
Additive Manufacturing of 2D material coated enclosure for EMI Shielding

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Electronic systems operating in high-reliability sectors such as telecommunications, aerospace, automotive, and defense are increasingly exposed to aggressive environmental conditions including humidity, particulate contamination, and electromagnetic interference (EMI) [1][2]. These stressors can lead to severe degradation in system performance, signal integrity, and long-term reliability. While traditional EMI shielding solutions rely heavily on metallic enclosures, their inherent limitations including excessive weight, susceptibility to corrosion, and limited design flexibility pose significant challenges for modern lightweight and miniaturized systems [1][3].

This research addresses these limitations by developing polymer-based EMI shielding enclosures using fused deposition modeling (FDM) combined with post-processed graphene coatings [4][5]. The objective is to fabricate lightweight, corrosion-resistant enclosures capable of achieving shielding effectiveness in the 60–80 dB range over X-band frequencies (8.2–12.4 GHz), while maintaining mechanical integrity and providing environmental sealing [1].

Four thermoplastic filaments, polylactic acid (PLA), polycarbonate (PC), carbon-fiber reinforced Onyx, and carbon-fiber reinforced polyether ether ketone (PEEK CF), were additively manufactured with varying thicknesses (1–5 mm) and two print orientations (horizontal and flat). These specimens were subjected to tensile testing, and their EMI shielding effectiveness (SE) was evaluated using a network analyzer [6]. Based on superior mechanical and electrical performance, Onyx and PEEK CF were selected for dip-coating using both commercial graphene dispersed in isopropanol (IPA) and a sustainable graphene ink synthesized in-house [4][7].

Characterization of the coated samples was carried out using scanning electron microscopy (SEM) to assess surface morphology and layer consistency, and Raman spectroscopy to confirm graphene quality, coating uniformity, and defect density. Results indicate that horizontally printed PEEK CF samples coated with graphene exhibited the highest EMI shielding, attributed to aligned conductive pathways and uniform coating coverage [7].

This study demonstrates that the integration of FDM with 2D graphene coatings enables the production of multifunctional enclosures with tailored electrical, mechanical, and environmental protection properties. The proposed approach offers a scalable and cost-effective alternative to conventional metal shielding, with promising applications in mission-critical embedded systems operating in harsh or electromagnetically noisy environments.

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