Ultrafast lasers as an effective tool for miniaturized energy storages

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The energy scarcity to meet the demands of the technological advancements in the society like wearable and portable applications along with household requirements [1] enhances the requirement of self-powered and self-sustaining integrated systems. The necessity needs to be supported by an integrable high-performance energy storage in less footprints. Direct laser writing (DLW) is a cost-effective single-step technology for the fabrication of three-dimensional (3D) structures with submicron features sizes [2].

We have adopted the efficient use of femtosecond (fs) - lasers for the DLW fabrication of miniaturized micro-supercapacitors (MSCs) in 3D graphene oxide (GO) film prepared by the layer-by-layer assembly with a thickness of 42 µm, as shown in Fig. 1 [3]. We utilized the bioinspired fractal electrodes (BFE) designs for the MSCs [4], and the optimized conditions for the 3D BFE-MSC electrode fabrication have been obtained using the effective tuning of 3D GO film under controlled laser fluence, scanning speed and use of proper objective. In our studies, we used the ionic gel made of an ionic gel, made of mixing fused silica (0.7 nm in size) and 1-butyl-3-methyimidazolium bis (trifluoromethyl sulfonyl)imide (Sigma-Aldrich) in the ratio 0.03 g/1.0 g as the electrolyte.

The obtained miniaturized 3D BFE-MSC in an area of 1mm^2 performance with an electrode interdistance of 1 µm and thickness 23 µm was studied using the electrochemical measurements. Herein the formulas were given in the reference with the removal of capacitance effect from the gold pads and the GO film. Ragone plot (Fig. 1) compares the performance of this work with other existing miniaturized MSCs which utilizes the GO material along. The calculated energy storage density and power density for the 3D BFE-MSC from the cyclic voltammetry (CV) are equal to that Panasonic commercial lithium-ion batteries at lower scan rates with a power density improvement of an order of 10^1 compared to in-plane BFE-MSCs.

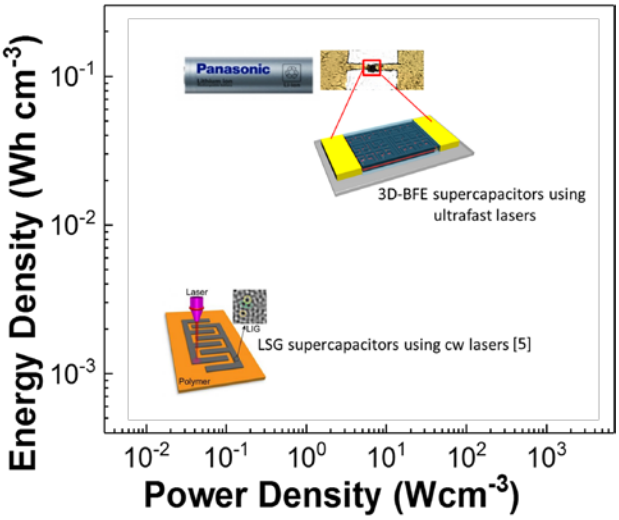

Figure 1: 3D BFE-MSC fabricated using the ultrafast lasers. Highlighted: Ragone plot to compare the performance of the 3D BFE-MSC with other energy storages. Image source:

References

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