VO₂ thin films as electromagnetic shields with dynamic effectiveness

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Sensitive electronics must be protected from electromagnetic interferences such as those associated with high intensity radiated field (HIRF). This is currently achieved by plain electronic boards in a metallic enclosure that behaves as a Faraday cage. Indeed, most metals provide suitable levels of shielding effectiveness (SE) at microwaves because of their high electrical conductivity. Nevertheless, depending on the electromagnetic environment, a high level of SE is not always required, and can even be detrimental to the normal operation of some electronics. Moreover, in the absence of any surrounding HIRF sources, it is advantageous to keep the SE level as low as possible to prevent any electromagnetic self-perturbation of electronics that can arise in a high Q-factor metallic enclosure.

VO₂ is a good candidate to produce shields whose SE can dynamically be tuned as such material exhibits an insulator to metal transition (IMT) above 65°C [1]. The present study aims at controlling the SE level of a VO₂-based device through a heating/cooling process acting directly on the material electrical conductivity. A 725 nm-thick VO₂ film was deposited by RF magnetron sputtering on a 50 mm × 50 mm C-cut sapphire substrate, and then in-situ post-oxidized to get the required stoichiometry as shown by XRD analyses. The IMT thin film was also characterized using the standard four-point probe technique. It displayed a resistivity variation from 1.243 Ω.m at room temperature (25°C) to 3.078×10⁻⁵ Ω.m at 75°C. The SE of the sample was then measured using the nested reverberation chamber procedure (Fig. 1(a)), as detailed in [2]. The VO₂ shield exhibits a SE variation of more than 8 dB over the 2-34 GHz frequency range between the insulating and conducting states (Fig. 1(b)). To our knowledge, this sample constitutes the first example ever of an EM shield whose SE level can dynamically and reversibly be controlled. An analytical model previously developed was used to compare numerical simulations with SE measurements [3]. It predicts the trend of the shield behavior with a satisfying accuracy from the a priori knowledge of the reported resistivity in the conducting state.


Figure 1: Picture of the Shielding Effectiveness measurement setup (a); Shielding Effectiveness measurements of the VO₂ sample vs. frequency at 25°C and 75°C against numerical simulations (b)