Relevant results obtained by MIT within the Solar Frontiers Program – 2008 - 2009

Current photovoltaic modules are rigid glass sheets encapsulating otherwise brittle silicon wafer based solar cells, with a supporting aluminum frame which adds to the energy pay-back time and to the weight of the device.

This kind of structure, although reliable and suitable for outdoor exposure for more than 25 years, has little chance to allow full competition with conventional energy sources, and has a fairly limited possibility of application – mostly retrofits on buildings or vast, land consuming ground-based installations.

Next generation of photovoltaic devices will be characterized by a number of innovations which include:

- the use of less expensive photoactive materials in thin layers - such as polymers and nano-structured materials
- low cost processing techniques closer to common printing than to the sophisticated semiconductor derived processes used today
- the use of different packaging materials, such as flexible plastic sheets, or even paper or tissues, which open the door to a wide variety of applications which are not imaginable today – such as lightweight, flexible devices which can easily be installed on non flat surfaces, in different shapes and dimensions.

Some of the most remarkable results obtained so far by the MIT teams at work in the Eni-MIT Solar Frontiers Centre include devices realized with new materials and completely new – and largely unexplored - application potential.

The following provides some insight on the most promising and innovative results.

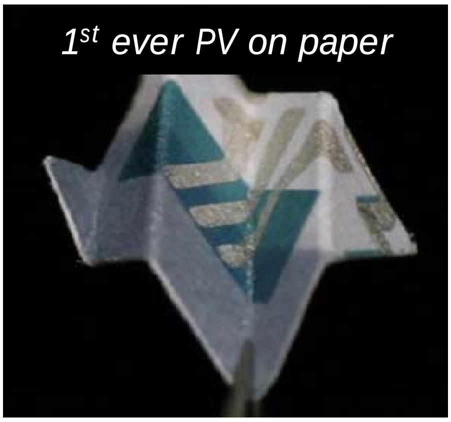
1. ***Ultra-flexible solar cell***. It is the first prototype of this sort realized at MIT, consisting of a thin layer of photoactive material coated on a transparent plastic sheet with an innovative, potentially inexpensive, low temperature realization method.

The cells can be bent without cracking or losing performance, which implies the potential for covering uneven surfaces without the need for bulky supporting metal frames and structures, and also reducing the weight constraint for covering e.g. tensile structures, greenhouses, noise-barriers on highways, boats, and a number of applications inside buildings. However the device performance and durability are still limited and this is the challenge MIT researchers will have to face in the coming period.

2. Solar cell on paper. It is the first time ever that a working device has been realized on paper, just like you would print a document. The innovative technique used to realize the device is the same able to produce cells on plastic, flexible substrates.

A "paper cell" may be the ultimate low cost solution for applications in which duration is not necessarily key, and where easy to transport, quick to set up power devices are needed – that is, for instance, in an increasing number of applications when traveling.

One could imagine folding a solar panel in an envelope, slip it in a brief case, and unfolding it to power a light weight laptop - no need for heavy cumbersome untidy cables or plug adapters in different countries. Of course this is still in the future, but although the device are still quite a way from being close to commercial, as they still need to optimize performance, this first prototype demonstrates that it is indeed possible to move away from the classic rigid module.



3. Virus based metal contacts for solar cells. One of the key elements in next generation solar cells will be the possibility of moving away from the metals currently used – which are the same used in flat panel displays in TV's and computers.

Today's technology in fact uses thin transparent layers of coated metals which include indium – a true bottleneck for very large scale deployment of photovoltaics but also of displays. Researchers at MIT may have a solution to this problem. They are in fact able to engineer certain kinds of viruses enabling them to electro statically bind to nanoparticles of different kinds.

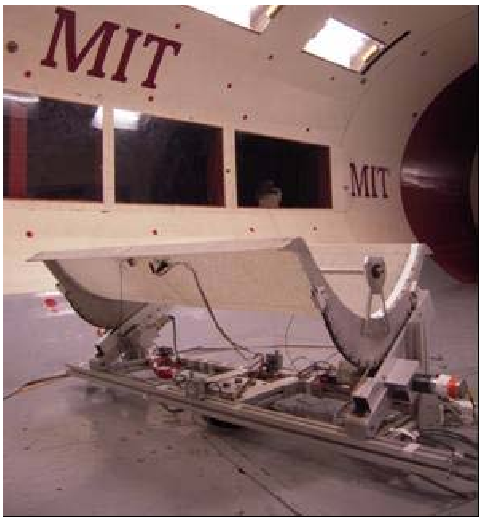
In particular, by a two-fold modification of a virus called M13 they have been able to produce a compound in which the virus binds to carbon nanotubes on one side, and to e.g. titania nanoparticles on the other. Such a compound can be used instead of the indium-based transparent metal contact to realize a titania-based solar cell, a potentially low cost solution. Performance is still limited but the potential would be very large, and not only for solar cells.

4. *Photosynthetic solar cells*. Researchers at MIT have realized a prototype device demonstrating the possibility to reproduce the self-repair mechanism used by leafs in the photosynthetic process.

Understanding this mechanism, together with the possibility to realize self-assembling ordered nanostructured devices is a step forward on the path to building solar harvesting devices more resistant to solar degradation effects, imitating what nature is already able to do.

5. *Understanding how photosynthesis splits water molecules*. The greatest contribution of photosynthesis to energy storage is in water splitting, a complex transformation of light energy into chemical energy, i.e. separation into Hydrogen and Oxygen. Researchers at MIT have shed light on the fundamentals of such mechanism.

This will enable in the long run the realization of photo-electro-chemical or photo-catalytic devices which can efficiently and inexpensively reproduce what leafs do.



6. Prototype of low cost mirror based on concentrating solar power system. Most of the high cost of concentrating solar power systems which focus sunlight on special receivers with parabolic mirrors is in the investment part.

The work at MIT has focused on low cost system design from the mechanical structure point of view, the ability to self-cleaning and also on low cost material approaches such as foil-coated glass fibre or something resembling a large beer can. A small scale prototype has been built and is currently being tested. If cost saving figures can be demonstrated at commercial scale, this could pave the path for a sustainable deployment of concentrating solar power.