FINAL REPORT FOR AWARD # 0452045

GA Tech Res Corp - GIT
Design of advanced sensing materials

Participant Individuals:
CoPrincipal Investigator(s) : Miroslawa Josowicz
Post-doc(s) : J. Anthony Smith
Graduate student(s) : Hang Chen; J. Anthony Smith; Isao Sasaki; Temitope Aiyejorun; Amir Saheb; Linda van Rosmalen; Liz Thompson; Jamie Maddox-Summerour
Undergraduate student(s) : Shino Ohira; Emma Turner
Post-doc(s) : George Yu
Graduate student(s) : Ryan Cantor; Greg Moakes
Undergraduate student(s) : David Lovett
Graduate student(s) : Ryan West; Alex Jonke; Jennifer Steeb
Undergraduate student(s) : Robin Forrest
Other -- specify(s) : Bambang Kuswandi
Undergraduate student(s) : Roya Kalantari; Kevin C Vavra; India Mayo; Michelle Leon; Heather Jekot; Jerrica Mathis; Travis Banks
Other -- specify(s) : Marta Lewandowska

Participants' Detail

Partner Organizations:
ETH Zurich, Switzerland: Collaborative Research

Weizmann Institute of Science: Collaborative Research; Personnel Exchanges

Center for Disease Control, Atlanta GA: Collaborative Research

Emory University: Collaborative Research

Medical College of Georgia: Collaborative Research

Oak Ridge National Laboratory: Collaborative Research

Pacific Northwest National Laboratory: Collaborative Research

Georgia Tech - MiRC: Collaborative Research

University of Namur, Belgium: Collaborative Research

GenProbe, Inc.: Collaborative Research

Variable Technologies, Inc.: Collaborative Research

Other collaborators:

Janusz Kowalik, Georgia Tech
Andreas Hierlemann, ETH Z&#65533;rich, Switzerland
William Brogdon, CDC Atlanta
Muhannad Bakir, MiRC, (Georgia Tech)
Angela Caliente (Emory University)
William Dynan (MCG)
Facundo Fernandez (Georgia Tech)
Laszlo Hevesi (University of Namur, Belgium)
Muhannad Bakir (MiRC, Georgia Tech)
Mark Engelhard (PNNL)
George Yu (VT, Inc.)

Activities and findings:

Training and Development:

Post-Doctoral
none

PhD Students:
Ryan West
Alex Jonke
Linda van Rosmalen
Jennifer Steeb (graduated 2010)

MSc Students
none

Undergraduates:
Michelle Leon
Heather Jekot (graduated Dec 2010)
Jerrica Mathis (graduated Dec 2010)
Travis Banks

Visiting undergraduates:

Marta Lewandowska
ETH Zurich, D-BSSE

MSc Students
Ryan Cantor (graduated 06/30/09)

Undergraduates:
Roya Kalantari (since 07/01/08)
Kevin C. Vavra (since 07/01/08)
India Mayo (07/01/08-06/30/09)

Visiting undergraduates:

Carlos Gonzales
University of Valencia, Spain
Spring semester 2009

Marta Lewandowska
ETH Zurich, D-BSSE

Teacher Program

NNIN RETs (National Nanotechnology Infrastructure Network
Education & Outreach Coordinator)

Berkil Alexander
Physics teacher
Pebblebrook High School in Cobb County, GA
June/July 2009

Outreach Activities:

Advisory Panel of CONICYT (Chilean equivalent of NSF)
Science Advisory Panel of Abo Akademi, Turku, Finland

Journal Publications:

J. A. Smith, M. Josowicz, J. Janata, "Gold/polyaniline composite: Part I Moving electrochemical interface", *Phys. Chem. Chem. Phys.*, vol. 7, (2005), p. 3614., " " Published

J. A. Smith, M. Josowicz, J. Janata, M. Engelhard, D. R. Baer, "Gold/polyaniline composite: Part II Effect of nanometer size clusters", *Phys. Chem. Chem. Phys.*, vol. 7, (2005), p. 3619., " " Published

John Hartung, Janusz Kowalik, Christine Kranz, Jiri Janata, Mira Josowicz, Ashwini Sinha, Kendra McCoy, "Electropolymerization of bilayer with phosphonic acid tethers for immobilization of biomolecules", *J. Electrochem. Soc.*, vol. 152, (2005), p. E345., " " Published

Temitope Aiyejorun, Janusz Kowalik, Jiri Janata, Mira Josowicz, "Label-free detection of DNA hybridization by cyclic voltammetry", *J. Chem. Educ.*, vol. , (), p. ., " " Accepted

Jamie Summerour, Yanfeng Chen, MIra Josowicz, Thomas M. Orlando, Alena Paulenova, Jiri Janata, "A beta microirradiator", *Radiation Physics and Chem.*, vol. , (2005), p. ., " " Accepted

Isao Sasaki, Mira Josowicz, Jiri Janata, "Photo-induced stabilization of polyaniline matrix for gas sensor applications", *Chem. Mater.*, vol. , (), p. ., " " Submitted

Hang Chen, Arun Rambathia, Jiri Janata, "Origin of electric field-modulation in organic field-effect transistors", *J. PHys. Chem. B*, vol. , (), p. ., " " Submitted

Carla dos Santos Riccardil, Yideko Yamanaka, Mira Josowicz, Janusz Kowalik, Boris Mizaikoff, Christine Kranz, "Label-free DNA detection based on modified conducting polypyrrole films at microelectrodes", *Anal. Chem.*, vol. 78, (2006), p. 1139., " " Published

Temitope Aiyejorun, Janusz Kowalik, Jiri Janata, Mira Josowicz, "Label-free detection of DNA hybridization by cyclic voltammetry", *J. Chem. Ed.*, vol. 83, (2006), p. 1208., " " Published

Isao Sasaki, Mira Josowicz, Jiri Janata, "Long-term stabilization of conductivity and work function by uv irradiation of campphorsulfonic acid-doped polyaniline", *Synth. Metals*, vol. , (), p. ., " " in preparation

Isao Sasaki, Mira Josowicz, Jiri Janata, Ari Glezer, "Continuous monitoring of filter performance using jet-sensing array", *The Analyst*, vol. 131, (2006), p. 751., " " Published

Amir Saheb, Jiri Janata, Mira Josowicz, "Reference electrode for ionic liquids", *Electroanal.*, vol. 18, (2006), p. 406., " " Published

Greg Moakes, Leslie T. Gelbaum, Johannes Leisen, Jiri Janata, Vladimir Maracek, "Solvation dynamics of lithium salts in wet nitrobenzene", *J. Electroanal. Chem.*, vol. 593, (2006), p. 111., " " Published

Hang Chen, Arun Rambathia, Karin Potje-Kamloth, Jiri Janata, "Origin of electric field-modulation in organic field-effect transistors", *J. Electrochem. Soc.*, vol. , (), p. ., " " Submitted

Greg Moakes, Leslie T. Gelbaum, Johannes Leisen, Jiri Janata, Vladimir Marecek, Luke L. Daemen, "2D NMR studies of dynamics of lithium/water/nitrobenzene system", *J. Phys. Cond. Matter*, vol. , (), p. ., " " Submitted

Isao Sasaki, Mira Josowicz, Jiri Janata, "Study of selective layer for HCN sensing", *Electroanal.*, vol. , (), p. ., " " Accepted

Greg Moakes, Jiri Janata, "Spectroscopic study of dynamics of nitrobenzene/water system", *Acct. Chem. Res.*, vol. , (), p. ., " " Submitted

Hang Chen, Arun Rambathla, Karin Potje-Kamloth, Jiri Janata, "Study of electric field-modulation in organic field-effect transistors", *J. Electrochem. Soc.*, vol. 154, (2007), p. H453., " " Published

Isao Sasaki, Mira Josowicz, Jiri Janata, "Study of selective layer for HCN sensing", *Electroanalysis*, vol. 19, (2007), p. 37., " " Published

Isao Sasaki, Jiri Janata, Mira Josowicz, "Stabilization of electronic properties of (1R)-(9-)-10-camphorsulfonic acid doped polyaniline by UV irradiation", *Polymer Degradation and Stability*, vol. 92, (2007), p. 1408., " " Published

R. Cantor, H. Ishida, J. Janata, "Sensing array for coherence analysis of modulated chemical plume", *Anal. Chem.*, vol. , (2007), p. ., " " Accepted

Greg Moakes, Jiri Janata, "Slow solvation dynamics of water/nitrobenzene system", *Accounts Chem. Res.*, vol. 40, (2007), p. 720., " " Published

Amir Saheb, J. Anthony Smith, Mira Josowicz, Don R. Baer and Mark H. Engelhard, "Controlling size of gold clusters in polyaniline from top down and from bottom up", *J. Electroanal. Chem.*, vol. , (2007), p. ., " " Accepted

George Yu, Mira Josowicz, William Hunt, Jiri Janata, "Magnetic quartz crystal microbalance", *Rev. Sci. Instr.*, vol. 78, (2007), p. 065111-1., " " Published

G. Yu, J. Janata, "Proximity effect in QCM", *Anal. Chen.*, vol. , (), p. ., " " Submitted

Wen Chen, Mira Josowicz, Bhaskar Datta, Gary B. Schuster, and Jiri Janata, "In situ electropolymerization of DNA-templated aniline assemblies on a gold surface", *Electrochem.Solid State Lett.*, vol. 11, (2008), p. E11., " " Published

Amir Saheb, Mira Josowicz and Jiri Janata, "Chemically Sensitive Field-Effect Transistor with Polyaniline-Ionic Liquid Composite Gate", *Anal.Chem.*, vol. 80, (2008), p. 4214., " " Published

Jiri Janata and Mira Josowicz, "Organic Semiconductors in Potentiometric Gas Sensors", *J.Solid State Electrochem.*, vol. 13, (2009), p. 41., " " Published

George Yu and Jiri Janata, "Magnetic Quartz Crystal Microbalance: A Multi-layer Gold/Nickel Stack", *J.Appl.Phys.*, vol. 104, (2008), p. 043908., " " Published

Amir Saheb, Mira Josowicz and Jiri Janata, "Field-Effect Transistors with Mixed Ionic-Electronic Grate", *Electroanalysis*, vol. , (2008), p. ., " " Accepted

Jiri Janata, "Role Of Analytical Chemistry In Defense Strategies Against Chemical And Biological Attack", *Anal.Reviews*, vol. , (2009), p. ., " " Accepted

Jennifer Steeb, Mira Josowicz and Jiri Janata, "Nickel-63 Microirradiator", *Anal. Chem.*, vol. , (2009), p. ., " " Submitted

Ryan West, Mira Josowicz, Jiri Janata, Isabelle Mine and Laszlo Hevesi, "Controlled Electropolymerization of 1-pyrrolyl-10-decanephosphonic acid: an Anion Barrier Layer", *J.Electrochem.Soc.*, vol. , (2009), p. ., " " Submitted

dos Santos Riccardi, Carla; Kranz, Christine; Kowalik, Janusz; Yamanaka, Hideko; Mizaikoff, Boris; Josowicz, Mira, "Label-Free DNA Detection of Hepatitis C Virus Based on Modified Conducting Polypyrrole Films at Microelectrodes and Atomic Force Microscopy Tip-Integrated Electrodes", *Analytical Chemistry*, vol. 80, (2008), p. 237., " " Published

Hatchett, David W.; Josowicz, Mira, "Composites of Intrinsically Conducting Polymers as Sensing Nanomaterials", *Chemical Reviews*, vol. 108, (2008), p. 746., " " Published

Saheb, Amir; Smith, J. Anthony; Josowicz, Mira; Janata, Jiri; Baer, Don R.; Engelhard, Mark H., "Controlling size of gold clusters in polyaniline from top-down and from bottom-up", *J Electroanal. Chem.*, vol. 621, (2008), p. 238., " " Published

Janata, Jiri; Josowicz, Mira; Kowalik, Janusz; Hierlemann, Andreas; Heer, Flavio; Kirstein, Kay-Uwe., "Electrochemical biosensor arrays and systems for use with a CMOS detection and/or actuation circuit having a plurality of chem. detection channels and methods of making same", *PCT Int. Appl.*, vol. , (2008), p. 48., " " Published

Jiri Janata, "Organic semiconductors in potentiometric gas sensors", *Electrochem.*, vol. 13, (2009), p. 41., " " Published

Amir Saheb, Mira Josowicz, Jiri Janata, "Field-effect transistors with mixed ionic electronic gate", *Electroanalysis*, vol. 21, (2009), p. 290., " " Published

Jiri Janata, "Role of analytical chemistry in defense strategies against chemical and biological attack", *Anal. Reviews*, vol. 2, (2009), p. 321., " " Published

Jennifer Steeb, Mira Josowicz, Jiri Janata, "Nickel-63 Microirradiator", *Anal. Chem.*, vol. 81, (2009), p. 1976., " " Published

Ryan west, Mira Josowicz, Jiri Janata, Isabelle Mine, Laszlo Hevesi, "Controlled electropolymerization of 1-pyrrolyl-10-decanephosphonic acid: An anion barrier layer", *J. Electrochem. Soc.*, vol. 156, (2009), p. F55., " " Published

Jennifer Steeb, Asiri S. Galhena, Leonard Dyadong, Jiri Janata, Facundo M. Fernandez, "Beta-assisted direct chemical ionization (BADCI) probe for ambient mass spectrometry", *Chem. commun.*, vol. , (2009), p. 4699., " " Published

Jiri Janata and Petr Zuman, "Electrochemical acidity functions", *Coll. Czechoslov. Chem. Commun.*, vol. 74, (2009), p. 1635., " " Published

Jiri Janata, "Potentiometry in gas phase", *Coll. Czechoslov. Chem. Commun.*, vol. 74, (2009), p. 1623., " " Published

G.Y.Yu, K.C.Vavra and J. Janata, "Magnetic Quartz Crystal Microbalance: Alternating Ferromagnetic/Diamagnetic Multilayers", *ECS Trans.*, vol. 19, (2009), p. 343., " " Published

India Mayo, Alex Jonke, Jiri Janata and Mira Josowicz, "Gel Hybrid Material as the Sensing Gate of CHEMFET", *ECS Trans.*, vol. 19, (2009), p. 343., " " Published

Ryan West, Mira Josowicz and Jiri Janata, "Electropolymerization of a Cation-permeable Layer Using 1-pyrrolyl-10-decanephosphonic Acid", *ECS Trans.*, vol. 19, (2009), p. 191., " " Published

Jennifer Steeb, Jiri Janata and Mira Josowicz, "Electrochemically Prepared Beta Microirradiator", *ECS Trans.*, vol. 19, (2009), p. 305., " " Published

Alex Jonke, Mira Josowicz, Jiri Janata, "Electrochemically Controlled Atom by Atom Deposition of Gold to Polyaniline", *J. Electrochem. soc.*, vol. 157, (2010), p. P83., " " Published

Mira Josowicz, Roya Kalantari, Ryan Cantor, Hang Chen, George Yu, Jiri Janata, "Label-free voltammetric detection method using individually addressable oligonucleotide microelectrode arrays", *Anal. Chem.*, vol. 82, (2010), p. 9028., " " Published

Kevin C. Vavra, George Yu, Mira Josowicz, Jiri Janata, "Magnetic Quartz Crystal Microbalance: Magnetoacoustic Parameters", *J. Appl. Phys.*, vol. , (2011), p. ., " " Accepted

ryan West, Colby Watts, Mira Josowicz, Jiri Janata, "Fluctuation Analysis of Work Function of Organic Semiconductors", *Coll. Czech. Chem. Commun.*, vol. , (2011), p. ., " " Accepted

Book(s) of other one-time publications(s):

Amir Saheb, Mira Josowicz, Jiri Janata, Benjamin R. Mattes, "Electropolymerization of aniline from ionic liquids" , bibl. ECS Proceedings Volume 2004-18, p. 192-203, (2004). *Proceedings* Published of Collection: Viola I. Blirss, Dennis Evans, Mira Josowicz, Masatoshi Osawa, "Electrode Processes VII"

Temitope Aiyejorun, Liz Thompson, Janusz Kowalik, Mira Josowicz, Jiri Janata, "Control of chloride ion exchange by DNA hybridization at polypyrrole electrode" , bibl. Elsevier Publishers, (). *Book* Accepted of Collection: E. Palecek, F. Scheller, J. Wang, "Electrochemistry of Nucleic Acids and Proteins"

Amir Saheb, Mira Josowicz, Jiri Janata, Benjamin R. Mattes, "Electropolymerization of aniline from ionic liquids" , bibl. ECS Proc., Vol 2004-18, p. 192-203, (2004). *Proceedings* Published of Collection: Viola I. Blirss, Dennis Evans, Mira Josowicz, Masatoshi Osawa, "Electrode Processes VII. Proceedings of the International Symposium"

J. Janata, et al, "Defending the US Air transportation system against chemical and biological threats" , bibl. National Academies Press, ISBN 0-309-10074-7, (2006). *Book* Published

J. Janata, "Principles of Chemical Sensors" , bibl. 2nd edition, Springer Verlag, (). *Book* In preparation

J. Janata, "Principles of Chemical Sensors, 2nd edition" , bibl. Springer-Verlag, (2009). *Book* Published

Various, "35 Years of Chemical Sensors- An Honorary Symposium for Professor Jiri Janata's 70th Birthday Celebration" , bibl. In ECS Trans., 19(6), (2009). *Book* Published of Collection: Li, J.; Brown, R.; Hatchet, D.; Vanysek, P.; Bruckner-Lea, C.; Josowicz, M., ""

Other Specific Products:

Internet Dissemination:

http://www.chemistry.gatech.edu/sensingforum-02/welcome.html http://www.frostmiller.com/biosensing/

Contributions:

Contributions within Discipline:

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 Co-Chair Symposium (Beyond Sensing Arrays). Pittcon 2011
Extensive refereeing for funding agencies as well as for scientific journals

Presentations (2010/2011)

'Current Research', OPTI Systems, Inc., Roswell, April
'Potentiometry in Gas Phase', U. of Puerto Rico, May
'Potentiometry in Gas Phase', General Electric, Schenectady, August
'Magnetic Quartz Crystal Microbalance', Charles U. Prague, October
'Modern Potentiometry and its Environmental and Health Applications',
Prague, Charles U. October
'Magnetic Quartz Crystal Microbalance: Magnetoacoustic Analysis', Pacifichem
Meeing, Honolulu, December
'Doping Of Organic Semiconductors For Use In Chemical Electronics', Argonne
Natl. Lab., February
'Potentiometry in Gas Phase', Pittcon, 2011, Atlanta, March
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Contributions to Other Disciplines:

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 None.
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Contributions to Education and Human Resources:

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 The training of students, particularly undergraduate students has been
a major educational thrust in this project.
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Contributions to Resources for Science and Technology:

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 The DNA experiment that grew out of this project is being used successfully
in the senior undergraduate class CHEM 4861 (the 'Capstone' course) in
the Fall 2010.
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Contributions Beyond Science and Engineering:

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 None.
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Conference Proceedings:

Categories for which nothing is reported:
Research and Education Activities
Findings
Products: Other Specific Product
Conference Proceedings

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Activities and Findings (Percentages of effort in parentheses)

(I) Research Activities Supported from this Grant:

(A) Fluctuation Analysis of Work Function of Organic Semiconductors. (25%)

The validity charge-transfer doping equation has been further confirmed. However, due to lack of funding further work on this topic has been suspended. Fluctuation-dissipation theorem has been used to perform stochastic analysis of fluctuation of work function of organic semiconductors. We believe that this is a new and only technique by which the dynamics of work function can be studied under atmospheric conditions (Ref. 4).

(B) Atom – by- atom deposition of metals into organic semiconductors (25%)

The optimization of bottom-up synthesis of atomic alloys continued. The goal has been to achieve greater degradation stability, which will be important for application of these materials for chemical sensors and as catalytic materials (Ref. 1)

(C) Magnetic Quartz Crystal Microbalance (MQCM) (25%)

A protocol for quantitative evaluation of magneto-acoustic admittance and magneto-acoustic capacitance has been developed. New and interesting magnetic properties of thin films of CuNi alloys have been evaluated (Ref.3)

(D) Electrochemical DNA Array (10%)

This project has been terminated for the lack of funding. However, it has served as training for undergraduate students (Ref. 2). It has been transferred to the Albany State University (Historically Black College). We are supporting it by providing no-cost consultation to our former student (Dr. Amir Saheb, Assistyant Professor at ASU).

(E) Microirradiator (15%)

Upon graduation of Dr. Jennifer Steeb (now at Argonne National Laboratory) this project has been terminated for the lack of funding.

(III) Educational Activities:

We currently have three graduate students in the group. Four undergraduate interns were working with us in Summer/Fall 2010.

Major Findings:

(A) We have optimized preparation of the PANI/Au_n composites with the range of atomic clusters from n = 0 to n = 8. The major change in the protocol has been the stabilization of the PANI matrix prior to Au deposition. Preliminary studies indicate major improvement in the catalytic activity for oxidation of alkyl alcohols. (Ref. 1)

(B) The methodology for evaluation of kinetic parameters from equilibrium fluctuations, using the fluctuation-dissipation theorem has been developed. It is a new and only technique that allows stochastic analysis of fluctuations of work function of organic semiconductors (Ref. 4)

(C) Deposition of NiCu alloys on Magnetic Quartz Crystal Microbalance has been developed. It allows study of magnetoacoustic properties of thin films of materials (Ref. 3)

(D) Project focused on label-free electrochemical DNA hybridization array has been concluded (Ref. 2). We are now assisting Albany State University (historically black college) with adopting this approach in their science curriculum.