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Description of Masters' Project at CSEM Brasil / SUNEW

Project Title	Performance and stability of OPV with non-fullerene acceptor (NFA)
Project Supervisor at CSEM Brasil / SUNEW	Dr Diego Bagnis (diego.bagnis@csembrasil.com.br)

Project Introduction / Aims

As sustainability and renewable energy become increasingly important global issues, the use of photovoltaic technology to generate electricity from sunlight is rapidly expanding. For Brazil, the market for solar energy is very promising, with its dispersed, hard-to-access communities and vast territory presenting a challenge to the conventional grid-based electrical distribution system. However, while most parts of Brazil benefit from higher solar irradiation levels than most European countries, the deployment of solar energy projects here are miniscule compared to several European nations.

Organic photovoltaic (OPV) technology has been the subject of intense scientific interest, as it offers the possibility of generating low-cost energy from sunlight. Compared to conventional inorganic solar cells, OPV could offer advantages such as being flexible, printable, scalable, low cost, light weight, semi-transparent, and easily integrated into different applications. OPV has benefited from considerable investment from industry and academia and performance is steadily improving, with highest certified power conversion efficiencies exceeding 11% for a single-junction device.

Among the challenges facing OPV commercialization is guaranteeing a long lifetime for finished OPV modules. The stability of OPV can be categorized into intrinsic effects (stability of the absorber layer, often tested under thermal and UV exposure in a glovebox) and extrinsic effects (stability of the finished, encapsulated device subjected to air, moisture, heat, and sunlight). For example, low bandgap polymers in combination with fullerene-derivatives can give high performance. However, poor intrinsic light stability for several of these systems can give a loss of performance between 30% and 50% in the early hours of testing, depending on the donor involved.

One reason for this instability is connected to the presence of fullerene-based acceptors. One approach to combat this effect is the use of non-fullerene acceptors (NFA) in order to have higher light stability and potentially obtain efficiency. NFAs can also give additional benefits, such as higher absorption, colour tuning and potentially, lower price.

The principal aim of the project is to design and conduct experiments to investigate several donors in combination with NFAs in order to achieve improved intrinsic stability, and overall performance. The project has a scale-up vision and the solutions encountered will have to be applied on flexible substrates, in air with non-halogenated solvents. The challenge is also to understand the effects of the encapsulation process on NFA-based devices, optimizing the process to improve the stability of devices when subjected to the sunlight. The aim of this project is to identify an NFA-donor material system that is suitable for scale-up to R2R production.

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Selected References:

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Equipment and Methods

Roll-to-Roll Coating Machine
Our R&D coating machine will be used to produce meters of 10 cm wide OPV modules for testing. This is an adaptation of a commercially-available single-pass system, with the flexible plastic web passed through the system for each deposited layer, until the device stack is formed.

Other Coating Machines
We have several coating machine for small devices, such as spin-coaters, blade-coaters, spiral-roll and mini-roll that can be used with flexible substrates under lab-conditions.

Semi-Automatic Laminator
R&D lamination machine to encapsulate R2R-printed modules. A custom operating program has been built to automate and control the various process parameters.

Indoor and Outdoor Stability Tester
Custom-built equipment and software for lifetime and stability testing includes a light stability simulator, light soaker and roll-up tester for mechanical stress. For outdoor testing, an automatic measurement system has been developed.

Solar Simulator (Class AAA)
This system simulates the terrestrial solar spectrum at air-mass 1.5. A custom control interface allows for automated testing control and analysis of electrical data to calculate the key performance parameters of PVs.

Source-meters
Additional electrical measurements can be performed using Keithley 2400 source-meters.

Climate Chamber
The climate chamber is used to expose the laminated modules to high heat and humidity to perform accelerated lifetime testing of modules.

Glovebox
To eliminate the effects of oxygen and water vapor, stability tests can be performed in a nitrogen-glovebox environment.

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Hotplate / Ovens
Standard equipment to anneal devices and test the thermal stability of modules.

Mechanical Stability Tools
A set of custom-built tools to examine the mechanical stability of laminated modules. There is a possibility of developing further tools using our Mechanical Instrumentation Workshop.

LBIC
Custom-built Light (Laser) Beam Induced Current (LBIC) to map and allow easy identification of defects, coating errors, shunts and photovoltaic inactive regions with an additional indication of lamination quality.

Additional Tools:
In addition to the above-mentioned equipment, further characterization equipment is available at CSEM Brasil: metal evaporator, semi-automatic screen printer, profilometer, optical microscopes, and UV-VIS spectrometer. For more detailed surface characterization, atomic-force microscopy and scanning-electron microscopy are available through our partnership with the Microscopy Centre at the Federal University of Minas Gerais (www.microscopia.ufmg.br).

Company Background

CSEM Brasil was created in 2006, by FIR Capital and by CSEM S.A., with support from the Government of the State of Minas Gerais, through the Minas Gerais State Agency for Research Development (FAPEMIG). Our goal is to transform cutting-edge technologies into products, services and innovative companies, creating a bridge between science and industry, and between Brazil and the world. In the 2015, CSEM Brasil co-founded with FIR Capital and other investors a spin-off company called SUNEW that has R2R installed in-line production capacity of 400,000 sqm /year. CSEM Brasil and SUNEW work in close technical partnership to deliver technology from R&D to commercialization.

CSEM Brasil
Belo Horizonte, 25th September 2017