Laser induced graphene for flexible hybrid energy harvesting and storage devices

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A major part of the increasing number of connected IoT devices is represented by large wireless sensor networks powered by disposable or rechargeable batteries which, despite being reliable power sources, have the need of be replaced/recharged. This could be a problem when devices are placed in remote and inaccessible places. In many of these applications, a hybrid technology able to harvest and store energy from ambient sources would represent a viable alternative to power low consuming IoT devices.

Substantial research has been carried out on hybrid solar harvesting and storage technologies and, in most of the cases, dye-sensitized solar cells (DSSC) were directly integrated with supercapacitors (SC) by sharing an electrode or the encapsulation material [1-2]. DSSC show a very high efficiency when employed under low-light illumination condition and indoor light sources [3-4]. Supercapacitors, despite having lower energy density than batteries, show much higher cycle life and a much lower sensibility to the intrinsic fluctuation of the photovoltaic energy which allows them to be directly integrated with photovoltaic harvesters without the need of an additional circuit [5].

Herein we present the possibility of fabricating a flexible hybrid energy harvesting and storage device by integrating a dye-sensitized solar cell and a laser induced graphene (LIG) micro-supercapacitor able to harvest and directly store energy both from natural solar light and from indoor light sources. Previous studies reported the possibility of using graphene as a catalytic material for the fabrication of the counter electrode for DSSC as a substitute to more expensive materials like platinum [6]. To the best of our knowledge, only one study reported the exploitation of laser induced graphene as a common material to be used both as a counter electrode for the DSSC and as a capacitive material for the SC, but a very low solar-to-energy conversion efficiency (<1%) was reported. Moreover, the LIG electrodes of the two devices were contacted by means of an FTO conductive glass losing the flexibility of LIG on polyimide [7]. We show the possibility of realizing a flexible counter electrode for DSSC by inducing the formation of porous graphene-like material on a polyimide (Kapton) substrate by irradiating with a CO2 pulsed laser working at 10.6 μm wavelength. The resulting electrode shows a high surface area and allows to have a much higher light-to-energy conversion efficiency with respect to the only previous work where LIG was employed. Moreover, thanks to the high catalytic area given by the porosity of the obtained LIG, it shows a comparable behavior when compared with a standard platinum coated, rigid FTO electrode.

The proposed results open the way to the possibility of realizing a flexible hybrid harvesting and storage device where a LIG electrode can simultaneously function as the counter electrode for a DSSC and as the capacitive material for an interdigitated micro-supercapacitor.

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