Microstructural Analysis of Composite Cu-Cr-Ag-(CeO2, Al2O3) Processing by Powder Metallurgy

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Microstructural Analysis of Composite Cu-Cr-Ag-(CeO_2, Al_2O_3) Processing by Powder Metallurgy

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Copper has long been used by mankind, since the 20th century they have gained industrial and technological importance [1]. They can be combined with ceramic materials in the synthesis of modern composites, optimized and with balanced properties [2]. The studied composite has a metal as a matrix (copper or copper, chromium and silver), the ceramic oxide as the reinforcing phase (ceria or alumina) and was synthesized by powder metallurgy. A possible application of this material is like anodes in Solid Oxide Fuel Cells (SOFC), cermets based on rare earth oxides and metals such as copper, silver and nickel have been studied in this component [3]. The objective of this work was the analysis of the particle size by SEM and chemical composition by EDS of the starting material (powders of copper, chromium, silver, ceria and alumina) and the microstructural characterization by MO of copper composites with four compositions: (a) 80% Cu – 8% Cr – 4% Ag – 8% CeO_2; (b) 80% Cu – 20% CeO_2; (c) 80% Cu – 8% Cr – 4% Ag – 8% Al_2O_3; (d) 80% Cu – 20% Al_2O_3. For analysis in the SEM/EDS the powders were fixed in the sample port with carbon paint, for the powders of ceria and alumina was made gold coating for 2 min. The copper powder presented nodular agglomerates; the chromium powder presented large particles with coarse contours and irregular shape; the silver powder presented a dendritic shape; the ceria powder presented very small particles and it was not possible to observe them due to the limitation of the SEM and the alumina powder presented flake-shaped agglomerates, figure 1. The EDS microanalysis results for copper, silver, ceria and alumina powders were adequate, for chromium powder indicated silicon and iron (manufacturer predicted) and calcium impurities (not predicted but with low percentage), figure 1. The powders were weighed on a precision balance (according to each composition), mixed manually and cold-compacted in uniaxial press with 180 MPa pressure and sintered in a tubular furnace with vacuum of 10^{-7} torr, temperature of 750 °C and time of 6 h. The samples were obtained in laboratory scale with a 31x12x 3.5 mm parallelepipedal shape, hot mounting, grinded (240, 320, 400, 600, 800) and polished (3µm and 1µm diamond and 0.02 µm silica). The optical micrographs indicated coalescence of copper particles, homogeneity, porosity and an unknown (black) phase, possibly related to ceramic materials, figure 2. The sample (c) was the only one that presented different microstructure between the normal and transverse directions, possibly due to segregation of the powders during mixing. It was possible to make an adequate analysis of the particle formats of the copper, chromium, silver and alumina powders; however, the ceria powder needs to be analyzed again in SEM with higher capacity of increase. The results of EDS microanalysis were promising for all powders. The optical micrographs suggest a good adequacy of the compaction and sintering parameters, forming a homogeneous microstructure and with the desired porosity, except for sample (c), that the mixture was not suitable. In order to study the formed phases it is necessary to perform an X-ray mapping on SEM and X-ray diffraction in the samples after sintering.

References:

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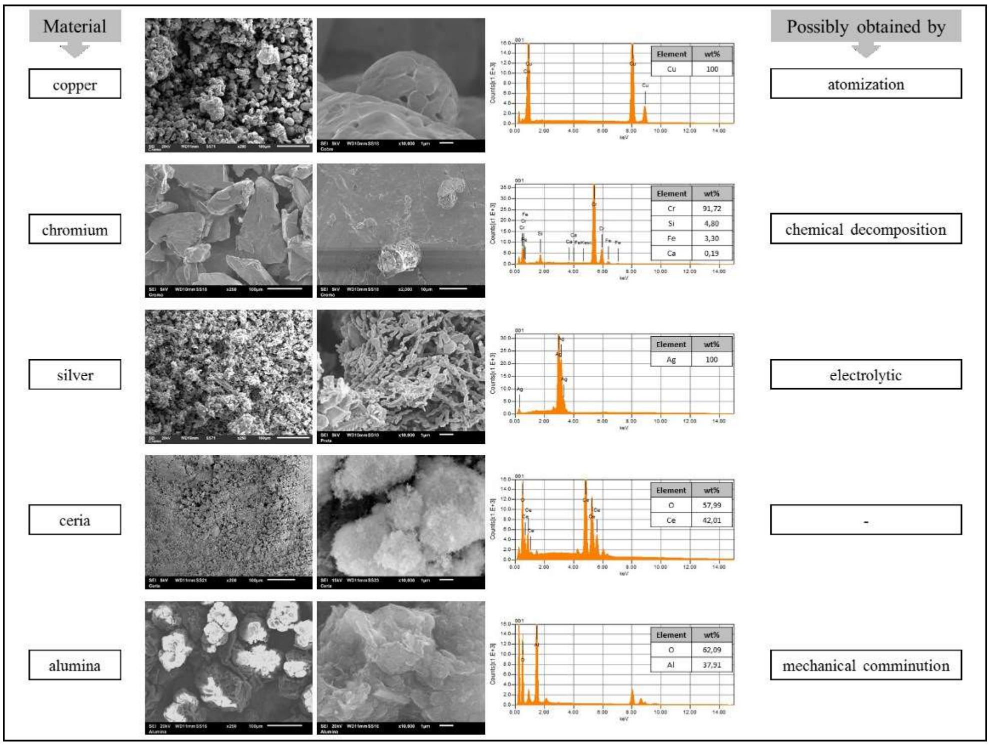

Figure 1: SEM micrographs by secondary electrons and EDS results of copper, chromium, silver, ceria and alumina powders (100 µm and 1 µm scale).

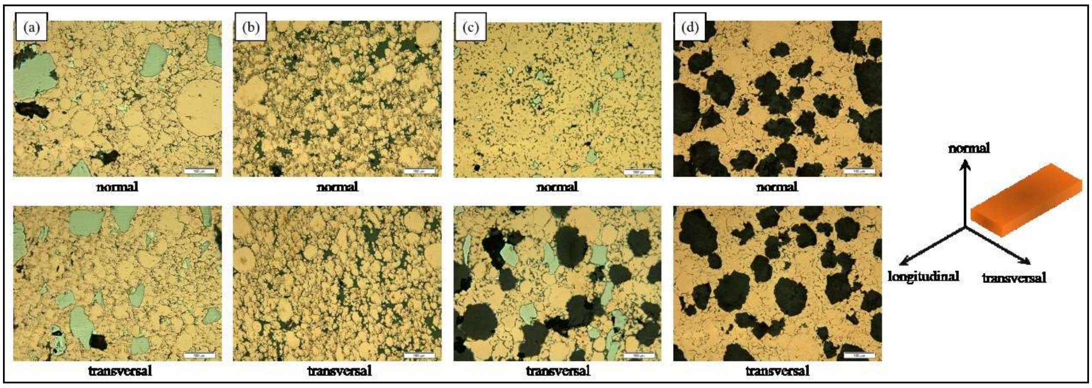

Figure 2: Optical micrographs of the composites Cu-Cr-Ag- (CeO_2, Al_2O_3) in normal and transversal directions, as polished (100 µm scale).