Abstract

Crystalline organic semiconducting monolayer materials ensure a brilliant future for flexible ultrathin organic electronics as they combine efficient charge transport and promising luminescence properties. In particular, they can be used for manufacturing low-cost optoelectronic devices with unique characteristics such as light weight, high flexibility, high tunability and good adaptivity.

One of the greatest electrical performance has the devices based on organic single crystals prepared by 2D self-assembled technique. Monolayers produced by this method have electrical mobility values of the order of 1-10 $cm^2V^{-1}s^{-1}$, which exceeds the mobility of amorphous silicon. However, during the preparation, the substrate covers with many chaotically oriented separate single-crystals with a relatively small size regularly less than 1mm. Usually, the electrical properties of organic crystals are significantly anisotropic. Hence this, manufacturing of the devices with uniformal electrical properties remains an essential challenge.

To probe the monolayer domain structure with a spatial resolution less than 1µm Raman microscopy can serve as a useful tool. Due to the Raman anisotropy effect, one can distinguish differently oriented domains proving the crystallinity of the sample.

In this work, we report Raman study of 1,4-bis(5'-hexyl-[2,2'-bithiophen]-5-yl) benzene (TTPTT-Hex-TTPTT) thiophene-phenylene co-oligomer semiconducting thin-film. To choose the optimal Raman intensities for Raman mapping we performed DFT (density functional theory) analysis of Raman anisotropy effect via GAMESS. With this we have found strong dependence of 1450 cm^{-1} and 1475 cm^{-1} peaks relative intensity on molecular orientation in crystal. Raman mapping for dHex-TTPTT thin-film shows great agreement with theory, demonstrating similar 1450 cm^{-1} and 1475 cm^{-1} lines behavior in different sections of the film. The Raman anisotropy effect between adjacent areas of the film in accordance with polarized optical(C-DIC) and atomic force microscopies (AFM) allowed us to prove crystalline structure of the material. Furthermore, using Raman mapping and AFM we have found presence of the non-crystalized film molecules between crystallites. This residual substance can be essentially important for final device manufacturing causing electrical leakage.