The influence of morphology on the optical properties of PEDOT:PSS thin solid films - insight from spectroscopic ellipsometry studies

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It became well known that microstructure, particular molecular conformations, or more generally, morphology of the active organic layers formed of conjugated polymers influence strongly their optoelectronic properties [1]. PEDOT (poly(3,4-ethylenedioxythiophene)) is one of important members of this family of conjugated polymers known for its good electrical conductivity. However, PEDOT as poorly soluble polymer is difficult in application for optoelectronic devices fabrication. For this reasons, aqueous dispersion of PEDOT with the polyelectrolyte poly(4-styrenesulfonate) (PSS) has been evolved. For example, thin solid films of PEDOT:PSS are commonly used as auxiliary layers or even as transparent electrode in optoelectronic devices, especially in organic photovoltaic cells. As follows from literature, morphology of PEDOT:PSS thin films prepared from solutions can be modified by deposition technics [2], applying diverse chemical additives to the dispersion [3], as well as, by applying diverse post-deposition physical processes [4].

It has been demonstrated that spectroscopic ellipsometry is an accurate and sensitive tool to study influence of morphology on the optical properties of thin polymer films. Importantly, such characterization of the optical properties of PEDOT:PSS thin films is consistent with the conductivity values determined from electrical measurements [5]. In this work, we report results from spectroscopic ellipsometry studies on series of PEDOT:PSS thin films undergo to the morphology modification. Our main purpose is to analyze consequently the results within the uniaxial anisotropic optical model of PEDOT:PSS. For this reason, we developed a consisted description based on the effective medium approximation in order to accounts for PSS contribution within the Tauc-Lonentz optical model and for PEDOT part within the Drude-Lorentz model. Generally, in our description the samples with improved electrical conductivity are characterized by the increased relaxation time of the free carriers.

[1] Ioan Botiz and Natalie Stingelin, *Materials* **7**, 2273 (2014).
[2] Stergios Logothetidis, et al., *Solar Energy Materials & Solar Cells* **112**, 144 (2013).
[3] O.P. Dimitriev, Synthetic Metals **159**, 2237 (2009).
[4]S.A. Rutledge and A.S. Helmy, *Journal of Applied Physics* **114**, 133708 (2013).
[5] J. Gąsiorowski, et al., *Thin Solid Films* **536,** 211 (2013).

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