

Carbon Nanomaterials as Dielectric-Active Interfaces

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Abstract: Carbon nanomaterials have emerged as highly versatile interface components in electronic and photoelectrochemical (PEC) devices, where their role extends well beyond electrical conductivity. In this contribution, we show how graphene oxide, carbon nanodots, and graphitic carbon nitride act as dielectric-active interfacial materials, governing polarization phenomena, charge separation, and chaqJl extraction at semiconductor junctions. By tailoring surface chemistry, defect density, and nanostructure morphology, carbon nanostructures enable precise modulation of the local dielectric environment at carbon-semiconductor and electrode-electrolyte interfaces.

Focusing on hybrid systems based on metal oxides, polymer semiconductors, and two-dimensional materials, we demonstrate how carbon-derived interfaces influence interfacial electric fields and band alignment, thereby enhancing charge extraction and suppressing recombination pathways. The presentation further highlights water-based processing strategies for carbon nanomaterials, enabling the fabrication of sustainable dielectric thin-fihn interfaces with controlled microstructure and functional stability.

These results underline the importance of carbon nanomaterials as interfacial dielectric design elements, offering new opportunities for improving efficiency, durability, and scalability in photoelectrochemical energy conversion and advanced electronic devices

Keywords: Carbon Nanostructures, Dielectric Interfaces, Energy and Environmental Applications

References

1. Martinez-Baron, C., Garrido Zoido, J.M., Alvarez-Sanchez, M.A., Cintas, P., Palacios, J.C., Anson-Casaos, A., Gil, M.V., Benito, A.M., Maser, W.K.: Graphene Oxide -Enamino Xanthene Charge Transfer Hybrids as High-Performance Sensitizing Interface for TiO₂ Photoanodes. ACS Appl. Mater. Interfaces 2026. DOI: 10.1021/acsami.5c20186.
2. Galan, A., Galindo-Callen, J.G., Fernandez, I., Zaluzec, N.J., Cambre S., Arena!, R., Benito, A.M., Maser, W.K.: Fabrication of a-Fe₂O₃ Nanoparticles/g-C₃N₄ direct Z-Scheme heterojunction of durable photocatalytic activity. ACS Appl. Nano Mater. 8, 9364-9375 (2025)
3. Colom., E., Hernandez-Ferrer, J., GaJan, A., Navarro, M., Palacios-Lid6n, E., Colchero, J., Urbina, A., Arena!, R., Benito, A.M., Maser, W.K.: Graphene oxide: Key to efficient charge extraction and suppression of polaronic transport in poly(3-hexylthiophene) nanohybrids. OJ.em. Mater 35, 3522-3531 (2023)
4. Palacios-Lidon, E., Colchero, J., Ortuno, M., Colom, E., Benito, A.M., Maser, W.K., Somoza, A.: Nano scale charge density and dynamics in graphene oxide. ACS Mater. Lett. 3, 1826-1831, (2021)
5. Anson-Casaos, A., Hernandez-Ferrer, J., Vallan, L., Xie, H., Lira-Cantu, M., Benito, A.M., Maser, W.K.: Functionalised carbon dots on TiO₂ for perovskite photovoltaics and stable photoanodes for water splitting. Int. J. Hydrogen Energy 46, 12180-12191 (2021)
6. Victor-Roman, S., Garcia-Bordeje, E., Herruindez-Ferrer, J., Gonzalez-Dominguez, J.M., Anson-Casaos, A., Maser, W.K., Benito, A.M.: Controlling the surface chemistry of graphene oxide: Key towards highly efficient ZnO-GO photocatalysts. Catalysis Today 357, 350-360 (2020)