Laser-Induced Graphene: from physical sensing to electrochemical biosensors

Nuno F. Santos[1], Bohdan Kulyk[1], Sónia O. Pereira[1], Alexandre F. Carvalho[1], António J. S. Fernandes[1], Florinda M. Costa[1]

The ability to directly synthesize laser-induced graphene (LIG) on different carbon-containing flexible materials such as polyimide and paper (Fig. 1) opens the door to a wide range of potential applications, from consumer electronics to biomonitoring. LIG, with its foamy graphene structure having high specific area, is inexpensive, fast, and easy to produce when compared to many other forms of graphene. This way, electrically conductive paths can be promptly defined on insulating substrates by selective laser scribing.

Using this approach, several sensors employing LIG were developed (Figure 2). LIG scribed tracks defining electrical circuits on paper enabled the fabrication of strain and bending sensors based on the intrinsic piezo-resistive response of this exciting material, attaining a gauge factor of 42 for the former [1]. Also, LIG electrodes were fabricated and successfully used in electrochemical sensors to detect dopamine with excellent sensitivities, for both LIG produced with IR (10600 nm) and UV (355 nm) radiation [2]. Additionally, the electrochemistry of glucose oxidase adsorbed by LIG electrodes demonstrated its adequacy for glucose biosensors, taking advantage of LIG's superior electron transfer characteristics and high surface area [3].
These results open the door to novel applications in environmentally friendly, low-cost, flexible point-of-care sensing platforms for personalized medicine scenarios.

1 – Department of Physics & i3N, University of Aveiro

FIGURE 1
Schematic illustration and electron microscopy images depicting the conversion of polyimide and paper into laser-induced graphene (LIG).

FIGURE 2
Schematic illustration and response of different chemical and physical LIG sensors.

[1] Laser-Induced Graphene from Paper for Mechanical Sensing
B. Kulyk, B.F.R. Silva, A.F. Carvalho, S. Silvestre, A.J.S. Fernandes, R. Martins, E. Fortunato, and F. M. Costa
ACS Appl. Mater. Interfaces. (12 pgs) 2021.
https://dx.doi.org/10.1021/acsami.0c20270

[2] IR and UV Laser-Induced Graphene: Application as Dopamine Electrochemical Sensors
N.F. Santos, S.O. Pereira, A. Moreira, A.J.S. Fernandes, F.M. Costa
Advanced Materials Technologies, 2021, 6(6) (13 pgs) 2100007. https://doi.org/10.1002/admt.202100007

[3] Electrochemical response of glucose oxidase adsorbed on laser-induced Graphene.
S.O. Pereira, N.F. Santos, A.F. Carvalho, A.J.S. Fernandes, F.M. Costa
Nanomaterials, 11(8), 1893 (18 pgs) 2021.
https://doi.org/10.3390/nano11081893