Laser Propulsion of Three-Dimensional Graphene Structures For Space Applications

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Abstract

Advancements in space exploration enhance our understanding of the universe and drive cross-cutting technological innovation [1]. Photonic propulsion, using light's momentum to generate thrust, is a promising alternative to traditional systems [2]. It offers higher velocities, improved thrust-to-weight ratios, greater efficiency, reduced spacecraft mass by eliminating need for propellant, making it ideal for long-duration missions [3]. Recent studies highlight the potential of graphene & related materials (GRMs) for light propulsion due to their exceptional properties; graphene aerogels have low density (>0.16 mg/cm^3) [4], high electrical conductivity (>100 S/m) and a Young's modulus (>20 MPa) [5,6]. In this work we produce three-dimensional graphene structures using a novel intercalation, expansion, and liquid phase exfoliation technique. The study utilized directional freezing to optimize the microstructure and pore alignment of 3D graphene structures for laser propulsion applications, testing their application in simulated space environment in a state-of-the art setup. We tested a suspended graphene aerogel with a density of 0.16 g/cm^3, at a vacuum level of 2x10^{-5} torr and with laser power input of 7 watts. Graphene 3D structure deflected by 2.7 mm in the x- and 0.009 mm in the y-direction, as analyzed using Tracker video analysis software. Experiments controlled for laser wavelength at 422 nm and less than 1-second strike time revealed variations in propulsion characteristics based on density and vacuum environment. This study is the first to develop an innovative setup for intensively investigating graphene 3D structures' propulsion, advancing beyond previous research on reduced graphene oxide.

References

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Figures

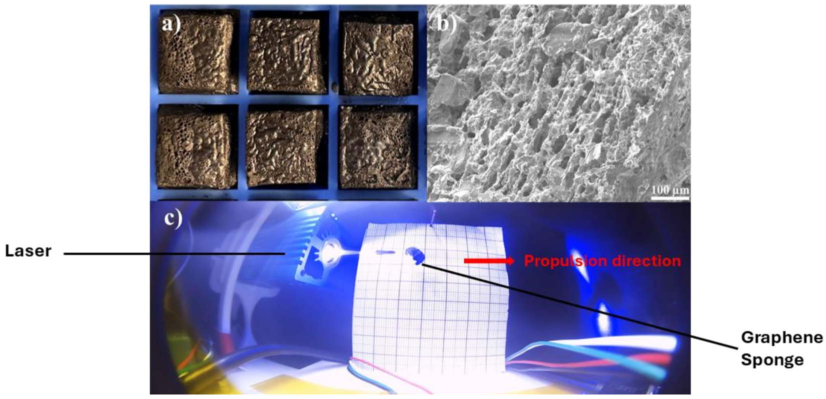

Figure 1: (a) Cubic Graphene Aerogels, (b) Aligned pores under SEM, (c) Laser Propulsion snapshot