Laser-Induced Graphene from lignocellulose – scaling, quality, cost and sustainability

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Abstract

Green printed electronics is an emerging research area focused on replacing strategic, critical, and toxic materials with non-toxic, biobased alternatives. This study explores the potential of laser-induced graphene derived from lignocellulose, specifically sourced from side streams within papermaking. The research evaluates precursor formulations, laser variables, structural and electrical performance, life cycle assessment (LCA), and techno-economic performance. Graphene, considered as a bulk material, was produced by applying lignin sulphonate, hydroxyethyl cellulose and boric acid as a coating on a PET substrate. The coating was heated with a CO_2 laser under ambient conditions, see Figure 1. The structure of the obtained graphene was analysed using Raman scattering and X-ray techniques, while its electrical conductivity was characterized using four-probe measurements. Combinations of laser scan speed and average laser power resulted in three distinctly different outcomes: (1) amorphous carbon with low conductivity (2) incineration and (3) graphitic carbon with high conductivity. The graphitic carbon in the form of cm-sized flakes was further exfoliated into an aqueous ink and printed as electrically conductive patterns on a substrate. The results corroborate previous work demonstrating record low sheet resistance compared to other printed carbons.[1]

The transdisciplinary approach, involving master students and senior supervisors from various complementary disciplines, proved effective in advancing knowledge in this field. The combined analysis from experimental, techno-economic, LCA, and structural characterization perspectives supports the potential industrialization of biobased laser-induced graphene for applications in medtech, IoT, and energy storage. This holistic evaluation highlights the importance of considering multiple perspectives to identify hotspots and focus further development efforts in promising innovative technologies.

References

[1] J. Edberg, R. Brooke, O. Hosseinaei, A. Fall, K. Wijeratne, and M. Sandberg, *npj Flex Electron*, vol. 4, no. 1 (2020), pp. 1–10.

Figures

Figure 1: Laser-induced graphene (black area) in a lignosulphonate, cellulose, boron nitride coating.