, A. C. F. M. Difração de raios X e refinamento por Rietveld de ferritas Mn0.65Zn0.35Fe2O4 sintetizada por reação de combustão. Revista Eletrônica de Materiais e Processos, v.6.3 (2011), p. 145-150, ISSN 1809-8797.

This research was supported by Universidade Presbiteriana Mackenzie, Instituto de Pesquisas Energéticas e Nucleares and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.

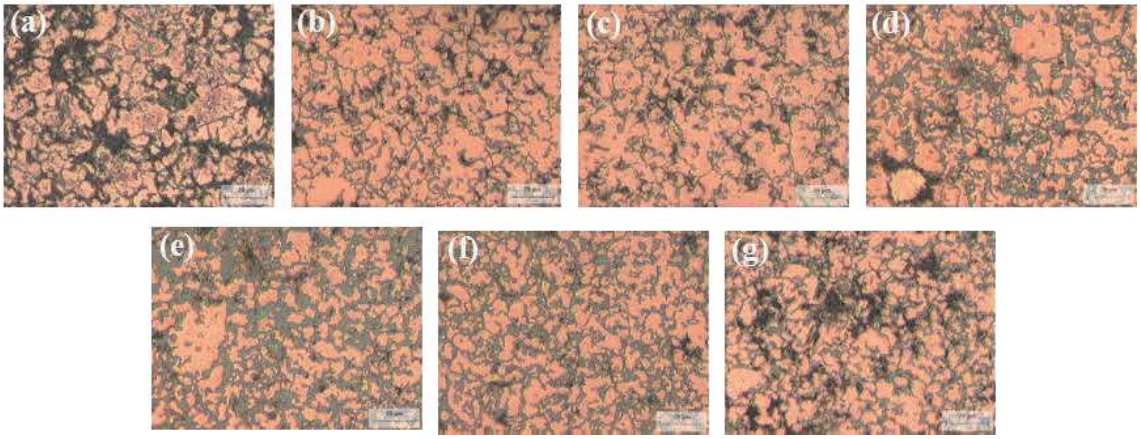

Figure 1: Optical micrographs of the composites Cu-Cr-Ag- Al_2O_3, as polished (20 μm scale). It was observed porosity, coalescence of the copper particles and partial homogenization.

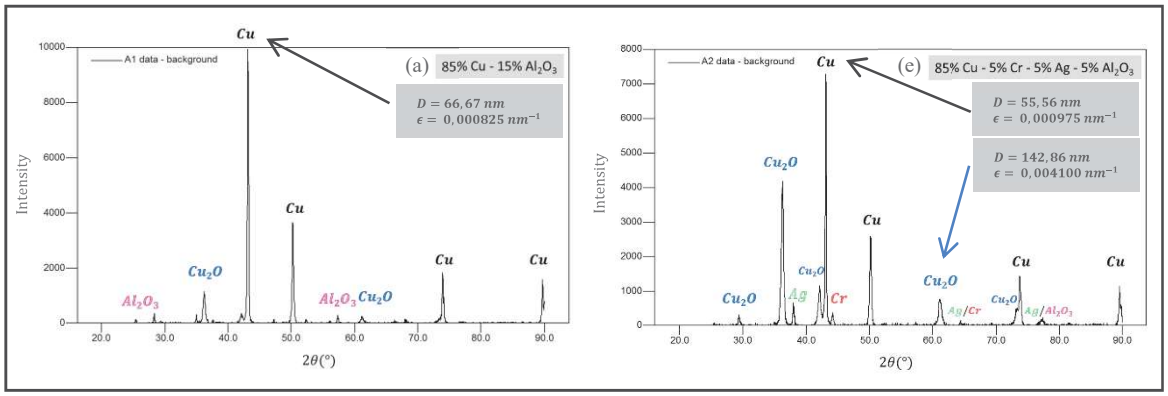

Figure 2: Diffractogram and results of the Williamson-Hall method for sample (a) and (e). The phases of copper and copper oxide were identified with greater intensity, some phases were not possible to identify due to the overlapping of peaks. A suitable crystallite size was found for the copper phases in both samples.