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Blade-Coating Deposition of Semiconducting Polymer Thin Films: Light-To-Heat Converters

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Abstract : Poly(3,4-ethylene dioxythiophene) polystyrene sulfonate (PEDOT: PSS), is a polymer mixture well-known for its semiconducting properties and is widely used in the coating industry for its visible transparency and high electronic conductivity (up to 4600 S/cm) as a transparent non-metallic electrode and in organic light-emitting diodes (OLED). It also possesses strong absorption properties in the Near Infra-Red (NIR) range (λ ranging between 900 nm to 2.5 µm). In the present work, we take advantage of this absorption to explore its potential use as a transparent light-to-heat converter. PEDOT: PSS aqueous dispersions are deposited onto a glass substrate using a blade-coating technique in order to produce uniform coatings with controlled thicknesses ranging in ≈ 400 nm to 2 µm. Blade-coating technique allows us good control of the deposit thickness and uniformity by the tuning of several experimental conditions (blade velocity, evaporation rate, temperature, etc...). This liquid coating technique is a well-known, non-expensive technique to realize thin film coatings on various substrates. For coatings on glass substrates destined to solar insulation applications, the ideal coating would be made of a material able to transmit all the visible range while reflecting the NIR range perfectly, but materials possessing similar properties still have unsatisfactory opacity in the visible too (for example, titanium dioxide nanoparticles). NIR absorbing thin films is a more realistic alternative for such an application. Under solar illumination, PEDOT: PSS thin films heat up due to absorption of NIR light and thus act as planar heaters while maintaining good transparency in the visible range. Whereas they screen some NIR radiation, they also generate heat which is then conducted into the substrate that re-emits this energy by thermal emission in every direction. In order to quantify the heating power of these coatings, a sample (coating on glass) is placed in a black enclosure and illuminated with a solar simulator, a lamp emitting a calibrated radiation very similar to the solar spectrum. The temperature of the rear face of the substrate is measured in real-time using thermocouples and a black-painted Peltier sensor measures the total entering flux (sum of transmitted and re-emitted fluxes). The heating power density of the thin films is estimated from a model of the thin film/glass substrate describing the system, and we estimate the Solar Heat Gain Coefficient (SHGC) to quantify the light-to-heat conversion efficiency of such systems. Eventually, the effect of additives such as dimethyl sulfoxide (DMSO) or optical scatterers (particles) on the performances are also studied, as the first one can alter the IR absorption properties of PEDOT: PSS drastically and the second one can increase the apparent optical path of light within the thin film material.

Keywords : PEDOT: PSS, blade-coating, heat, thin-film, Solar spectrum
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