1. **Project Description**

**A Fully Automated System for Local Spectral Analysis and Current-Voltage Characterization for Novel Organic Semiconductor Photovoltaic Devices Designed and Fabricated at the Electron Devices Laboratory, Department of Electrical Engineering, Santa Clara University**

Thin film devices, especially those incorporating organic semiconductors (OS), have become a promising alternative in technical applications that have been limited by conventional manufacturing techniques. From compact and vibrant light emitting displays to innovative thin film transistor designs, semiconductor researchers and manufacturers have been increasingly turning to thin film OS devices to improve on traditional mineral semiconductor implementations. Accordingly, the analysis and improvement of thin film devices has become an area of great importance in industry and academic research. To this end, researchers in Santa Clara's Electron Devices Laboratory (EDL) have been seeking to develop improved analytic techniques for fabricating and characterizing new materials and structures for photovoltaic devices. A typical cell structure being studied is shown in Fig. 1 [1].

The Local Spectral Analysis system proposed to be used for this work shows a good repeatability (0.5%) and high accuracy (6.3%) in the computer controlled spectral characterization of photovoltaic devices by the determination of internal quantum efficiency over an extended wavelength range. Biasing conditions (for both light and voltage) are fully controlled by computer as well. A corresponding I-V curve can be obtained in the same location without moving the sample on a different set-up. Scanning images (maps) of internal quantum efficiency (IQE) and of external quantum efficiency (QE) can be obtained with a spatial resolution better than 10 microns. Parameters extracted from I-V curves can be mapped with the same spatial resolution. Because IQE curves and I-V curves are obtained in the same location and using same optics, a full characterization of the photovoltaic device under test is possible in a single run. By providing the high accuracy and extended versatility, this system will have wide-range of application in photovoltaic both research and production.

2. **Previous Work**

This project is a continuation of research initiated at the Electron Devices Laboratory by the faculty applicant and further explored by previous and current Kuehler grant recipients. As a result of past Kuehler grants, a fully functional UHV system, as shown in Fig. 3, has been made available, and a variety of experimental OS thin films have been produced, imaged and analyzed.

In addition to previous year’s equipment grant of $35 K which was used to acquire a New port 300W Solar Simulator and Current-Voltage characterization system, as shown in Fig. 2, the faculty applicant has received another $45 K equipment grant in this academic year. Using this new grant funds the faculty applicant is in the process of acquiring a Newport QE System shown in Figs. 4 and 5 and described above. With the above $80 K worth of equipment it would be possible to upgrade immensely the capabilities of Solar Devices research and teaching of our graduate and undergraduate students population in the important overall and timely field of alternative energy sources.

3. **Project Objectives**

During the project, students will be involved in experimental and analytical tasks such as:

1. Setting up the newly acquired fully Automated Integrated System for Local Spectral Characterization as shown in Figs. 4 and 5.
2. Calibrate and test the above system for full operation by measuring Spectral Response (see Fig. 6) of Reference Solar Cells.
3. Set up and calibrate the Solar Simulator and Current-Voltage (I-V) Characterization system shown in Fig. 2.
4. Design and fabricate novel organic semiconductor photovoltaic devices and characterize them using the methodology described in Refs. 1 and 2 to extract various important parameters of the devices [2-3].
5. Contribute to ongoing improvements of the UHV PVD System shown in Fig. 3, including routine maintenance and the ongoing addition of a fine-grained control system.

The design, fabrication and elaborate characterization of novel organic polymer solar cells to extract important material a device parameters of the devices will lead the students to a more complete understanding of how research can advance the technology of current photovoltaic devices. As a result of this project, students will experience:

- i) Exposure to semiconductor processing equipment and methods.
- ii) Exposure to emerging technologies involved in the production of solar cells.
- iii) Avail the opportunity to set up and calibrate state-of-the-art photovoltaic characterization systems.
- iv) Have the opportunity to assist and interface with doctoral researchers in a cutting-edge field.
4. **Students' names and GPA's**

The research team will consist of the following three undergraduate students working in close collaboration with the faculty member and a postdoc, a Ph. D. candidate, and two M.S. students as additional mentors. (i) Jules Salvador, (ii) Mendel Hung, (iii) Dylan Rust.

5. **Deliverables**

Sigma Xi, Santa Clara University Chapter Research Poster Session, Kuehler Alumni Night Poster Presentation, conferences such as IEEE Photovoltaic Specialists Conference (PVSC), 2012, Materials Research Society (MRS) Fall 2011, Spring 2012 Symposia, IEEE Device Research Conference (DRC) 2012, etc., and submission to journals, such as Applied Physics Letters, Electron Devices Letters, etc.

6. **Availability of Faculty**

The faculty applicant M. Rahman is available throughout summer of 2011 to guide the project.

7. **Benefit to Faculty and Students**

The QE and I-V measurement system set up and calibration will effectively used to teach graduate and undergraduate courses on photovoltaic devices, such as ELEN 183, etc. This project involves the practical application of cutting-edge technologies that could contribute to the production of more efficient photovoltaic devices. Specifically, advances in the field of thin film OS devices and solar cells could assist in the development of next generation applications. Within the Santa Clara community, devices produced over the course of this project will be used directly in ongoing graduate and doctoral research. Undergraduate researchers will learn how to use the solar simulator and the Quantum Efficiency Characterization System, various process equipment and improvements to equipment will benefit future students.

8. **Figures**

![Fig. 1. The Organic Polymer Solar Cell Structure and its typical I-V Characteristics](image1)

![Fig. 2. The Solar Simulator I-V System](image2)

![Fig. 3. The UHV PVD Deposition System](image3)

![Fig. 4. A Perspective view of the Quantum Efficiency (QE) Characterization System](image4)

![Fig. 5. A schematic of the set up of components of the QE Characterization System](image5)

![Fig. 6. A typical Spectral Response curve.](image6)

**References**