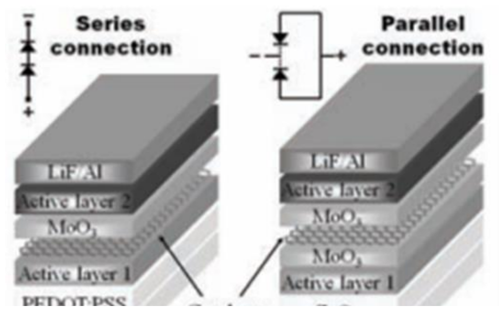
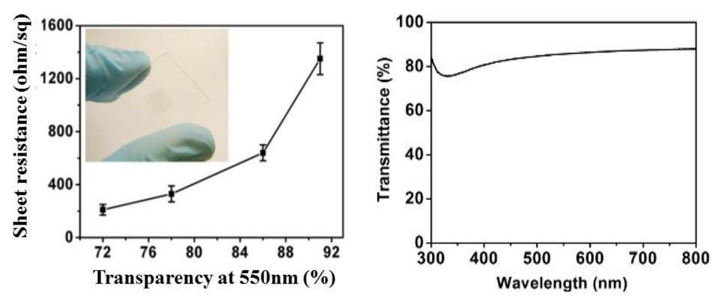
Joint Development Opportunity

Graphene as Intermediate Layer in Tandem Solar Cell



Schematic diagram of structures of photovoltaic devices: series and parallel arrangements

Ref: S. W. Tong, Y. Wang, Y. Zheng, M.-F. Ng and K. P. Loh. *Adv. Funct. Mater.* 2011. **21**. 4430-4435



(a) High optical transparency at close to 90% with sheet resistance of 1350 ohm/□; (b) around 80% transmittance across 300 to 800 nm wavelengths

Technology Background

The stimulus for this invention is to find an organic material-based solar cell that is a low-cost, flexible, low-energy consuming, produced with high-throughput processing technologies, aesthetically pleasing with broad versatility in terms of applications. The proposed tandem solar cell is a viable alternative to inorganic solar cells as well as polymer or fullerene based bulk-heterojunction (BHJ) polymer solar cells.

The tandem solar cell inventions are made of two or more single photoactive cells arranged in series or in parallel with graphene as an interlayer. This tandem arrangement boosts efficiency to 15% compared with a maximum of 10% for single BHJ solar cells which have high optical bandgaps that results in inefficient absorption of solar irradiation. The commercial use of transparent conductive oxides, e.g. ITO and conductive metallic thin films like gold or aluminium silver (Al/Ag) as the intermediate layer (IML), suffers from solar cell-damaging film deposition process and low transparency (less than 60%) respectively.

Performance

Source	Open circuit voltage, V_{oc} (V)	Short circuit current density, J_{sc} (mA cm^{-2})	Fill factor	Power conversion efficiency (%)
Invention *(lab conditions)*	**1.08**	**4.8**	**0.48**	**2.9**

Application Areas

- Tandem light emitting diodes, e.g. organic LEDs, infrared LEDs or near IR LEDs;
- Capacitors, batteries;
- Flexible photovoltaic cell devices;
- Portable sources of electricity (in form of chargers) for electronic devices like mobile phones, digital cameras, handheld computer games, and notebooks

Benefits Offered

- Low sheet resistance facilitates effective collection of charge carriers;
- Tunable work function (between 3 eV and 5.5 eV) of pristine/doped/functionalized graphene IML that makes matching with various energy levels of the photoactive layers easy;
- Improved solar cell efficiency with the tunable feature of the tandem cell;
- Graphene layer may be a recombination contact zone for electrons and holes from the subcells (photoactive layers), to prevent the buildup of charges and maximise the open circuit voltage;
- Increased capability for manufacturing of solar cells through simplified process;
- Different variants of graphene can also be deployed, e.g. doping with conductivity-enhancing compound like HCl and HNO_3 as well as functionalization of the graphene with modifying layers like nanostructured polymers, MoO_3, V_2O_5 and WO_3 to improve energy level alignment and interfacial morphology;
- Compact design using stacking of photoactive subcells supported by strong graphene layer.

Solutions to Problems

- High optical transparency of graphene intermediate layer (> 80% at 550 nm) captures maximum amount of photons from incident sunlight compared with conductive metallic thin films;
- Use of single graphene substrate compared to separate substrates for conductive metallic thin films;
- Achieves high solar conversion efficiency without the complex manufacturing process issues.

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