# Optical and Electrical modeling of Thin Film Organic Solar Cells for efficient solar Spectrum harvesting

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Photovoltaic (or solar cell) has been an active area for research and development, driven by the world's constantly increasing needs for power. Our planet receives 160,000TW solar energy, while the present global energy demand is about 16TW. While the solar resource is virtually unlimited, conversion of solar energy to readily usable form is too expensive to be commercially successful at present. Among the current solar technologies, thin film solar cell promises lower cost, but at the expense of lower power conversion efficiency Furthermore, reliable solar technology has to be complemented by energy storage system to accommodate the daily and seasonal variations in the solar radiation. From this perspective, many countries have formulated their long term solar energy utilization roadmap. For instance, the Japanese roadmap includes development of solar photovoltaic at competitive price by 2030. Large demonstrative projects (~MW) are underway in USA, Australia, and in several European countries.

Being a developing country with a huge burden of fuel import, the need of solar energy research and development in India cannot be over-emphasized. The geographical location of India is also quite favorable for solar energy implementation. However, a densely-populated country like India, with a fragmented electricity market, poses endless challenges to the scientists and entrepreneurs. The nature of Indian electricity market is quite unique, and cannot be compared directly with other countries. Unlike USA or Japan, India has *numerous villages and islands unconnected from the main grid,* spatial and seasonal variation in agricultural demand, and cottage- to large-scale industrial sectors. Our country, therefore, requires solar energy development at different scales such as, small (~W) to large (~MW), grid-connected to islanded, supplemented with some energy-storage to no-storage capabilities. Also important is the hybridization of solar energy with other renewable sources. Considering this socio-economic scenario, the present state of solar energy technology in India stands far from being adequate, but several initiatives are being planned. On 30th June 2008 the Prime minister of India, Dr.Manmohan Singh, announced the National Plan for Climate Change. This includes a National Solar Mission to "significantly

increase the share of solar energy in the total energy resources while recognizing the need to expand the scope of other renewable and non-fossil options such as nuclear energy, wind energy, and biomass”. The departments of Science and Technology (DST) and the ministry for New and Renewable Energy
(MNRE) have taken initiatives to promote formation of networks of premier research institutes to work on solar power generation related projects.

Polymer-based organic photovoltaic systems hold the promise for a cost-effective, lightweight solar energy conversion platform, which could benefit from simple solution processing of the active layer. The function of such excitonic solar cells is based on photoinduced electron transfer from a donor to an acceptor. Fullerenes have become the ubiquitous acceptors because of their high electron affinity and ability to transport charge effectively. Organic solar cells have the potential to be low-cost and efficient solar energy converters, with a promising energy balance. They are made of carbon-based semiconductors, which exhibit favourable light absorption and charge generation properties, and can be manufactured by low temperature processes such as printing from solvent-based inks, which are compatible with flexible plastic substrates or even paper

Organic Solar cell (OPV) using with conjugated polymer donor and fullerene acceptor, has rapidly been developed for recent years. The most effective solar cells have been made from bicontinuous polymer–fullerene composites, or so-called bulk heterojunctions. The best solar cells currently achieve an efficiency of about 5%, thus significant advances in the fundamental understanding of the complex interplay between the active layer morphology and electronic properties are required if this technology is to find viable application.

It is surely one of the alternatives with high potential in the future field of PV. The unit cell with photoactive materials that were recently developed has more than 8% efficiency, commercializing in a short time. Of course, the large-sized module applied with flexible substrate still has low efficiency but is rapidly being improved by developing sequence printing technology. Many are increasingly in expectation of commercialization.

The project proposal aims at increasing the energy conversion efficiency of organic photovoltaic devices as well as improving the stability of their nanomorphology. Progress on both fronts would allow envisaging outdoor large-scale application of these nanostructured PV-devices. The approach to improve the performance of these devices relies essentially on more efficient energy harvesting from the solar spectrum. Efficient spectrum harvesting will be based on the introduction of novel concepts. The voltage losses due to exciton dissociation will be reduced by the introduction of novel polymers with increased permittivity or by the introduction of nanoparticles resulting in an increased dielectric constant. The spectral absorbance of the organic solar cells will be widened by the development of organic multijunction approaches

**Objectives:**

1. To develop CAD tools required for design and simulation of Organic Solar Cell

2. Study of Optical & Electrical model of organic solar cell and Prepare Code for Optical & Electrical Model.
3. Study of Exciton Dynamics for Organic Photovoltaic.
4. To study basic processes and mechanisms in organic semiconductors specific to their application in optoelectronic devices.

The primary goal of our research group is to apply ideas and techniques from nanoscale optics to making solar cells better and cheaper, from a fundamental physical perspective. This entails understanding and developing physical models of absorption enhancement in thin solar cells, and using them to design optically nanostructured solar cell layers that are much better absorbers of light.

We use a rigorous electromagnetic approach (RCWA) to analyze the fundamental limit of light-trapping enhancement in grating structures and observed 2D gratings provide more enhancement than 1D gratings. We started RCWA simulation with GSOLVER /GDCalc and now developing our own simulator.