1. SUMMARY OF ACTIVITIES – YEAR 3

1.1 Wind Turbine Health Studies: Epidemiological study

In July 2012, a pilot study of the epidemiological methods was completed in Thamesville, Ontario. This work included an evaluation of survey distribution techniques and the accuracy of obtaining distances from residences to the closest wind turbine. Two hundred surveys were delivered to homes within 3 km of wind turbines in the vicinity of the township of Thamesville in Chatham-Kent. The response rate for the pilot study was 22.5% (n=45) and it was determined that the survey instrument was appropriate for a larger epidemiological study, but that a manual, door-to-door distribution method, although providing the most accurate assessment of distances to wind turbines, was not feasible. An additional focus of the pilot study was the development and psychometric evaluation of scales to measure key independent and dependent variables in the epidemiologic investigation. Scales were evaluated first to remove individual items with floor and ceiling effects. Measures of each of the scales' internal consistencies and scaling successes indicated the utility and appropriateness of the overall questionnaire for the population. Approaches for assessing response bias included comparing demographic characteristics of the sampled population to information from previously administered population surveys. Although the response rate was modest, this comparison indicated that the demographic characteristics of the sample were no different than the overall population within the study area.

In January 2013, the survey was sent to 5000 homes across eight Ontario communities with wind generation facilities. The counties where residents received surveys were Bruce, Dufferin, Elgin, Essex, Frontenac, Huron, Norfolk, and Chatham-Kent. The survey was distributed with Canada Post unaddressed ad mail to postal routes that were contained within 5km of a wind turbine. In order to improve the response rate for this arm of the research, the survey has been put online and by July 2013, all non-respondents from the 5000 homes were be re-invited to take the survey online. This analysis and findings are part of an upcoming manuscript that will be submitted for peer-reviewed publication; preliminary findings were presented at the Canadian Public Health Association 2013 Annual Conference.

1.2 Wind Turbine Health Studies: Biomarkers

In August, 2012 two nursing students from McMaster University, supervised by a Nursing School faculty collaborator, participated in the clinical and biomarker component of the study. These students, working on research practicums, participated in all aspects of a pilot project which was conducted to develop, test, and refine the measurement aspects of the clinical and biomarker research. Through these assessments, extensive health data was collected on five community members living near the wind turbines in Thamesville, Ontario. The assessments included obtaining samples of hair and saliva to determine levels of stress biomarkers, physical health assessments, administration of health questionnaires, sleep diaries, and symptom journals. Laboratory analysis of biological materials was completed by an experienced laboratory technician and techniques to improve extraction and analyses of biomarkers from the matrices were examined. This pilot work resulted in the refinement of both field and laboratory protocols. In the summer of 2013, saliva samples were collected three times per day over the course of three days from 15 residents living in proximity of a wind turbine.

1.3 Geographical Information Systems (GIS) and Health

Work with GIS and Health is being done alongside the epidemiological aspects of the project. Two approaches were used to create survey distribution protocols utilizing GIS technology. For the pilot study the Ontario Parcel Data set (with address information) was used to identify where parcels of land and homes were located. Surveys were then delivered to all the addresses located in the Ontario Parcel Data set file. However, some of these addresses were business or had multiple units (apartments, townhouse units, etc). Also, some parcels of land had houses on them contrary to the assumption that they were vacant lots. Because of the underestimation of the number of homes in Thamesville, surveys were delivered to every home within 2 km of the wind turbines and to randomly selected homes within 3km. However, this method was deemed inappropriate for the study.

The next GIS approach was used to in a protocol to distribute 5000 surveys to homes across Ontario. Local Delivery Unit shapefiles (which include delivery routes) from Canada Post were used to identify each 6 digit postal code that contained a wind turbine in our 8 study communities. Then, only the postal codes and corresponding delivery routes that had 5 or more wind turbines were selected. Surveys were delivered to each house in the postal codes (and corresponding delivery routes) with 5 or more wind turbines using Canada Post's unaddressed admail service. Now that some surveys have been returned, google maps are currently being used to geo-locate the approximate location of survey respondent. The mapping of these homes will be used to example dose-response relationships.

1.4 Wind Turbine Health Studies: Sleep study

There are two arms of the sleep research component for the project. First, an exploration of the impact of industrial wind turbines on sleep among rural Ontario residents was done in the frame of a master's thesis research. A graduate student researcher spoke with residents about their experience living with renewable energies and collected information on their sleep. The research used daily sleep diaries and actigraphy to collect information about an individual's sleep. Sleep actigraphs were worn on the wrist and collected data continuously in order to measure sleep patterns, including awakenings . Collection of sound pressure levels within the bedrooms of participants was conducted in order to correlate sleep patterns and awakening with noise exposures. Twelve participants living near wind turbines participated as an "exposed" group and ten participants residing in a community with no wind turbines served as an unexposed group. Although numerous actigraphy sleep parameters were poorer in the exposed group, including lower average sleep efficiency (89% vs. 92%), longer sleep onset latency (6 min vs. 4 min), and longer wake after sleep onset (42 min vs. 29 min), the differences were not statistically significant. When the data was dichotomized by quality of sleep, the prevalence of poor sleep in the exposed group was greater than in the unexposed group (22 vs. 11 per 100 person-nights), although the results of logistic regression modeling indicated that the differences were not statistically significant (after adjustment for age and sex). Sample size considerations led to the finding of no significant differences between the groups in sleep parameters derived from the sleep diaries. Key findings of this research were that both actigraphy and sleep diaries can provide valuable information to understand the impact of industrial WTs on the quality of sleep for residents living in the vicinity. This pilot study had a small sample size which reduced the likelihood of identifying differences in sleep quality between the exposed and unexposed groups. The study provided information regarding the variability of exposure and effect measures in wind turbine sleep research that will be useful in future field studies. This work has been published by the University of Waterloo and is currently available through the University of Waterloo library. Moving forward, these findings are being prepared for publication in an academic journal, to increase the availability of the knowledge and share research experience.

Second, the research group will be examining sleep by collecting polysomnographic (PSG) signals from residents while simultaneously recording sound pressure levels. Existing methods of investigating the effect of wind turbine noise on quality of sleep have been challenging due to the complex character of the sounds, confounding influences of environmental conditions and logistical difficulties in collecting polysomnographic (PSG) signals without interfering with sleep. Noise from wind turbines has a major low frequency component and also has considerable amplitude modulation that makes it unique and challenging in terms of measurement as well as in the interpretation of its potential impacts on sleep. A PhD student, with a background in sleep medicine completed an internship at a local sleep clinic and is collaborating with one of their physicians in the design of an intensive sleep assessment project to investigate the impacts of wind turbine noise on sleep. This student is now certified by the Board of

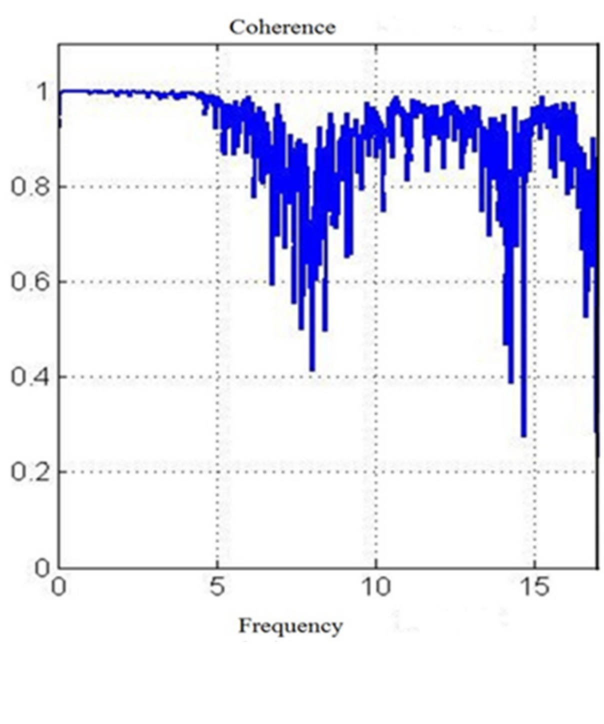
Registered Polysomnographic Technologists and her PhD study will involve the use of portable polysomnographic instrumentation that is less likely to interfere with sleep. This study will be the first epidemiological study measuring the sleep disturbance using the gold standard of PSG in people living around wind turbines and is necessary for thorough understanding and assessment impacts of wind turbine noise on sleep.

1.5 Lived Experience

In the summer of 2013, thirty-four residents from four communities across Ontario were interviewed to assess how wind turbines have impacted their quality of life. These open-ended qualitative interviews asked general questions and elicited detailed information about how wind turbines have impacted health, social life, relationships with others, and community cohesion along with other issues raised by participants. Transcription of the interviews is being conducted and Nvivo 10 will be used for detailed thematic analysis.

1.6 Wind Turbine Noise measurement

Indoor and outdoor measurements continued to be carried out in building near wind turbines. Four low frequency, high-precision electret microphones in accordance with the IEC 61094-4 measurement standard were set up inside and outside to collect sound data continuously. Outdoor measurements include data collection in varieties of distances from wind turbines. The microphones were all ½" prepolarized free-field low frequency microphones with a relatively flat frequency response from 1 Hz to 20 kHz and cut-off frequency of 0.5 Hz. High sensitivity of 50 mV/Pa and a large dynamic range made them perfect candidates for infrasound measurements. ¼" CCP preamplifiers with very low noise floor were also employed along with the microphones. Every channel of the tool that records and stores the data is an independent Class1 noise meter in compliance with IEC 651 standard. Its real time digital filters are also in compliance with IEC 1260 Class 0 standard covering frequencies from 0.04 Hz to 20 kHz. Putting all of these requirements together, the equipment was capable of collecting sound data down to 0.5 Hz frequency. The spectral plots show useful data down to about 0.2 Hz. Long term measurements allows us to investigate different sound patterns with respect to different wind directions/wind speed/seasons. On different occasions the turbines have been upwind, down wind and cross wind.



Weather data (wind direction & speed, temperature, humidity, humidity) along with sound data is also synchronously and continuously collected. The process of data analysis has also started where the time domain data is transformed to frequency domain using FFT. In order to evaluate the difference between collected sound data in different locations of the room a coherence test using Welch's averaged periodogram is performed. The results show that collected data for all microphones in different locations of the room were in high coherence with each other at very low infrasonic frequencies.

Figure 1: Sample coherence test result

1.7 Intelligent Damage Detection with MEMS Multisensor Data Fusion:

A real-time non-destructive health monitoring technique based on multi-sensor data fusion is developed to identify and localize damages in wind turbine blades. The structural properties of blades before and after damage are investigated through different sets of finite element method simulations. Based on the obtained results, it is shown that information from MEMS smart sensors, measuring strains and vibrations, distributed over the turbine blades can be used to assist in more accurate damage detection and overall understanding of the health condition of blades. If the blade structure is damaged at a particular location, sensors readings show a sudden change in comparison to its value in the undamaged state near the damage location or even located inside the blade in the main spar beneath the crack location. Based on this fact, the strain field distribution analysis can be used as a damage identification method. Moreover, damages occurring in the blade can be related to changes in natural frequencies too. Since the MEMS sensor is also able to perform accurate vibration measurements, combination of strain sensing and natural frequency analysis is used in this work as a structural health monitoring method. Finally, data fusion technique is proposed to combine these two diagnostic tools to improve the detection system with providing a more robust reading and fewer false alarms. Measurements from single sensors cannot be fully reliable and are often incomplete. Incorporating data fusion into a structural health monitoring system seeks to combine and integrate different diagnostic tools to improve the detection system.

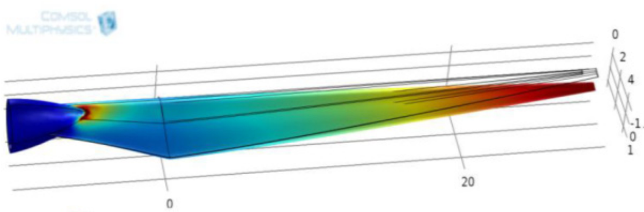


Figure2a. Finite element method simulation model of wind turbine blade under various load conditions.

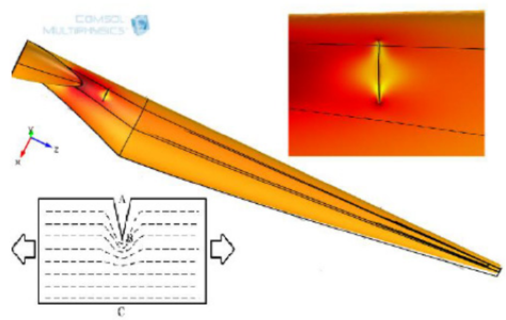


Figure 2b. Damaged blade's strain field distribution

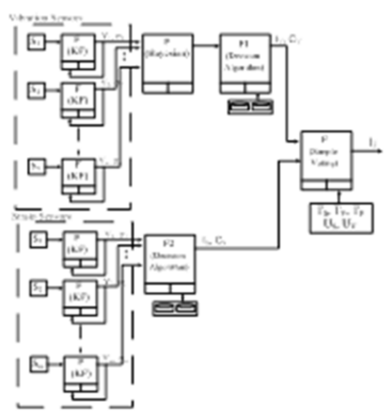


Figure 2c. The operation of the proposed intelligent wind turbine damage detection system

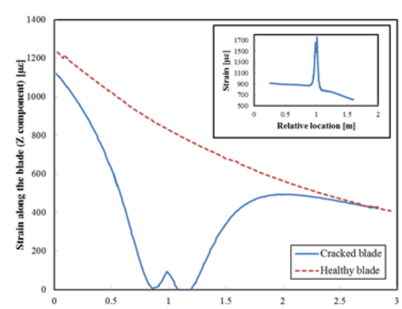


Figure 2d. Sudden change of strain magnitude is detectable near damage locations

1.8 MEMS Strain Sensors –Design and Fabrication:

The design of different MEMS physical sensors for strain measurement of wind turbine blades are completed now. While the proposed structures are high sensitivity, they are based on simple operating principle of displacement amplification. Four straight beams are connected to central interdigitated fingers creating capacitors with fixed top and bottom electrodes. The proposed microdevice converts even small amount of applied strains to measurable changes in capacitance. The devices performances are validated both by analytical solution and also by finite element methods. In order to realize the sensor, the optimization of the laboratory fabrication steps are under way with LPCVD polycrystalline silicon selected as the structural layer and PECVD silicon nitride as the sacrificial layer. The next step would be the fabrication of the complete design of interdigitated comb-drive sensors. The transmission of strain fields in adhesively bonded MEMS strain sensors is analytically modelled, validated by simulations and completely analyzed to provide insight and accurate formulation for strain transfer mechanism for bonded sensors. The model is capable of predicting the strain transmission ratio through a sensor gauge factor and also by using the developed model, modifications to sensor substrates, by the implementation of micromachined, tapered edges and trench etching, are proposed in order to increase the strain transmission ratio. The sensor sensitivity is enhanced by up to 30% by this method.

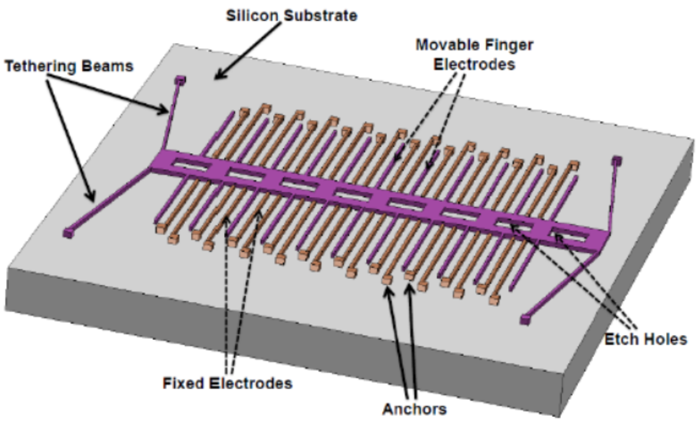


Figure 3a: Differential capacitive strain sensor with four mechanical amplifying beams

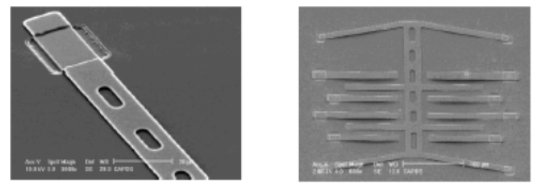
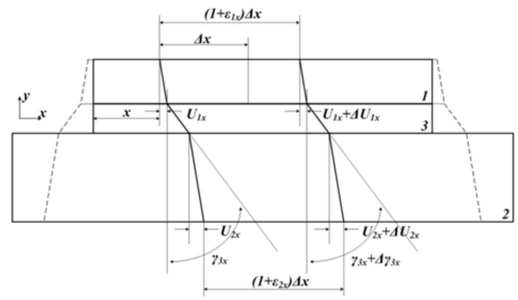


Figure 3b: Scanning electron micrographs of the fabricated structures.



Figue 3c: Displacement equilibrium diagram of the investigated adhesive bonded structure

1.9 Safer Grid-integration Considerations for Solar PV systems

Following the studies to address the reliability and operational safety aspects of the grid-connected PV systems, harmonic analysis of LCL filter degradation has been performed using model-based simulations. The PV system in this model consisted of four parallel strings of 25 series-connected 65 W modules and an MPPT control block. The focus of failure analysis in this study is on the degradation and life-time behaviour of the LCL filter. The degradation of the inductors and capacitor of this filter has been modeled by single-value variation of individual components. In this approach, the inductance value of L3 (inverter-side-inductor), L4 and capacitance of C are varied from the initial design values to zero in different percentage steps. The simulation results show that among these three components the failure of L3 is more critical. While the degradation of L3 does not affect the grid current and voltage strength and their quality in term of harmonics, the filter’s capacitor should pass more currents and higher orders of high frequency components. These capacitors’ life time is directly related to the number of charge / discharge cycles. Ultimately, the failure of L3 inductor leads to short-circuit of C which in return damages the performance of the whole PV system. This issue is found to be less critical for L4 because even the complete elimination of this component, will only change the filter topology from LCL to a slightly off-characteristic LC filter. Finally, a high tolerance window is observed for the capacitor component of the LCL filter up to the complete failure point. Complete elimination of this capacitor will result in a reduction of 14.6% in the grid current.

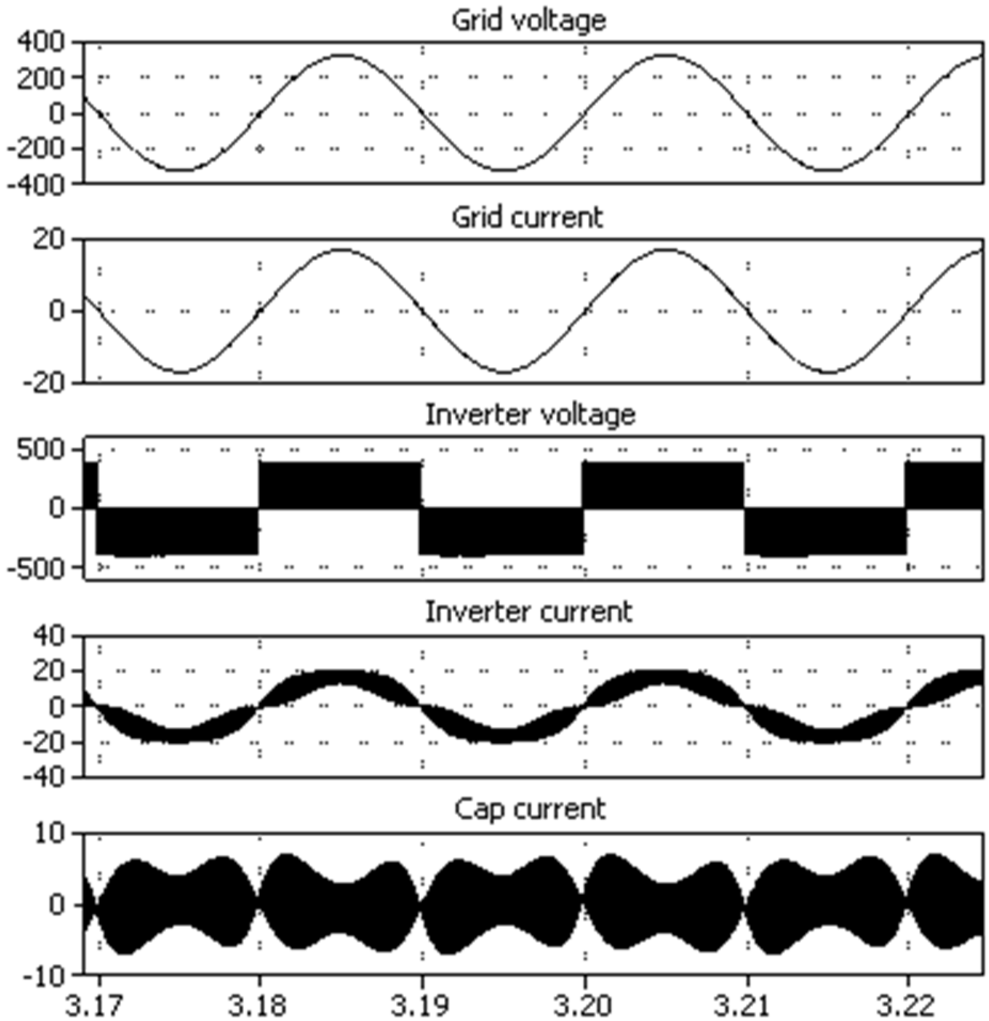


Figure 4: Waveforms of the grid and inverter voltage and current and, current passing through LCL filter capacitor

1.10 New Approaches in Solar Module Configuration

Following the investigation of new ideas to reconfigure PV array components in real time when module shading happens, a special shading case has been studied and a generic bypass reconfiguration algorithm has been developed. In this study a typical module with 54 series-connected cells are used for simulations with a random, cloud shaped shading pattern. Taking into account the manufacturing constraints such as the diode lifetime and encapsulation, in this study, the number of bypass diodes is limited to three, which is a typical case for similar-sized PV modules. Also, an individual cell in the module is considered shaded only if 1% or more of the cell area is shaded. Different bypass configurations were generated for a given each shading scenario. Depending on how the diodes are placed, different strings are bypassed and consequently significantly different output powers resulted. In an attempt to develop a machine-readable algorithm for dynamic bypass diode configuration, a computer code was written using C programing. In this program, the number of possible configurations is calculated and the power for each configuration is assessed by numerical methods. The output power for all possible configurations is calculated and the configuration with maximum power is produced as the output. The concept can be extended to employ it in PV farms where the goal is to bypass shaded modules in a series-connected configuration. The study underlined the need and benefits developing dynamic (re)configuration interconnect architectures. Options to achieve this will be investigated.

1.11 Electrically conductive Adhesives for screenprinted electrodes in solar cells

Progress has been made in developing screen-printable, electrically conductive adhesives (ECA) and contact formation on wafer substrates. ECA materials were also modified by controlled addition of silver nanowires to develop ECA-NW printable materials. Residual stress induced by the new, screen-printed electrodes on silicon wafers has been systematically analyzed. Initial results indicated that, compared to traditional metal paste electrodes the new material induces much less stress. Research is under way with the chemical synthesis of Ag nanoparticles as additives to create ECA composites with even better performance.

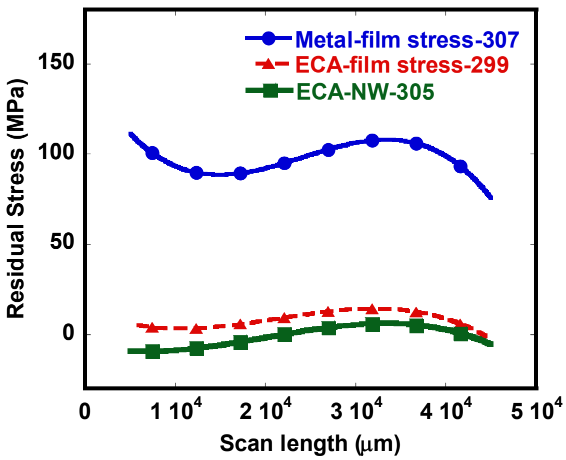


Figure 5a: Residual stress in silicon wafers with screenprinted metal and ECA layers.

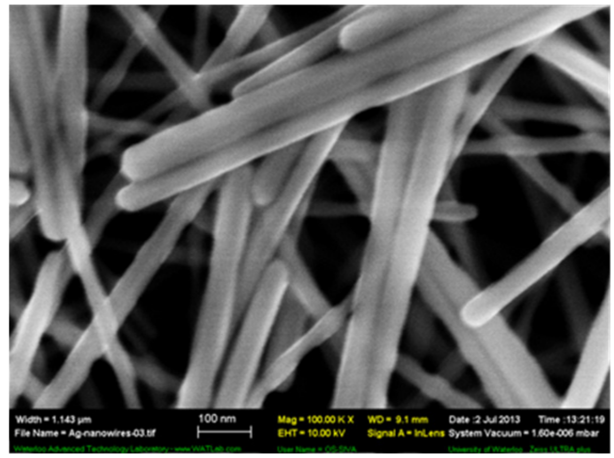
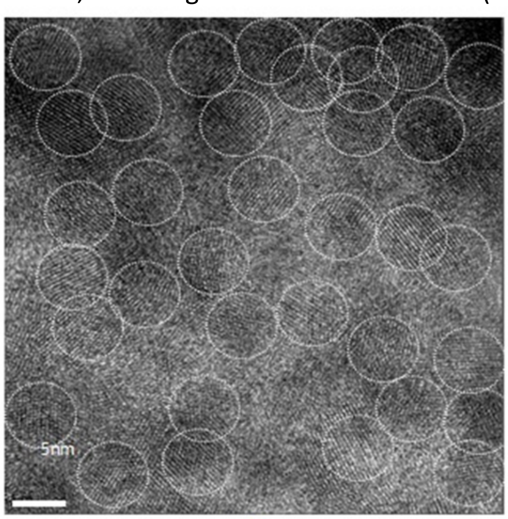


Figure 5b: Scanning electron micrograph of Ag nanowires used to develop the ECA material (scale bar = 100nm)

1.12 Materials processing for next generation photovoltaics and safety considerations

Progress has been made in the formation of arrays of cadmium selenide/zinc sulphide (core/shell) quantum dots (QD) with a high degree of periodicity. A dip-coating process has been established for the layer formation. QDs of 6.5nm size in a toluene-held solution was used for the process development. Processes for the formation of stacked, multiple layers have been successfully implemented. Establishing periodic arrays of QDs by employing simple yet safe methods is key for next generation nano-photovoltaic devices, including the intermediate band (IB) structures.



The nano-PV material processing facility is also used for studying/establishing safety options and particle monitoring for the processing of new materials. Efforts are under way to acquire a Scanning Mobility Particle Sizer (SMPS) spectrometric system (capable of covering a size range of 2.5nm to 1000nm with a collection range of 1 to 10^6 particles/cm^3.), and a water based condensation particle counter (with a counting capability of one to 4 * 10^6 particles/cm^3) through a joint research grant proposal in collaboration with other researchers.

Figure 6: Mutilayer QD layer after 16 times dipping cycles of the sample in the solution (scale bar is 5nm)

1.13 Bio-resource Technology

Work has continued on the solvent extraction of 5-hydroxymethyl furfural (5-HMF) material. 5-HMF can be produced from various renewable biomass sources, such as glucose and fructose, even cellulose, sawdust or other biomass feedstock that are usually converted to bioenergy or bio-oil. Single and mixed solvents were used to extract 5-HMF from simulated hydrothermal conversion (HTC) products composed of 5-HMF, levulinic acid, furfural and water. The mixed solvents applied were DCM-THF, DCM-2-butanol and 2-butanol-THF solvents with different mixing ratios. In addition, 20 and 10 wt% NaCl were added into the solvents to improve the extraction performance. Results showed that 20 wt% of NaCl and mixed solvents performed better than respective single solvents in the extraction of 5-HMF. The highest partition coefficient reached 6.87. pH level affected the extraction of levulinic acid more than that of 5-HMF and furfural. Based on the results within this study, it was found that the extraction of 5-HMF from simulated HTC products depended on solvent polarity, salt concentration and pH level of the solvent. The extraction capacity of DCM-THF and THF-2-butanol mixed solvent was independent on solvent volume fraction. Increasing NaCl concentration improved partition coefficients of all 5-HMF, levulinic acid and furfural.

2. PUBLICATIONS

Published papers

- M. Kamali, S. Sivoththaman, and S. McColl, "Analysis of Models for Audible and Low Frequency Noise Prediction for Wind Turbine Case Studies", *Proc. 15th Conference on Low Frequency Noise LFN 2012* (May 22-24, 2012, Warwickshire, UK).

- M. Moradi and S. Sivoththaman, "MEMS Strain Sensors with High Linearity and Sensitivity with an Enhanced Strain Transfer Mechanism for Wind Turbine Blades", *Proc. Nanotechnology 2012: Chapter 3: MEMS & NEMS Devices & Applications* (Santa Clara, California, June 18-21, 2012), pp.122-125.

- T. Christidis and J. Law, "The use of geographic information systems in wind turbine and wind energy research", *Journal of Renewable and Sustainable Energy,* vol.4(1), pp.12701-9, 2012.

- S. Visakhamoorthy, J. Wen, S. Sivoththaman, and C. Koch, "Numerical Study of a Butanol/Heptane Fuelled Homogeneous Charge Compression Ignition (HCCI) Engine Utilizing Negative Valve Overlap", *Journal of Applied Energy,* vol.94, pp.166-173, 2012.

- T. Christidis and J. Law, "Challenges to Studying the Health Effects of Wind Turbines among Different Research Designs", *Proc. International Conference on Clean and Green Energy,* (January 2012, Hong Kong), IACSIT Press, Vol. 27, pp 1-5, 2012.

- N. Bakhshizadeh and S. Sivoththaman, "New Screen-printed Metal Paste Options for PV Manufacturing", *Materials Research Society (MRS) Proceedings* (April 2012, San Fransisco, CA) Vol.1447, DOI: 10.1557/opl.2012.1464, p.1-5.

- T. Christidis and J. Law, "Annoyance, health effects, and wind turbines: Exploring Ontario's planning processes". *Canadian Journal of Urban Research,* 21(Suppl. 1), 81-105, 2012.

- B. Deignan, E. Harvey, L. Hoffman-Goetz, "Fright factors about wind turbines and health in Ontario newspapers before and after the Green Energy Act", *Health, Risk & Society,* 15(3), (2013) p.234-250.

- B. Janfeshan, B. Sadeghimakki, N. Jahed, and S. Sivoththaman, “Zinc Oxide Nanowire Arrays for Photovoltaic and Light-emitting Devices”, *SPIE Physics, Simulation, and Photonic Engineering of Photovoltaic Devices II,* Ed. Alexandre Freundlich, (2013) vol.8620, pp. 86201Z 1-9.

- B. Deignan and L. Hoffman-Goetz, “Readability of Canadian newspaper articles about renewable technologies and health: Implications for health literacy”, in D.L. Begoray, D. Gillis, G. Rowlands (Eds.), *Health Literacy: Developments, Issues and Outcomes,* (2013) NOVA Publishers (NY), in press.

- M. Moradi and S. Sivoththaman, “Strain Transfer Analysis of Surface-Bonded MEMS Strain Sensors“, *IEEE Sensors Journal,* vol.13, No.2, (2013) pp. 637-643.

- M. Gharghi, E. Fathi, B. Kante, S. Sivoththaman, and X. Zhang, “Heterojunction Silicon Microwire Solar Cells”, *Nano Letters,* vol.12 (2012) pp. 6278−6282.

- L. Tian, E. Fathi, R.S. Tarighat and S. Sivoththaman, "Nanocrystalline Silicon Deposition at High rate and Low temperature from Pure Silane in a Modified ICP-CVD System", *Semiconductor Science and Technology,* vol.28, (2013) pp.105004 (1-5).

- F. Liu, S. Sivoththaman, and Z. Tan, “Solvent extraction of 5-HMF from simulated hydrothermal conversion product”, *Sustainable Environment Research,* vol.23, (2013) (in press).

- P. Bigelow, “Wind Power” in *Encyclopedia of Quality of Life Research.* Ed. A. Michalos, Springer (2013) (in press).

Papers under review

- G. Campbell, S. Arai, and P. Bigelow, “Wind Energy Blows! An Analysis of Anti-Wind Activism Narratives”, *Health & Place.*

- T. Christidis, A. Wilson, C. Paller, S. Jamal, S. Majowicz, and P. Bigelow, “Creating and testing a survey to assess the impact of wind turbines on quality of life”, *Environmental Health Review.*

- T. Christidis, and J. Law, “Creating a map of Ontario’s wind turbines for studying their impacts on health: Challenges and Limitations”, *International Journal of Geographic Information.*

- E. Fathi and S. Sivoththaman, “Harmonic Analysis of LCL Filter Degradation in a Grid-connected PV System”, *AIP Journal of Renewable and Sustainable Energy.*

- B. Deignan and L. Hoffman-Goetz, “A content analysis of health risks and wind turbines in Canadian Newspapers, 2007-2011”, *Health, Risk & Society.*

- B. Sadeghimakki and S. Sivoththaman, “Toxicology Study of Quantum Dots and Nanoparticles for Photovoltaic Manufactures”, *Materials Research Society.*

- L. Jalali and P. Bigelow, “Investigation of Effects of Wind Turbine Noise on Sleep Disturbance: Review, Research Challenges and Directions”, *Noise and Health.*

- J. Lane, P. Bigelow, S. Majowicz, and S. McColl, "The Impacts of Wind Turbine Noise on Sleep Quality: Results from a Field Study of Rural Residents in Ontario", *Canadian Journal of Public Health.*

- M. Moradi and S. Sivoththaman, "A MEMS Multisensor Data Fusion Method for Intelligent Damage Detection in Wind Turbines", *IEEE Sensors Journal.*

- M. Quick, J. Law, T. Christidis, and C. Paller, "Exploring the Socioeconomic Characteristics of eight Wind Farm Communities in Ontario: Implications for Wind Farm Planning", *Canadian Journal of Urban Research.*

3. CONFERENCES / MEETINGS ATTENDED (YEAR -3)

- Canadian Association of Geographers Annual Meeting/Congress of the Humanities and Social Sciences, Waterloo, May 2012.

- Waterloo Institute for Sustainable Energy, Advisory Council Meeting, May 2012.

- Wind Power Conference and Exhibition - American Wind Energy Association, Atlanta, GA, June 2012.

- Leaders' Strategy and Tactics Event – Wind Concerns Ontario, London, Ontario, June 2012.

- NSTI: Nanotechnology 2012: Electronics, Devices, Fabrication, MEMS, Fluidics and Computational Conference, Santa Clara, CA, USA, June 2012.

- Energy Futures and Health Conference, Kitchener, Ontario, September 2012.

- Prescription for a Healthy Environment 19th Annual A.D. Latornell Conservation Symposium, Alliston, Ontario, November 2012.

- Public Health Ontario Roundtable Webinar, via Toronto, Ontario, January 2013.

- SPIE: Physics, Simulation, and Photonic Engineering of Photovoltaic Devices II Symposium, San Francisco, CA, USA, Feb 2013.

- Ontario Network for Sustainable Energy Policy Annual Workshop, Alliston, Ontario, April 2013.

- Applied Health Sciences Research Conference, University of Waterloo, Waterloo, Ontario, May 2013.

- Next Generation Solar 2013 Conference, Hamilton, Ontario, May 2013.

- Thin Film Photovoltaics Conference, Aix En Provence, France, May 2013.

- York University Sustainable Energy Initiative Seminar Series, May 2013.

- Canadian Public Health Association 2013 Annual Conference, Ottawa, Ontario, June 2013.

4. NUMBER OF STUDENTS SUPERVISED (YEAR-3)

Doctoral Students:	**10** Electrical and Computer Engineering: 6 School of Applied Health & Health Systems: 3 Mechanical and Mechatronics Engineering: 1
Master's Students:	**8** Electrical and Computer Engineering: 2 School of Applied Health & Health Systems: 4 Mechanical and Mechatronics Engineering: 2
Bachelor's Students:	**5** Electrical and Computer Engineering: 1 (exchange student from France) School of Applied Health & Health Systems: 4

Number of Master's theses completed during the year:	**5** Electrical and Computer Engineering: 2 School of Applied Health & Health Systems: 2 Mechanical and Mechatronics Engineering: 1

5. MEMBERS OF THE RESEARCH TEAM (other than graduate students) (YEAR-3)

Faculty Members*:

Dr. Siva Sivoththaman, Professor, Electrical and Computer Engineering
Dr. Philip Bigelow, Associate Professor, School of Public Health and Health Systems
Dr. Stephen McColl, Associate Professor, School of Public Health and Health Systems
Dr. Laurie Hoffman-Goetz, Professor, School of Public Health and Health Systems
Dr. Shannon E. Majowicz, Assistant Professor, School of Public Health and Health Systems
Dr. Jane Law, Associate Professor, School of Planning
Dr. Fue-Sang Lien, Professor, Mechanical and Mechatronics Engineering
Dr. Zhongchao Tan, Associate Professor, Mechanical and Mechatronics Engineering

*The team members also collaborated with several other faculty members on campus.

Post-doctoral Fellows:

Dr. Mahtab Kamali, School of Public Health and Health Systems
Dr. Ehsanollah Fathi, Electrical and Computer Engineering
Dr. Bahareh Sadeghimakki, Electrical and Computer Engineering

Technical Support:

Mr. Joseph Street, Facility Manager, Centre for Advanced Photovoltaic Devices and Systems
Ms. Julia Guan, Research Technician, School of Public Health and Health Systems

6. LINKAGES AND COLLABORATIONS (YEAR-3)

- During the last year, collaborations were established with two health units in Ontario. The interactions are further strengthening the team's research in the epidemiological/health studies related to wind turbines. Specifically, one of the health units was instrumental in the team's work assessing the impacts of wind turbine noise on sleep using actigraphy and sleep diaries. The other collaboration on intensive sleep monitoring studies will incorporate simultaneous measurement of noise levels and polysomnographic signals.

- Team members have started working with a sleep laboratory in the region. This collaboration will expand the technical capability and analytical techniques used for the sleep study. Physicians at the sleep laboratory have provided guidance on study designs for the sleep studies and the team is working with them to ensure that the portable polysomnographic instrumentation provides valid and reliable data in field settings.

- The team has submitted a proposal to collaborate with researchers from a variety of disciplines to address challenges in data handling in studies requiring simultaneous collection of real-time data from multiple sensors. Wireless sensor networking is a promising technology that would allow multi-subject monitoring for sleep, noise and environmental signals where sensors would be synchronized. This initiative has received letters of support from a company who manufactures noise instrumentation as well as a small start-up that is a leader in wireless sensor network technology.

- Team members also started working with a professor from Ryerson University in an effort to expand the turbine noise and health studies. Part of the team's work that requires simultaneous collection of polysomnographic data and sound pressure levels benefits from this collaboration.

- The team also started collaborating with a Distinguished Professor Emeritus from Physics department in analyzing the wind turbine noise data.

- A graduate student from the team had co-ordinated with the *Propel Centre and Public Health Ontario,* to obtain equipment to for a sleep assessment study. Faculty from these two organizations share expertise in the data interpretation.

- Connections were established with energy policy researchers through the ONSEP workshop

- The team is actively collaborating with a faculty member and students from Western University on wind power impacts on health and well-being. The faculty member will be participating as a member of one of the PhD student's advisory committee. Additionally, collaboration is under way on the preparation of a grant proposal to be submitted to the Canadian Institutes of Health Research.

- The team is engaged with a faculty member from RMIT University in Melbourne, Australia on field investigations examining wind turbine noise and sleep disruption. This researcher has extensive experience in health informatics and mobile health.

- Efforts are under way, in collaboration with nanotechnology researchers on campus, to acquire a nanoparticle monitoring/counting system (through a separate proposal), to complement the ongoing study on safety/toxicity aspects of nano-materials in processing environments including photovoltaics.

7. MEASURES TO PUBLICISE THE RESEARCH (YEAR-3)

- Some research results are communicated in conferences/workshops in the form of oral and poster presentations. The research team members continue to submit and publish peer-reviewed research papers. Completed Master's research works are also documented in the form of theses.

- A faculty member from the team along with two graduate students presented study findings at the Canadian Public Health Association Annual Conference in Ottawa. In addition to the formal presentations, the team members participated in various roundtables that touched on ways public health professionals and researchers can deal with the challenges related to the potential health impacts of wind power. The CPHA conference attracts public health professionals, policy makers and researchers from Canada and around the world so was an outstanding opportunity to communicate findings and network with a wide range of stakeholders.

- Team members also contributed to media interviews or articles on health studies and wind turbines. Examples include; Blackburn Radio (Sarnia), Blackburn News (Windsor), London Free Press (London), Chatham Daily News (Chatham), St. Thomas Times (St. Thomas), Chatham Kent Daily Post (Chatham).