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Lightweight and Flexible Carbon Foam Composite for High-efficient Electromagnetic Interference Shielding

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Extended Abstract

In recent years, considerable attentions have been paid on the development of microwave shielding materials due to the increasing applications of electromagnetic radiation in military and telecommunications, as well as the potential hazardous effect on human health. Despite the tremendous push in the research for advancing microwave shielding materials, the achievements of critical physical properties including high shielding efficiency, light-weight, and flexibility in recently developed materials have remained to be technically challenging. To overcome those hurdles, porous materials engineered with the microcellular structure by the incorporation of nano-scale building blocks are specially designed for high performance microwave shielding. In contrast to impermeable shielding materials, porous materials provide the following competitive advantages: (i) reduction of total weight and cost, ii) high porosity and low density, (iii) strong microwave-absorbing ability, enhancing attenuation of incident microwaves by the multi-reflections on the numerous cell/wall interfaces within the three-dimensional (3D) architecture.

In this work, we develop a novel type of carbonized melamine foam (cMF) by integrative modification with Au nanoparticles, graphene (G), Fe3O4 (IO) and poly(dimethyl siloxane) (PDMS). Our main goal is to construct a lightweight and flexible cMF composite with precisely engineered 3D hierarchical architecture for high-efficiency electromagnetic interference (EMI) shielding (Fig. 1). Through the engineering of the typical closed-cell structure and synergistic effect of the multifunctional components, the resultant cMF-Au-G-IO/PDMS composite demonstrate superior physical properties including low density (116 mg/cm3), high conductivity (81.3 S/m), large specific surface area (m2/g), super-paramagnetism (Ms=22.6 emu/g), and moderate compressive strength (110 KPa), collectively leading to the significant attenuation effect towards EMI. The total EMI shielding effectiveness (SE) of cMF-Au-G-IO/PDMS film with the thickness of 2 mm was 30.5 dB in X band (8.2-12.4 GHz), which clearly matched the technical requirement of EMI shielding materials in most commercial and military applications. Interestingly, SE was further raised up to 52.5 dB when the film thickness increases to 10 mm. The electromagnetic wave absorption mechanism can be attributed to the simultaneously incorporation of dielectric loss and magnetic loss. Hence, we envision that this multifunctional cMF-based composite is a promising candidate for the most demanding requirement in EMI shielding.

Keywords: Carbonized Melamine Foam, Graphene, Fe3O4, Electromagnetic Interference Shielding.

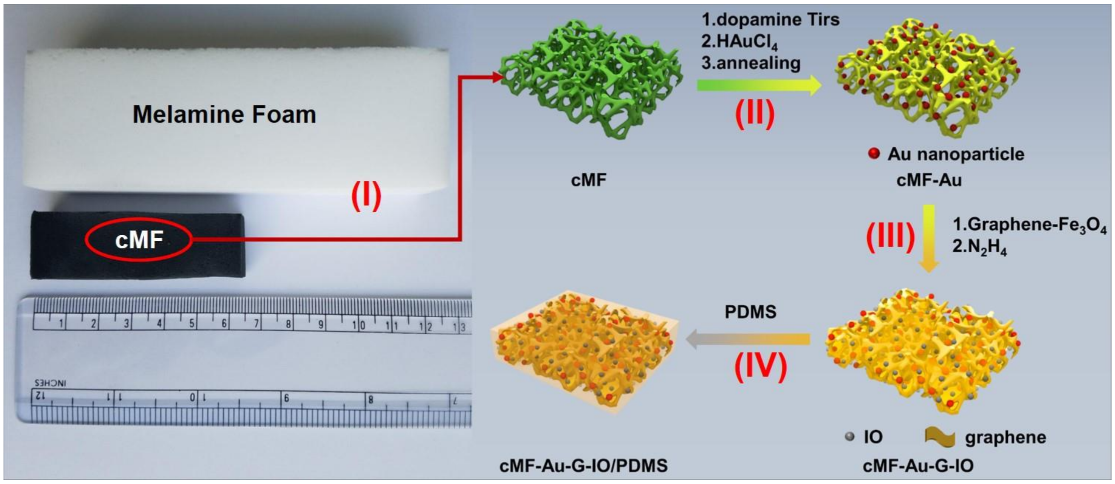

Fig. 1: Fabrication procedures for cMF-Au-G-IO/PDMS foam.