Contribution ID: **220** Type: **Oral Presentation**

Fabrication, Characterization, and Testing of Architected 3D Graphene Foams

Tuesday, 31 May 2022 14:50 (15 minutes)

Three-dimensional (3D) porous structures fabricated from a 2D material such as graphene have recently attracted huge attention owing to the outstanding electro-mechanical and thermal properties of various types of 2D materials. The interest has expanded to integrate the 2D materials into 3D printed structures to form an architected multifunctional foam. Several studies have focused on fabricating 3D porous structures from 2D materials using different techniques. Most of the existing fabrication techniques are often time-consuming and require specialized equipment. In this work, a practical and scalable self-assembly hydrothermal-assisted dip-coating technique has been employed to fabricate architected graphene foams. The graphene is coated on a 3D printed polymeric scaffold that takes the topology of the mathematically-known triply periodic minimal surfaces (TPMS). Then, the initial scaffold is removed by thermal etching to produce the freestanding graphene foam. Three different TPMS topologies (Gyroid, IWP, and Diamond) have been used in fabricating graphene foams. Different characterization techniques such as x-ray diffraction (XRD) and Raman spectroscopy were utilized to verify the presence of graphene. Scanning electron microscopy (SEM) and micro-computed tomography (Micro-CT) scans were used to visualize the internal pore structure and study the difference in pore size between the original TPMS structure and the 3D graphene foam. A series of tests were performed to measure the multifunctional (electrical, thermal, mechanical) properties of the TPMS-based graphene foams. The graphene foam based on TPMS structure shows an excellent specific stiffness value of 32.04 kPa cm3 mg-1 for a sample with low density of 69.6 mg cm-3. The specific thermal and electrical conductivity values were recorded to be 0.025 W cm2 K-1 mg-1 and 1.077 S cm2 mg-1, respectively. The unique structure and its multifunctional properties show that these lightweight 3D graphene foams (3DGF) can be used in various applications including heat sinks, energy storage, and sensors.

Keywords—Graphene Foams; Triply Periodic Minimal Surfaces; Self-assembly; Dip-coating; 3D Printing; Multifunctional Properties.

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Participation

In person

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Session Classification: MS22

Track Classification: (MS22) Manufactured Porous Materials for Industrial Applications