Carbon Nanotube-Conductive Polymer Composite Electrode for Transparent Polymer Light Emitting Device Application

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Organic light emitting materials have attracted increasing interest in the past two decades.[1,2] Soluble light emitting polymers are even more appealing for manufacture of large area, low cost light emitting devices.[3] In recent years, screen and inkjet printing have been successfully applied to this area, promising lower cost for area lighting, patterning and display applications.[4,5] In order to achieve low cost and high efficiency, it is crucial to have an air stable cathode with efficient electron injection properties.

Single wall carbon nanotubes (SWNT) have been demonstrated to be viable as electron injection material for application in OLEDs.[6-8] Poly(2,7-9,9-(di(oxy-2,5,8-trioxadecane))fluorene) (PFO) (**Figure 1**) conductive polymer was used as surfactant to stabilize the SWNT dispersions in organic solutions at 0.02% (by weight) concentration level.[9] The thin film cast from the PFO/SWNT/chlorobenzene solution is very uniform.

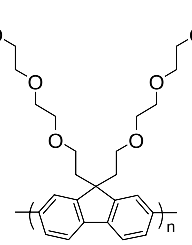

Figure 1. Molecular structure of surfactant poly(2,7-9,9-(di(oxy-2,5,8-trioxadecane))fluorene) (PFO).

The intimate interaction between the polymer and nanotube can be seen in TEM images of the thin film in **Figure 2**. Those images were taken at the edge of the PFO/SWNT composite material, where the material is thin enough to be observed. The upper right insertion shows a SWNT embedded in PFO; the main picture is at a protruding SWNT tube coated with PFO; and the left right insertion image is a enlarge of the back ground picture at the tip of the composite where SWNT is clearly visible through a layer of polymer coating.

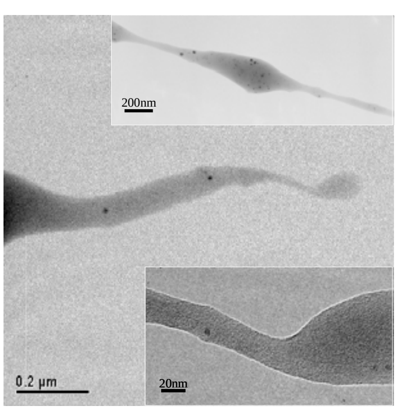

Figure 2. TEM image of PFO and SWNT composite material.

When 0.1% SWNT presents in PFO, the conductivity of the composite material is improved 6 orders of magnitude compare to pure PFO conductive polymer. **Figure 3** shows the conductivity of a PFO polymer and a 0.1% SWNT in PFO composite polymer film. The conductivity was measured using ITO/PFO (and SWNT)/Ag devices. The voltage bias was set with ITO as cathode and Ag as anode. At this reversed voltage bias from 0 – 4 V, the conductivity of PFO is only around 10^{-13}S/cm, whereas the 0.1% SWNT in PFO starts from 4×10^{-7} S/cm and increasing with voltage. At the low voltage bias (< 2 V), the SWNT provides the bulk conductivity. The gradually increase of conductivity happens at around 2.5 V, which may correlate to the charge injection from the SWNT to the PFO conductivity polymer.

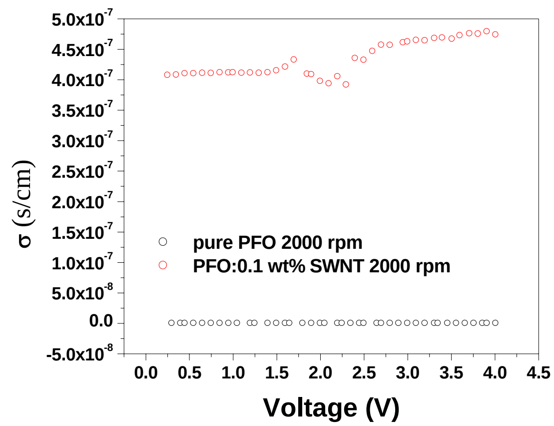

Figure 3. Conductivity of pure PFO polymer and PFO/SWNT composite film.

The transmittances of PFO and the composite film were measured at visible wavelength and compared with that of ITO film in **Figure 4**. The dip in transmittance at 400 nm is due to the absorption of PFO polymer. The SWNT/PFO film has around 10% absorption across the visible wavelength compare to pure PFO polymer. Transmittance of the SWNT/PFO is equivalent to that of the ITO film.

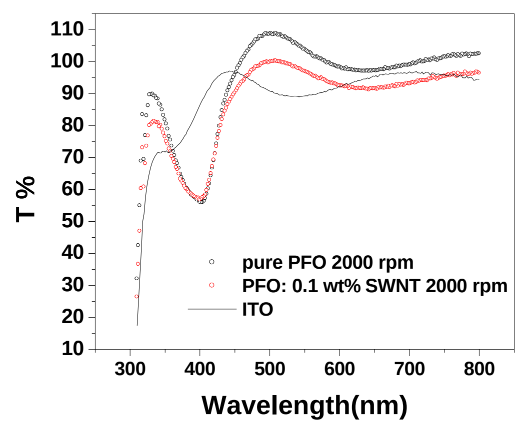

Figure 4. Transmittance properties of the SWNT/PFO thin film.

An amphiphlic conductive polymer was developed to effectively disperse SWNT in the solution phase. The polymer and SWCN composite electrode is solvent processible and readily applied onto the light emitting material using printing or other solvent-casting techniques. Conductivity of SWNT composites was improved significantly compared with conductive polymer host, while still preserving good light transmittance property of the host polymer. The conductivity of SWNT composites depends on the efficient dispersion of the SWNTs in a polymer matrix. Although the conductivity of the SWNT/PFO are still lower than the ITO thin film, further optimization on improving SWNT dispersion, and SWNT modification and purification can significantly improve the conductivity.

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