Flexible Luminescent Solar Concentrators

Naval Research Laboratory nrl.navy.mil

At a Glance

What is it?

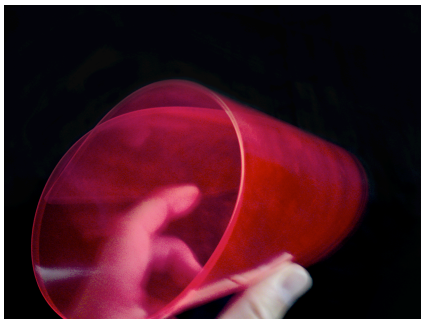
In collaboration with Imperial College and Columbia Biosciences, NRL is developing a photovoltaic (solar cell) system that uses proteins from blue-green and red algae to form an efficient, flexible, low-cost solar array.

How does it work?

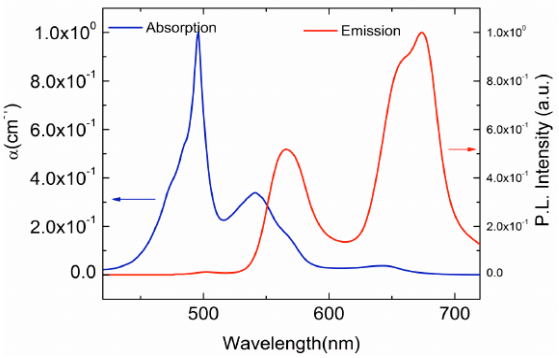
A luminescent solar concentrator (LSC) is a flat, planar material that channels light to solar cells coupled to the LSC edge. An LSC can be formed from inexpensive material and flexible material thereby enabling an efficient, man-portable solar blanket. Phycobilisomes, antennae proteins from algae, naturally absorb blue-green light and emit red and form the basis for an LSC forms well adapted for underwater operation.

What will it accomplish?

Underwater LSCs will provide continuous power for long-duration remote sensor missions making missions less expensive and longer lived. On land, these LSCs will provide a non-tracking, lightweight, flexible, inexpensive, high-power solar blanket. On a larger scale, the LSCs can be used for building integrated PV (BIPV), replacing conventional building materials.



Photograph of a flexible luminescent solar concentrator created by Imperial College London.



Absorption & emission of phycobilisomes. Blue-green absorption matches the transmission of water and emission in the visible matches to commercial solar cells.

Concentrating light with relatively inexpensive devices onto photovoltaic (PV) cells is a way of reducing the cost of PV energy. Luminescent solar concentrators (LSCs) are flat, planar concentrators that, unlike geometrical concentrators such as lenses or mirrors, do not require solar tracking and collect diffuse as well as direct light. Furthermore, the emission of the LSC can be spectrally matched to the absorption of the PV cell for maximum energy conversion.

Phycobilisomes are protein complexes found in blue-green and red algae that, as part of a highly efficient photosynthetic process adapted for underwater, absorb blue-green light and emit in the red. We seek to create a bio-derived technology that integrates the phycobilisomes into an LSC where a phycobilisome-containing material absorbs light and efficiently couples that light to a conventional solar cell. This has potential due to the efficient Förster resonant energy transfer (FRET), high quantum yields and the large Stokes shift of the phycobilisomes. In addition, Columbia Biosciences has commercially demonstrated a patented process for extracting and stabilizing the phycobilisomes establishing low cost access to the material.

In addition to underwater applications, this is attractive for man-portable power as it can form a non-tracking, lightweight, flexible, high-power, inexpensive solar blanket. On a larger scale, LSCs are of interest for building integrated PV (BIPV) application, where it could replace conventional building materials

Research Challenges and Opportunities

- Design phycobilisome-containing material for solar absorption
- Design a flexible, high efficiency LSC system
- Design system to couple phycobilisome emission into a conventional solar cell via a flexible LSC sheet
- Demonstrate functionality on land and underwater

List of publications:

M.J. Fisher, C. Ippen, D.J. Farrel, R.J. Walters**,** M. González**,** K.M. Trautz, J.P. Morseman, A. Büchtemann and A.J. Chatten, "Flexible luminescent solar concentrators using bio-derived tandem fluoroflores", to be published in the *Proceedings of 38th IEEE Photovoltaic Specialist Conference (PVSC), (Austin, TX, USA, 2012)*.

M. González, R. Bose, M.J. Fisher, D.J. Farrel, A.J. Chatten, J.P. Morseman, M. W. Moss, C. McLain, A. Büchtemann, P.P. Jenkins and R.J. Walters, "Bio-derived luminescent solar concentrators by using phycobilisomes", *Proceedings of 25th. European Photovoltaic Solar Energy Conference and Exhibition(EU-PVSC)* pp. 441-444 *(Valencia,Spain, 2010)*.

R. Bose, M. González, P.P. Jenkins, R.J. Walters, J.P. Morseman, M. W. Moss, C. McLain, P.Linsert, A. Büchtemann, A.J. Chatten and K.W.J. Barnham, "Resonance energy transfer in luminescent solar concentrators", *Proceedings of 35th. IEEE Photovoltaic Specialists Conference (PVSC)* pp. pp. 000467-000470,*(Honolulu, Hawaii, USA, 2010)*.