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

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The low band gap organic semiconductor poly(3,4-ethylenedioxythiophene) (PEDOT) doped with poly(4-styrenesulfonate) (PSS) found many different practical applications in organic optoelectronics [1]. Success of this material reflects also its wide commercial availability in the form of water colloidal dispersion with different PEDOT to PSS ratios. It is well known, that electrical conductivity of PEDOT:PSS thin solid films depend primary on the content of conductive PEDOT. Whereas, PSS acts as doping agent and enables hydration in the form of colloidal dispersion, but simultaneously significantly lowers electrical conductivity of the PEDOT:PSS system. It has been demonstrated, see e.g. Ref. [2], that the spectroscopic ellipsometric characterization of the optical properties of PEDOT:PSS thin films is consistent with the electrical conductivity values. This feature makes ellipsometry especially useful as nondestructive experimental technic in studies on PEDOT:PSS thin layers.

The uniaxial optical anisotropy in thin solid films of PEDOT:PSS has been identified by Pettersson et al. using multi sample and variable angle spectroscopic ellipsometric data analysis [3]. The authors used wavelength-by-wavelength fit procedure in order to determine reflection indexes and extinction coefficients. Recently, the isotropic Drude-Lorentz optical model was applied in description of ellipsometric data of PEDOT:PSS films [2,4]. In this work, we study details of the influence of the PEDOT to PSS ratio on the optical properties of PEDOT:PSS thin solid films using spectroscopic ellipsometry. Samples were prepared from commercially available aqueous dispersions with different PEDOT to PSS ratio by the spin coating technic. The emphasis is put on studies of the relation between the content of PEDOT and optical anisotropy of PEDOT:PSS films. For this reason, the limiting cases i.e. thin solid films of pure PEDOT and pure PSS are also studied. In our ellipsometric data analysis, 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. It appears, that the birefringence in studied PEDOT:PSS thin solid films is positive. For long wavelengths a systematic decrease of the real part of the ordinary component of dielectric function is observed for increasing content of PEDOT.

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Work supported by the NCN grant (Poland) No. DEC-2013/09/B/ST8/01629.