METALIZATION AND MANUFACTURING METAMATERIALS WITH 3D PRINTING TECHNOLOGY FOR VACUUM ELECTRON DEVICES*

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The design and fabrication of vacuum electron devices (VED) for high-power microwaves strongly depend on the manufacturing process. Due to the advance of additive manufacturing for 3D printers nowadays, it is possible to make devices with complex geometries using one machine only. The traditional manufacturing process in workshops is expensive because of many intermediate steps for fabrication, tools, and a significant amount of feedstock. The fabrication method based on the Fused Deposition Modeling (FDM) is the process that has presented the lowest cost to prototype from polymeric matrices.

This paper presents the process of manufacturing metamaterials through additive manufacturing with electroplating and sputtering metallization techniques. The figure 01 below illustrates the set of 02 complementary split-ring resonators for S band using a conductive polymer with resistances of 1.00 kΩ and 1.13 kΩ, respectively.

Figure 1- Split Rings printed with conductive material

Polymers with conductive properties are interesting to work as a seed layer in the material's metallization; however, high resistance and lack of material uniformity limit their application. Moreover, post-processing on the 3D printed material is necessary, and a conductive layer is applied. The results of this process and electroplating are in the figure 02.

Figure 2- Split rings printed and copper plated

After the metallization process, the initial surface resistance was reduced by up to 7E3 compared to the conductive polymer. The Sputtering process for 02 samples in figure 3 has a surface resistance of 0.2Ω and 0.68Ω, respectively. However, the deposition process was interrupted because of mechanical deformation that occurred in the samples.

Figure 3- Split rings printed copper plated with sputtering technique

The fabrication of split-ring resonators using 3D printers and metallization constitute an essential step in technological innovation for VED, allowing researchers to develop and manufacture complex geometries for metamaterials at a low cost quickly.