Investigation of the Microwave Dielectric Properties of Cu based Nanocomposites

F. Kara[1], F. Otmane[1], M. Azzaz[2]

1. PURPOSE

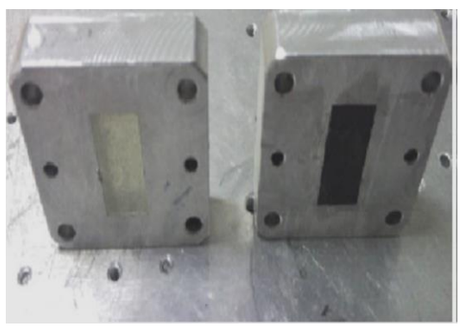
In this work, we looked over the structural and the microwave dielectric properties of skinny slabs of epoxy resin reinforced by nanocristalline Cu powders. By nanocrystalline powders, we mean materials with grain size below 100 nm. In such materials, the critical microstructural feature that determines properties and performance is the grain size. The grain size, in turn, depends upon the processing method used. The choice of nanocrystalline Cu powders is justified by the availability of copper powder and its skin-deep characteristic when exposed to microwaves.

2. EXPREMENTAL SECTION

Figure 1: Fracture- welding mechanism during powders milling.

Nanocrystalline Cu powders were obtained by mechanical milling. It is a severe plastic deformation technique, which allow metal powders to be nanostructured by repeated cold-welding, fracturing and re-welding in high- energy milling process. This process can induce material defects (dislocations and/or two-dimensional defects) that lead to the grain size refinement and packages of nanodefects. High-energy mechanical milling was accomplished using a planetary ball mill (RETSCH PM400). To carry out the experience, a milling velocity of 200 rpm were respected, 18 hardened steel balls were loaded with 10g of elemental Cu powder in a vial and all handling were performed in a glove compartment under protective atmosphere of Argon. Small samples of powder were retained after 3 h, 12 h, 33 h and 58 h milling durations for structural and microwave characterization. Obtained powders were subject to an X-Ray Diffraction (XRD) analysis using an X'PERT PRO MPD PANalytical diffractmeter in order to investigate their structural properties after milling. Grain size refinement, lattice parameter changes and accumulated defects were explored in the range of [10°-90°] Bragg angles with a step of 0.026° using CuKα radiation.

Figure 2: Nanocomposite sample within Rectangular Waveguide.



For microwave characterization, thin slabs of 1 mm thickness were shaped by solid solution dispersion technique. The bulk samples were subject to an experiment of two-port S parameters measurement in a rectangular waveguide (R120) in association with a vectorial network analyser (Keysight Technologies N5222A).

3. RESULTS AND DISCUSSION SECTION

A. Structural Characterization

Coarse Cu powder shows XRD peaks at 43.462°, 50.549°, 74.321° corresponding to the planes (111), (200) and (220) in the fcc crystalline structure of Cu. XRD spectra analysis is conducted related to the observed changes surrounding the named peaks after milling. The Cu peaks remain consistent after milling process. XRD lines move slightly and widen as the milling process continues. Additionally, their intensity decreases indicating that milling releases little to no energy, providing evidence that fcc crystalline structure remains intact.

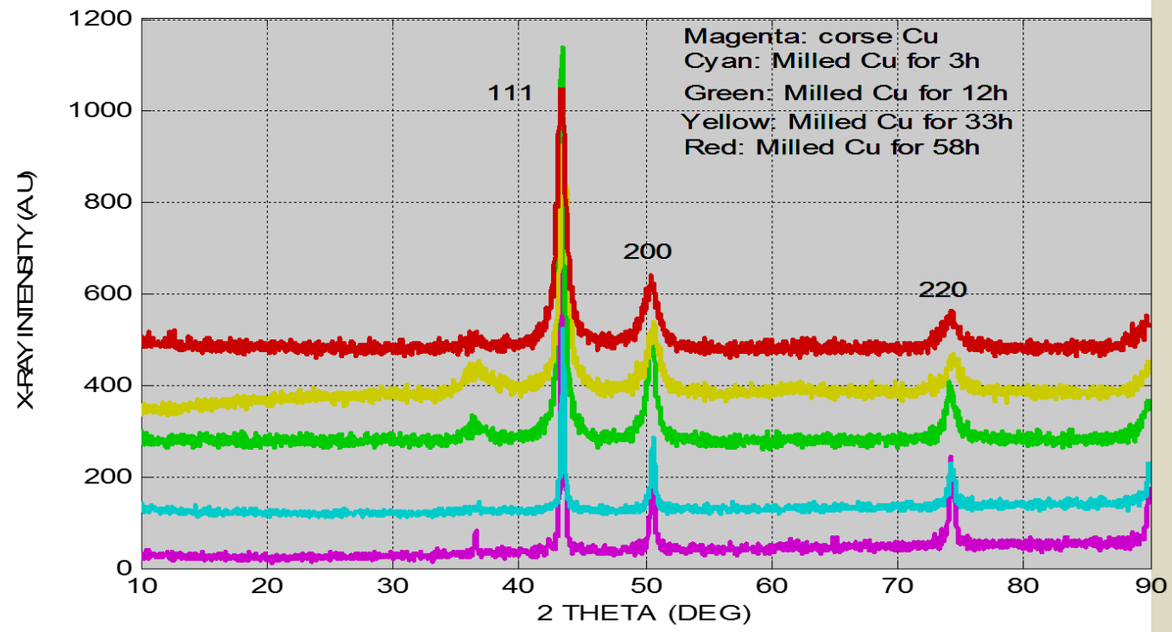
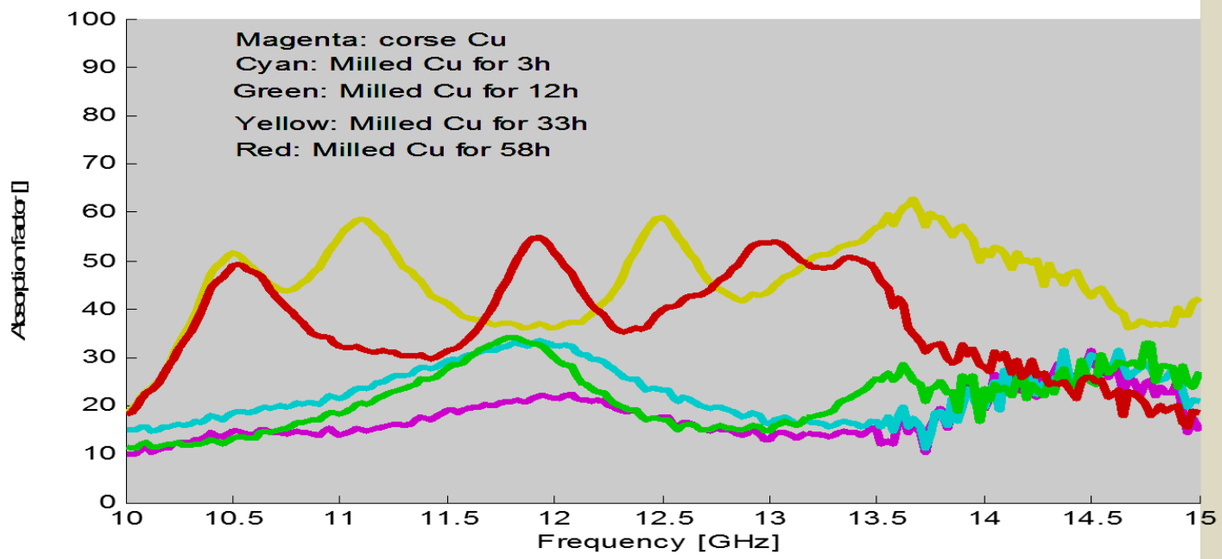
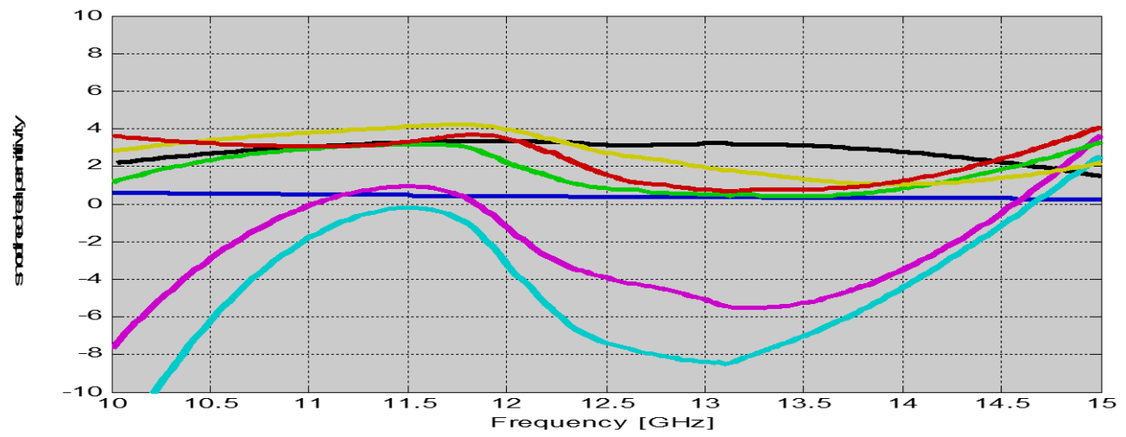


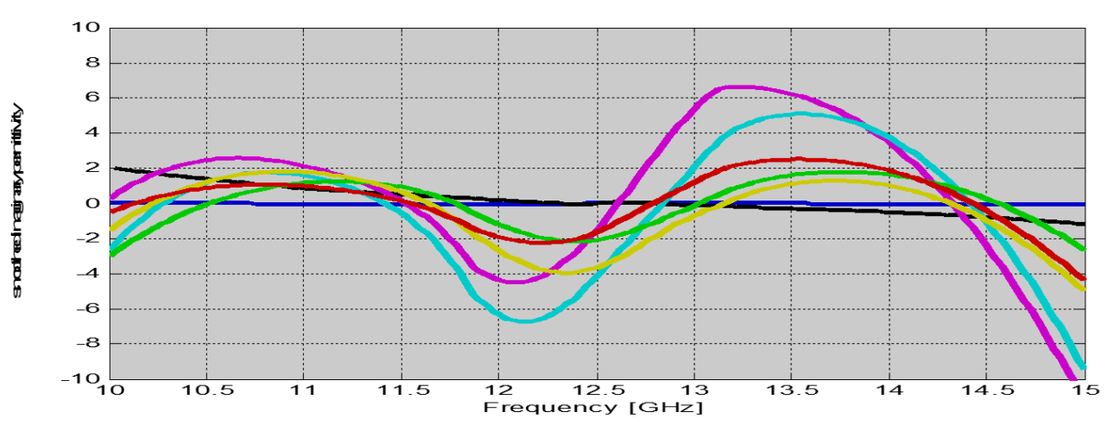
Figure 3: XRD Spectra of coarse and milled Cu powders.

B. Microwave Characterization

Figure 4: Absorption factors of Cu based nanocomposites.







The computation of complex dielectric permittivity followed the noniterative approach proposed by A.H. Boughriet. Dielectric permittivity spectra exhibit the effect of the structural refinement and the resulting morphology on the microwave absorbing properties.

4. REFERENCES

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[1]University of Blida1, LSA, Institute of Aeronautics and space studies, Algeria.
[2]University Houari Boumedienne of Technology, LSGM, Bab-Ezzour, Algeria.

DSL152