INDO SWISS JOINT RESEARCH PROGRAMME (ISJRP)

RESEARCH FELLOWSHIPS

EXCHANGE GRANT REPORT

Grant No.: RF40

Part 1 - General Information

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Thin film nanostructured scaffolds for electrical energy and storage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keywords</td>
<td>Solar cells, Supercapacitors, Nanotechnology</td>
</tr>
<tr>
<td>Start date</td>
<td>January 8th 2012</td>
</tr>
<tr>
<td>Duration</td>
<td>6 months</td>
</tr>
</tbody>
</table>

Part 2 - Exchange Participant(s) Details

VISITING SCIENTIST

Mini P A
Amrita Centre for nanosciences and molecular medicine
AIMS campus, Amrita lane, Edappally, Cochin-41
682041
India
Email: annaminiantony@gmail.com, minipa@aims.amrita.edu

HOSTING SCIENTIST

Michael Grätzel,
Professor
SwissLaboratory of Photonic and Interfaces, Station 6 Ecole Polytechnique Fédérale de
Lausanne CH-1015 Lausanne,
Switzerland.
Email: Michael.graetzel@epfl.ch
Part 3 - Scientific & Technical Information

3.1 Purpose of visit

The research work that I am carrying out in India was on the development of nanostructured thin film layers capable of charge storage using scaffold-based technology and also another part is involved in the development of dye sensitized solar cells (DSSC). However, the set up in the Indian laboratory is not yet optimum for the DSSC device fabrication and advanced characterization studies, which I could learn at EPFL.

The work conducted at EPFL:

1. To learn the techniques and characterization methods involved in the development of Dye sensitized solar cells (DSSC).
2. To develop carbon/polymer nanofibrous scaffold thin films and to study whether the scaffold can substantially enhance charge storage efficiency.
3. To develop nano metal oxides like NiO and RuO₂ based capacitor system and study its performance.

3.2 Short description of work carried out during the visit

Half of this exchange time was dedicated for the study of DSSC development. The primary goal of this work was to learn the fabrication of high efficiency DSSC and characterization of these devices with different analytical tools. Initially I was trained to develop DSSC with the standard dye and electrolyte system. Later part of studies were conducted on the development of DSSC’s with four new metal free organic dye molecule having different chemical structure of Donor-π-Acceptor design and studied their photo voltaic performance. The photovoltaic parameters such as conversion efficiency, short circuit current density, open-circuit photo voltage are obtained using voltage current (I-V) plots, Incident photon to current conversion efficiency (IPCE) measurements. Three different electrolytes, volatile solvent based electrolyte, ionic liquid based electrolyte and alternate cobalt redox electrolyte based electrolytes were used to investigate the device performances. Voltage decay transient and electrochemical impedance measurements were performed to understand the variations in the electrolyte influence on the device characteristics.
Second part of the study was devoted to the development of a storage device such as a Supercapacitor. From the light of earlier work conducted in India, carbon with conducting polymer composite is selected as the candidate for the storage material, specifically carbon nanotube (CNT) and polypyrrole (Ppy) composite. Electro polymerization of pyrrole monomer in an ionic liquid causes the incorporation of anion into the polymeric backbone and which could improve conductivity and surface area of the polymer film hence its storage performance.

Electrophoresis of CNT followed by electropolymerization of pyrrole is used for the development of CNT/Ppy composite. The reason of selection of CNT in the composite is that the polymer can adapt the surface area and conductivity of CNT to enhance the performance and active area for the charge storage. Detailed characterization studies like Cyclic Voltammetry (CV), Frequency response analysis (FRA) and the Charge-discharge kinetics were conducted to find its storage capacity. Specific capacitance, energy density and power density were calculated and found that CNT/Ppy composite is good material with higher area capacitance and moderate mass specific capacitance.

Some initial work carried out using nano nickel oxide/ruthenium oxide as a storage material showed promising results.

3.3 Outcomes

The objective of this project is a great success in terms of learning the fabrication of high efficiency DSSC and improving the storage capacity of capacitor electrode. I could reproducibly fabricate DSSC devices with an efficiency ~10% with standard dye (called as C106) and volatile electrolyte (Z960). Four new Donor-π-Acceptor dyes investigated and obtained the device performance of as high as 7.3% at full sunlight intensity. In case of cobalt complex redox electrolyte the open circuit potential of 940 mV was obtained.

The capacitor electrode with carbon nanotube/Polypyrrole (CNT/Ppy) composite synthesized in ionic liquid showed higher capacitance than the electrode prepared in normal organic medium like acetonitrile; CNT/Ppy electrode showed area capacitance of 425mF/cm² and mass specific capacitance of 470F/g.
3.4 Future collaboration with host institution

This is a great start for both the groups involved in this project. We will further continue our collaborative research in the field of photovoltaic and super capacitors. We will try to integrate these two devices together, using DSSC’s to generate the electricity from sunlight and store this in the capacitor to use it during the night.

3.5 Various comments

Everything worked well as expected and these types of exchange programmes will help students like me from India to learn and improve their skills. I wish, there will be more of this kind of student exchange programmes organized in future.

3.6 Projected publications/articles resulting or to result from the exchange

Two publications, one each from the super capacitor and DSSC work, are expected from this study and the manuscripts are under preparation.