Low-cost flexible solar cells

Very low-cost thin-film solar cells manufactured with roll-to-roll coating have the potential to make solar energy a cost-competitive energy source. We have identified one specific part of thin-film solar cells where improvement is feasible— that of the transparent conductive electrode. We are working to investigate whether carbon nanotube (CNT) films can be made into transparent conductors that are compatible with low-temperature, ambient pressure, and ultimately, low-cost based solar cell production techniques.

A New Thin-Film Compatible Transparent Conductor: CNT-Networks

A critical element of most thin film solar cells is the transparent electrode layer. This layer must transmit light while simultaneously providing a low-resistance path for electrical current to flow out of the solar cell. The current material of choice for organic thin-film solar cells is indium tin-oxide (ITO), a material with many shortcomings. CNT films could replace ITO.

- Solution processable
- High-quality ITO must be sputtered, annealed.
- High pressure raw materials
- Indium is scarce, expensive, (good ITO ~$100/m2)
- High flexibility
- Relatively brittle
- Excellent adhesion
- Delamination problems
- Material ~$0.75/m2 and falling
- Material ~$1.00/m2 and rising

Current ITO film price range: ~$200/m2

AFM topographical images of printed CNT films a) bare and b) after spin coating with conductive polymer, PEDOT:PSS. Addition of PEDOT:PSS smoothed nanotube film and lowered resistance by 20% from 200 Ω/□.

CNT-films perform similarly to ITO based cells

Expected performance:
- Current density: 7.8 mA/cm2
- Open circuit voltage: 605 mV
- Fill factor: 0.61

Current CNT-film performance: sufficient for small, lab-demonstration cells, but performance breakthroughs towards theoretical limits will enable very low-cost thin-film cells.

Future Work

- Demonstrated CNT-Film Electrodes in organic solar cells
- Developed SPM imaging setup and technique, and performed preliminary measurements on test films
- Found surprising answer to question of what limits CNT-film performance: a series of critical high-phonon-electron scattering points, potential future work: to add spatial information to our understanding of the performance of these CNT-films.

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