University of Missouri-University of the Western Cape
Academic Exchange Program 2014 Report

Candidate: Prof Christopher J. Arendse

Home Institution: Department of Physics, University of the Western Cape

Host: Prof Paul F. Miceli

Host Institution: Department of Physics and Astronomy, University of Missouri-Columbia
Contents

1. Objectives of the Visit ............................................................................................................. 3
2. Objective Successes .............................................................................................................. 3
3. Value of UM / UWC Exchange Program ............................................................................... 6
4. Challenges and Suggestions .................................................................................................. 6
5. Other Highlights .................................................................................................................... 6
6. Acknowledgements ............................................................................................................... 7
1. **Objectives of the Visit**

This research visit had the following objectives:

(a) The major objective of this visit was to initiate the collaborative research project on the synthesis and characterization of silicon nanowires. This research is part of a larger project that focuses on the incorporation of silicon nanostructures into solar cells, with the aim of improving the efficiency and stability, while reducing the overall cost of the solar cells.

(b) The second objective was to interact and identify possible synergies between the Department of Physics at UWC and its counterparts at both the Columbia and Rolla campuses of the University of Missouri.

(c) The next objective was to discuss and plan the overall collaborative research project with the co-investigator, Prof Miceli.

(d) Finally, I will give a presentation on my research activities.

2. **Objective Successes**

**Silicon nanowire synthesis and characterization:**

The main objective of this study is to investigate the growth mechanism of silicon nanowires (Si NWs) synthesized by chemical etching of a mono-crystalline silicon (Si) wafer, with the emphasis on the role of the silver (Ag) nanoparticle catalysts. The synthesis procedure was performed according to literature, using a AgNO$_3$/HF/H$_2$O solution for the supply of the Ag nanoparticles and a HF/H$_2$O$_2$/H$_2$O solution as the etchant of the Ag coated Si wafer. To enable a growth mechanism investigation, the etching time was varied from 30 s to 90 min, followed by the characterization of the resultant Si NWs. X-ray reflectometry and diffraction (facilities housed in Prof Miceli’s laboratory) were used to investigate the structural evolution of the surface. Scanning electron microscopy (housed in the Electron Microscopy Core of UM-Columbia) was used to probe the morphology of the structures, whereas Raman spectroscopy (housed in Prof Suchi Guha’s laboratory in the Physics building) was used to probe the vibrational and structural properties of the Si NWs.
Preliminary results indicate that the size, orientation and distribution of the Ag catalyst influence the eventual morphology of the Si NWs. X-ray reflectivity is severely limited by the thickness and roughness of the layers. Initial investigations hint at the possibility of extracting information on the Ag density and distribution on the pre-etched samples. However, results on the etched samples reveal new information that is worthy of further investigation. Raman spectroscopy has provided a direct link between the vibrational properties and the crystallinity of the Si NWs and can therefore be used as an indirect method to extract information on the nano-crystalline properties of the synthesized Si NWs. It should be noted that this investigation and experiments are currently continued at UWC and the aim for 2016 is to appoint a PhD student to continue this project, who will be supervised by Prof Arendse and Prof Miceli.

Interactions and Synergies:
During my visit I was privileged to meet with the following esteemed researchers:

- Prof Peter Pfeifer, leader of the Alternative Fuel Technology Group.
- Prof Suchi Guha, leader of the Organic Electronics Group and who provided her expertise and access to the Raman facilities.
- Prof Sashi Satpathy, the Department Chair of Physics and Astronomy at UM-Columbia.
- Prof Haskell Taub and Prof Deepak Singh, of the Neutron Scattering group.
- Prof Tommi White and Dr Thomas Lam, who provided a tour of the Electron Microscopy facilities at UM-Columbia, discussions on the instrument capabilities and possible exchanges between UWC Electron Microscopy Unit and the UM-Columbia Electron Microscopy Core.
- I also met with Prof Meera Chandrasekhar to identify synergies between her Physics Education research project and that of our department. After follow-up discussions with Dr Mark Herbert (UWC), it is clear that synergy does exist, specifically in the area of high school physics. Feedback will be provided to Prof Chandrasekhar by Dr Herbert.
Prof Miceli also arranged a full-day visit to the Missouri University of Science and Technology at Rolla, where we were hosted by the Department Chair of Physics, Prof George Waddill. The highlight of this visit was the tour of the Electron Microscopy Unit, where they house an FEI focused ion beam high resolution scanning electron microscope and an FEI 200 kV high resolution transmission electron microscope. Of specific mention is the strong alignment between our chemical vapor deposition expertise and the thin films depositions in this department.

Planning of future project:
In 2014 I have successfully secured funding from the National Research Foundation (NRF) of South Africa to foster and maintain collaborations between South African and International Universities. In this proposal, Prof Miceli of UM-Columbia was identified as the co-investigator and therefore we discussed and planned the research project, specifically around the infrastructure and teaching requirements at UWC and future research visits to UWC and UM-Columbia by both. It is also worth noting that during my visit I was informed that our NRF Equipment proposal for a multi-chamber deposition system was successful. This will now allow our collaboration to grow further, in that we will have the facilities at UWC to incorporate the fundamental knowledge and thin films into the manufacturing of complete solar cells.

Presentation:
On October 15, 2014 I presented a 1-hour seminar entitled: “Hot-wire chemical vapor deposition of intrinsic hydrogenated nano-crystalline silicon thin films” to an audience composed of mainly Condensed Matter Physicists. The main goal of the presentation was to communicate the benefit of chemical vapor deposition, specifically hot-wire CVD, for the growth of nano-structures for solar cell application. The presentation was well received and provoked some interesting discussions afterwards.
3. **Value of the UM / UWC Exchange Program**

The exchange program has enabled my participation in a world-renowned academic department and research group, with a rich research culture that promotes the incubation and growth of fundamental concepts and ideas. Through this exchange, I gained access to state-of-the-art equipment and expertise and engaged academically with world-renowned researchers with expertise ranging from Condensed Matter Physics and Astronomy to Physics Education. As in my case, this program will have a definite positive impact on the intellectual development and career advancement of both young and established researchers.

4. **Challenges and Suggestions**

The planning and preparation of this visit was perfect and for that I commend the International Relations Office of UWC and the Office of the President of UM. I support the suggestion by Prof Uphoff that the subsistence should be paid in US dollars upon arrival in the US, as this will eliminate any currency conversion costs and the possible restriction to one’s South African bank account.

5. **Other Highlights**

One of the major highlights of this visit was attending the screening of the documentary “Soft Vengeance: Albie Sachs and the New South Africa” at Ragtag Cinema in Columbia (on October 12, 2014), hosted by Prof Rod Uphoff with special guest Albie Sachs. My research visit also coincided with the Physics Leader’s Meeting (on October 17, 2014) and hence I had the privilege of attending the reception and banquet later that evening where I had some interesting discussions with faculty, guests and alumni.
6. Acknowledgements

I acknowledge the financial support of the UM / UWC Exchange Program and the support of Prof Rod Uphoff, Leolyn Jackson and their teams for all the planning and arrangements. I especially express my gratitude to Prof Miceli and his wife, Martha, for their friendship, kind hospitality and support throughout our visit and for the great dinners, discussions and excursions. I also wish to thank Prof Peter Pfeifer for initiating this research exchange visits and collaboration and for your friendship, valuable discussions and advice. I also thank Prof Miceli, Prof Guha and the Department of Physics and Astronomy at UM-Columba for hosting me and for the access to the analytical equipment. I also wish to thank Jesse and Yiyao for the valuable discussions and for the x-ray reflectometry and diffraction measurements.

Signed:

Prof Christopher J. Arendse

November 24, 2014

Date