Modeling-Based Methodology for Electromagnetic Screening of Copper Foils for High-Frequency Applications

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SUMMARY

There is a need for ultra-low-loss materials in high-frequency electromagnetic design. Combining low electric loss and high reliability is a main obstacle in designing, due to the conflicting requirements on the foil's roughness (low and high respectively). Projects [1][2] study the correlation of the roughness to the loss, aiming for a compromise. The reports of [1] indicate a need for new, fast, and industrially-relevant techniques for screening copper foils in terms of their electromagnetic properties (surface resistance or effective conductivity). Preliminary results reported in [3] demonstrate that test-fixtures based on Ruby Dielectric Resonator (RuDR, Fig. 1) at microwaves, and plano-concave Fabry-Perot Open Resonator (pc-FPOR) at millimeter-waves, are promising candidates to respond to such industrial needs.

In the NEMO presentation, we will first focus on the RuDR technique, from the electromagnetic perspective. We will discuss the computational model of RuDR and explain why the Bodies-of-Revolution Finite-Difference Time-Domain (BoR FDTD) algorithm is the tool-of-choice for the RuDR design and for creating a data-base correlating the measured resonant frequencies and Q-Factors to copper foils' effective conductivity.

In the second part of the presentation, we will present recent experimental results of applying the 13 GHz RuDR, with the accompanying software, to the characterization of copper foils produced using standard manufacturing techniques at Circuit Foils Luxembourg. We shall demonstrate that the effective conductivity is practically independent of the foil thickness (for the considered thicknesses of 35 µm or 70 µm), when the thickness exceeds several times the penetration depths. We will also correlate the effective conductivity to several roughness parameters like Rz, Sz, Sdr (defined as in [5]) and while a negative exponential trend applies in all cases, the best correlation is observed with respect to Sdr (which is one of the roughness parameters stemming from non-contact optical measurements).

Fig. 1. RuDR test-fixture designed by EM modeling: ruby cylinder in the center, mounted with a Teflon ring (white) in a metallic enclosure. Copper foils will be placed as top and bottom of the resonator.

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