Flexible and Conductive Polymers through Hybridization with Inorganics obtained by Vapor Phase Infiltration

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Advances in thin film technology form the base for the development of flexible electronics. However, existent methodologies were developed for rigid substrates and implementing them into flexible and soft materials poses challenges. For example, the use of polymeric substrates significantly limits the processing temperature, as the maximum operating temperature is linked to the glass transition, melting or degradation temperatures of the polymers. Moreover, once conductive materials are deposited on a polymer, the integrity and the electrical conductivity of those films can easily be lost upon bending, folding or stretching.

The choice of the manufacturing method has a significant impact on the characteristics, yield and stability of the produced devices and therefore the selection of the most appropriate strategy is crucial. The present research proposes to exploit vapor phase infiltration (VPI) to meet this challenge. VPI is based on atomic layer deposition (ALD). However, in contrast to ALD, it not only allows surface reactions, but also diffusion of a precursor into the bulk of a soft substrate. This results in the alteration of the subsurface layer of a polymer and formation of organic-inorganic hybrid materials with added and/or improved functionality.

The main advantage of this approach is the formation of a gradient hybrid layer with altered density and smooth transition from the bulk polymer to the metal oxide thin film on the surface (Fig. 1). This organic-inorganic layer can compensate mechanical stress and suppress crack formation upon bending, thus assisting in preservation of the electronic conductivity in case of mechanical treatment.

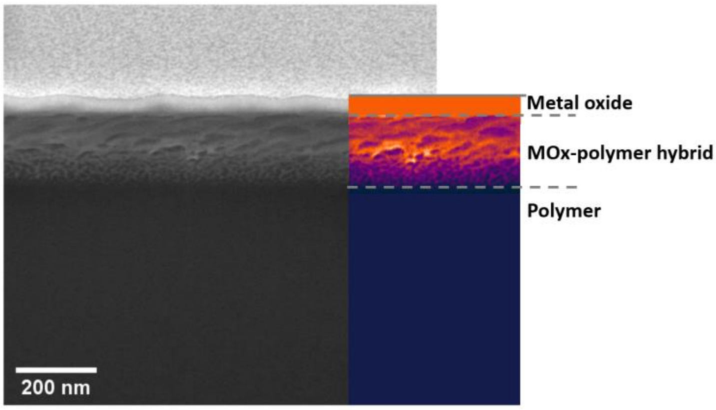

Fig.1. SEM micrograph of cross-section of PEN polymer modified with VPI of alumina oxide.

There are several conductive and transparent metal oxides that allow for low temperature VPI processing, including Al-doped ZnO, In_2O_3 or In-doped SnO_2 (ITO). In this presentation, our approach towards integrating such electronic properties into intrinsically non-conductive polymeric substrates by VPI will be shown. VPI is upscalable and applicable to a large variety of technical and cheap substrates, like polyethylene terephthalate (PET) or polyethylene naphthalate (PEN), which makes this method a promising tool for a boost of flexible electronics development.

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