Inducing Conductivity into Parylene C by Vapor Phase Infiltration of In_2O_3

Oksana Yurkevich [a], Eugeny Modin [a], Iva Šarić [c], Robert Peter [c], Mladen Petravić [c], Mato Knez [ab]

[a] CIC nanoGUNE BRTA, Tolosa Hiribidea 76, Donostia-San Sebastián E-20018, Spain;
[b] IKERBASQUE, Basque Foundation for Science, Maria Diaz de Haro 3, Bilbao E-48013, Spain
[c] Department of Physics and Centre for Micro- and Nanosciences and Technologies University of Rijeka, Radmile Matejčić 2, 51000 Rijeka, Croatia

The development of material for future electronics does not only rely on increasing the computational efficiency, but also on including completely novel functionalities, such as foldability. Hybrid organic-inorganic materials are especially promising for this task as they may combine the properties of inorganics, such as electronic conductivity, with the flexibility of organic polymers.

A hybrid system, consisting of a semiconducting material blended with a polymer matrix, may be beneficial over conventional approaches that rely on coatings and well-defined interfaces between the two materials. Vapor phase infiltration (VPI) meets this challenge by allowing diffusion of a precursor into the bulk of a soft substrate. VPI on polymer substrates leads to the formation of a gradient hybrid layer with altering density and smooth transition from the bulk polymer to the inorganic thin film on the surface (Fig.1). This gradient layer can compensate mechanical stress and suppress crack formation upon bending, thus preventing the loss of electrical conductivity upon bending, folding, or stretching.

In this work, we developed a VPI process of indium oxide by exposure of parylene C to alternating pulses of trimethylindium and water precursors. Parylene C is a CVD-deposited polymer with high thermal tolerance. The infiltration process was performed in the temperature range from 130 to 210°C. Despite the film growth even at low temperatures, the sheet resistance of those structures remained high at 130°C. Substitution of the water with hydrogen peroxide allowed to decrease the sheet resistance value by five orders of magnitude and highlighted the importance of the oxygen source choice. For higher infiltration temperatures this difference decreased to one order of magnitude for water and H_2O_2 precursors. However, the precursor choice made a significant impact on the infiltration depth, chemical distribution of the elements, and crystallinity. Moreover, transmission electron microscopy showed that in the case of hydrogen peroxide, there is no thin inorganic film growing on top of the surface, but the whole surface remained hybrid. Such functionalization of the dielectric polymer with electronically conductive material is a promising approach for the development of novel foldable organic electronic devices.

This work is funded by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement №765378.

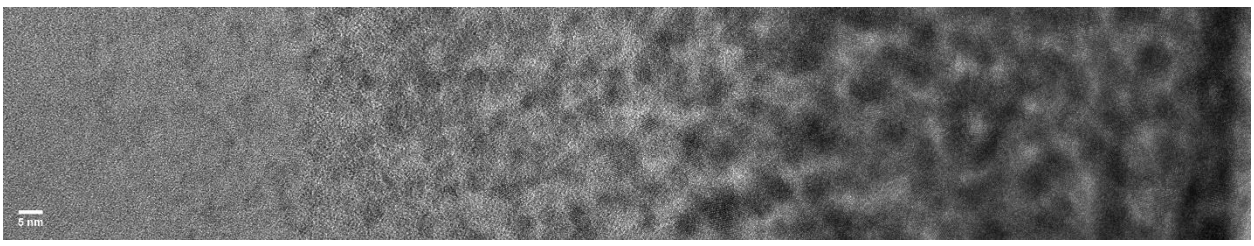

Fig.1. TEM micrograph of lamellae of paryleneC modified with indium oxide by VPI.