Wei-Chang David Yang | 917-331-1221 (cell) | 301-975-8398 (office) | david.yang@nist.gov

National Institute of Standards and Technology | 100 Bureau Drive, Mail Stop 6203, Gaithersburg, MD 20899, USA

Current Appointment

National Institute of Standards and Technology | Department of Commerce ***Gaithersburg, MD***

Materials Research Engineer • Physical Measurement Laboratory *January 2020 – Present*

- Develop and disseminate new measurement methods and application areas, utilizing an environmental transmission electron microscope (ETEM) and other optical analytical methods for advanced nanoscale devices, catalysts, and electronic materials.

Past Appointment

National Institute of Standards and Technology | University of Maryland (UMD) ***Gaithersburg, MD***

Post-doctoral Fellow • Institute for Research in Electronics and Applied Physics (IREAP), UMD *March 2015 – December 2019*

- Principle Investigator: Renu Sharma (NIST Physical Measurement Laboratory)

Education

Purdue University ***West Lafayette, IN***

Ph.D. in Materials Engineering *August 2009 – February 2015*

- Dissertation: Kesterite Thin-Film Solar Cell Absorbers Derived Using Inhomogeneous CZTS Nanoparticles
- Co-Advised by Eric A. Stach, Rakesh Agrawal, and Carol Handwerker
- Solar Economy IGERT Fellowship & GAANN Fellowship
- GPA: 3.91/4.0

National Tsing Hua University ***Hsinchu, Taiwan***

M.S. in Materials Science and Engineering *September 2004 – June 2006*

- Thesis: Silicide as a Catalyst and Source/Drain Electrode for Self-aligned Carbon Nanotube Field-Effect Transistor
- Advisor: Tri-Rung Yew
- GPA: 3.65/4.0

B.S. in Materials Science & Engineering *September 2000 – June 2004*

Research Experience

National Institute of Standards and Technology ***Gaithersburg, MD***

PML/UMD Postdoctoral Research Fellow • Physical Measurement Laboratory *March 2015 – Present*

Plasmon-induced chemical processes at gas-solid interfaces

- Utilizing electron-beam-excited localized surface plasmon (LSP) resonance to drive chemical reactions at the gas-solid interface.
- Characterizing LSP resonance and gas adsorption on the catalyst surface using in-situ EELS in an environmental TEM.
- Synthesizing facet-controlled nanostructures to accommodate selective LSP modes and gas adsorption on metal surface.
- Simulating LSP resonance energies and electric field using boundary element method (BEM) calculations in MATLAB.
- Analyzing hyperspectral datasets using unsupervised machine learning algorithms to achieve unbiased data analysis.

In-situ study of carbon nanotube growth and optical spectroscopy in a TEM

- Investigating carbon nanotube (CNT) growth using metal catalysts, such as Co, Ni and Na, in an environmental TEM.
- Conducting in-situ Raman spectroscopy and maintaining rigorous safe laboratory practices during carbon nanotube growth.
- Identifying defect-mediated charge-carrier recombination at grain boundaries in CdTe using cathodoluminescence (CL).
- Characterizing the electronic structure of transition metal chalcogenide 2D materials using STEM-CL and valence EELS.

Purdue University ***West Lafayette, IN***

NSF Solar Economy IGERT Fellow & GAANN Graduate Research Fellow *August 2009 – February 2015*

Kesterite copper-zinc-tin chalcogenide thin-film solar cells derived from nanoparticles ink

- Developed colloid synthesis of chalcogenide polymorphs and optimize the crystal growth from nanoparticles to thin films.
- Fabricated thin-film solar cells and performed device characterization using J-V, EQE, and C-V measurements.
- Discovered structural and chemical fluctuations in the nanoparticles and thin films using aberration-corrected S/TEM and FIB.

National Tsing Hua University ***Hsinchu, Taiwan***

Graduate Research Assistant *September 2004 – June 2006*

- Discovered the growth of single-wall carbon nanotubes from stacked layers of Co and Si
- Optimized the self-formation of silicide that provided the source and drain contacts in CNT field-effect transistors (FET)

Teaching Experience

Lecturer – ChE 597: Solar Energy Conversion (Structures & Defects in Semiconductors)	2011 – 2013	***West Lafayette, IN***
Teaching Assistant – MSE 230: Structure and Properties of Materials	2013	***West Lafayette, IN***
Teaching Assistant – MSE 235: Materials Properties Laboratory	2009	***West Lafayette, IN***
Teaching Assistant – Electronics (Undergraduate-level)	2005	***Hsinchu, Taiwan***
Teaching Assistant − Semiconductor Material and Device Characterization (Graduate-level)	2004	***Hsinchu. Taiwan***

Proposal Writing Experience

Dept. of Energy: Energy Frontier Research Centers Launching Earth Abundant Photovoltaics (PI: Prof. Rakesh Agrawal)	2014	***Declined***
Dept. of Energy: Brookhaven National Laboratory User Proposal at the Center for Functional Nanomaterials (PI: Prof. Rakesh Agrawal)	2013	***Declined***
Dept. of Energy: Brookhaven National Laboratory User Proposal at the Center for Functional Nanomaterials (PI: Prof. Rakesh Agrawal)	2012	***Approved***

Honors

Awards

Early Career Award, American Vacuum Society (AVS) Nanometer-scale Sci. and Tech. Division	2019	***Columbus, OH***
Microscopy & Microanalysis Postdoctoral Scholar Award, Microscopy Society of America	2019	***Portland, OR***
Travel Scholarship – 8th International Workshop on EELS and Related Techniques	2017	***Okinawa, Japan***
Best Poster Award – Tsing Hua MSE Poster Competition	2006	***Hsinchu, Taiwan***
President's Student Service Award – extraordinary impact on the University community	2004	***Hsinchu, Taiwan***
Presidential Award – awarded to top one student in academic performance	2004	***Hsinchu, Taiwan***

Scholarships

Solar Economy IGERT Fellowship, National Science Foundation	2011 – 2015	***West Lafayette, IN***
GAANN Fellowship, Department of Education	2009 – 2011	***West Lafayette, IN***
Mr. Feng-Chang Lu Memorial Scholarship, National Tsing Hua University	2003 – 2004	***Hsinchu, Taiwan***
Cathay Life Insurance Company Scholarship, Cathay Charity Foundation	2002 – 2004	***Hsinchu, Taiwan***

Outreach, Mentoring & Professional Activities

Organizer for the Microscopy & Microanalysis Pre-Meeting Congress by Electron Microscopy in Liquids and Gases Focused Interest Group (2020)	2019 – Present	***Milwaukee, WI***
Organizer for the Multimodal Methods for In Situ Electron Microscopy Workshop at NIST (2020)	2019 – Present	***Gaithersburg, MD***
Reviewer for scientific journals – *Solar Energy Materials & Solar Cells* and *Metrologia*	2014 – Present	***Gaithersburg, MD*** ***West Lafayette, IN***
Mentored one undergraduate researcher in NIST Summer Undergraduate Research Fellowships (SURF) program	2017	***West Lafayette, IN***
Volunteered in the annual NanoDays events (Birck Nanotechnology Center) to lead educational activities that introduce nanoscale science to students and teachers in grades K-12	2011 – 2014	***West Lafayette, IN***
Mentored one undergraduate researcher in Purdue University Summer Undergraduate Research Fellowships (SURF) program	2011	***West Lafayette, IN***

Core Skills

Nanoscience

- Colloid synthesis & crystallography
- Light-matter interactions
- Catalysis & interfacial chemistry
- Nanofabrication & crystal growth

In-situ Materials Characterization

- Transmission electron microscopy (TEM)
- Electron energy-loss spectroscopy (EELS)
- Cathodoluminescence spectroscopy (CL)
- Raman/Photoluminescence spectroscopy

Automated data processing

- Instrument integration for data acquisition
- Hyperspectral data analysis
- Scientific Programming in Python, MATLAB, LabVIEW, Mathematica

Publications

1. Wei-Chang D. Yang, Canhui Wang, Lisa A. Fredin, Pin Ann Lin, Lisa Shimomoto, Henri J. Lezec, and Renu Sharma, "Site-selective CO disproportionation mediated by localized surface plasmon resonance excited by electron beam," *Nature Materials* **18**, 614-619 (2019).
2. Yohan Yoon*, Wei-Chang D. Yang*, Dongheon Ha, Paul M. Haney, Daniel Hirsch, Heayoung P. Yoon, Renu Sharma, and Nikolai Zhitenev, "Unveiling Defect-Mediated Charge-Carrier Recombination at the Nanometer Scale in Polycrystalline Solar Cells," *ACS Applied Materials & Interfaces* **11**, 47037-47046 (2019). (*Contributed equally to this work)

3. Canhui Wang, Wei-Chang D. Yang, Alina Bruma, David Raciti, Amit Agrawal, and Renu Sharma, "Endothermic reactions at room temperature enabled by deep-ultraviolet plasmons," under review.
4. Richard Li, Erica Antunes, Estelle Kalfon-Cohen, Akira Kudo, Luiz Acauan, Wei-Chang D. Yang, Canhui Wang, Kehang Cui, Andrew Liotta, Ananth Govind Rajan, Jules Gardener, David Bell, Michael Strano, J. Alex Liddle, Renu Sharma, and Brian Wardle, "Low-Temperature Growth of Carbon Nanotubes Catalyzed by Sodium-based Household Ingredients," *Angew. Chem. Int. Ed.* **58**, 9204-9209 (2019).
5. Aaron C. Johnston-Peck, Wei-Chang D. Yang, Jonathan P. Winterstein, Renu Sharm, Andrew A. Herzing, "In Situ Oxidation and Reduction of Cerium Dioxide Nanoparticles Studied by Scanning transmission Electron Microscopy," *Micron* **115**, 54-63 (2018).
6. Wenhui Zhu, Jonathan P. Winterstein, Wei-Chang D. Yang, Lu Yuan, Renu Sharma, and Guangwen Zhou, "*In Situ* Atomic-Scale Probing of the Reduction Dynamics of Two-Dimensional Fe_2O_3Nanostructures," *ACS Nano* **11**, 656-664 (2017).
7. Caleb K. Miskin, Wei-Chang D. Yang, Charles J. Hages, Nathaniel J. Carter, Chinmay S. Joglekar, Eric A. Stach, and Rakesh Agrawal, "9.0% Efficient $Cu_2ZnSn(S,Se)_4$ Solar Cells from Selenized Nanoparticle Inks," *Progress in Photovoltaics: Research and Applications* **23**, 654-659 (2015).
8. Erik J. Sheets, Wei-Chang D. Yang, Robert B. Balow, Yunjie Wang, Bryce C. Walker, Eric A. Stach, and Rakesh Agrawal "An in situ phosphorus source for the synthesis of Cu_3P and the subsequent conversion to Cu_3PS_4 nanoparticle clusters," *Journal of Materials Research* **30**, 3710-3716 (2015).
9. Erik J. Sheets, Robert B. Balow, Wei-Chang D. Yang, Eric A. Stach, and Rakesh Agrawal, "Solution-based synthesis and purification of zinc tin phosphide nanowires," *Nanoscale* **7**, 19317-19323 (2015).
10. Nathaniel J. Carter, Roland Mainz, Bryce C. Walker, Charles J. Hages, Justus Just, Manuela Klaus, Sebastian S Schmidt, Alfons Weber, Wei-Chang D. Yang, Ole Zander, Eric A Stach, Thomas Unold, and Rakesh Agrawal, "The role of interparticle heterogeneities in the selenization pathway of Cu–Zn–Sn–S nanoparticle thin films: a real-time study," *Journal of Materials Chemistry C* **3**, 7128-7134 (2015).
11. Wei-Chang Yang, Caleb K. Miskin, Nathaniel J. Carter, Eric A. Stach, and Rakesh Agrawal, "Inhomogeneous Multinary Nanoparticles: A case study of Cu_2ZnSnS_4 nanoparticles," *Chemistry of Materials* **26**, 6955-6962 (2014).
12. Wei-Chang Yang, Caleb K. Miskin, Charles J. Hages, Evan C. Hanley, Eric A. Stach, and Rakesh Agrawal, "Kesterite $Cu_2ZnSn(S,Se)_4$ Absorbers Converted from Metastable, Wurtzite-Derived Cu_2ZnSnS_4 Nanoparticles," *Chemistry of Materials* **26**, 3530-3534 (2014).
13. Nathaniel J. Carter, Wei-Chang Yang, Caleb K. Miskin, Charles J. Hages, Eric A. Stach, and Rakesh Agrawal, "$Cu_2ZnSn(S,Se)_4$ Solar Cells from Inks of Heterogeneous Cu-Zn-Sn-S Nanocrystals," *Solar Energy Materials and Solar Cells* **123**, 189-196 (2014).
14. Brian K. Graeser, Charles J. Hages, Wei-Chang Yang, Nathaniel J. Carter, Caleb K. Miskin, Eric A. Stach, and Rakesh Agrawal, "Synthesis of $(CuInS_2)_{0.5}(ZnS)_{0.5}$ Alloy Nanocrystals and Their Use for the Fabrication of Solar Cells via Selenization," *Chemistry of Materials* **26**, 4060-4063 (2014).
15. Qijie Guo, Grayson M. Ford, Wei-Chang Yang, Charles J. Hages, Hugh W. Hillhouse, and Rakesh Agrawal, "Enhancing the performance of CZTSSe solar cells with Ge alloying," *Solar Energy Materials and Solar Cells* **105**, 132-136 (2012).
16. Qijie Guo, Grayson M. Ford, Wei-Chang Yang, Bryce C. Walker, Eric A. Stach, Rakesh Agrawal, "Fabrication of 7.2% Efficient CZTSSe Solar Cells Using CZTS Nanocrystals," *Journal of the American Chemical Society* **132** (49), 17384-17386 (2010).
17. Chung-Min Tsai, Guo-Dung Chen, Tzu-Chun Tseng, Chung-Yang Lee, Chi-Te Huang, Wan-Yu Tsai, Wei-Chang Yang, Ming-Shih Yeh, Tri-Rung Yew, "CuO nanowire synthesis catalyzed by a CoWP nanofilter," *Acta Materialia* **57** (5), 1570-1576 (2009).
18. Wei-Chang Yang, Tsung-Yeh Yang, Tri-Rung Yew, "Growth of self-aligned carbon nanotube for use as a field-effect transistor using cobalt silicide as a catalyst," *Carbon* **45** (8), 1679-1685 (2007).
19. Hui-Lin Hsu, Wei-Chang Yang, Ya-Lien Lee, Tri-Rung Yew, "Polyacrylonitrile as a gate dielectric material," *Applied Physics Letters* **91**, 023501 (2007).
20. Tsung-Yeh Yang, Wei-Chang Yang, Tzu-Chun Tseng, Chung-Min Tsai, and Tri-Rung Yew, "Ni–Cr alloy to enhance single- and double-walled carbon nanotube synthesis for field-effect transistor fabrication," *Applied Physics Letters* **90**, 223103 (2007).

Invited Talks

1. Wei-Chang D. Yang *et al.* "Identifying Catalytic Mechanisms of Plasmonic Nanostructures Using Multimodal Methods for In Situ Electron Microscopy," Annual EM-Situ Workshop, Harvard University, Boston, MA (2019).
2. Wei-Chang D. Yang *et al.* "Application of electron-beam-excited localized surface plasmon resonance to provide guidelines for designing plasmonic catalysts," Microscopy & Microanalysis Pre-meeting Congress x60, Portland, OR (2019).
3. Wei-Chang D. Yang *et al.* "Unveiling active sites for surface plasmon induced chemical reactions on plasmonic catalysts using electron beam excitation," School of Chemical Engineering, Purdue University, West Lafayette, IN (2019).
4. Wei-Chang D. Yang *et al.* "Application of electron-beam-excited localized surface plasmon resonance to provide guidelines for plasmonic catalysts," Nanoscale Device Characterization Division Staff Meeting, Gaithersburg, MD (2019).
5. Wei-Chang D. Yang *et al.* "Characterizations of functional nanomaterials using analytical and environmental transmission electron microscopes," Naval Research Laboratory, Washington, D.C. (2017).

Contributed Talks

1. Wei-Chang D. Yang *et al.* "Application of electron-beam-excited localized surface plasmon resonance to provide guidelines for plasmonic catalysts," American Vacuum Society 66th International Symposium & Exhibition, Columbus, OH (2019).

2. Wei-Chang D. Yang *et al.* "Application of electron-beam-excited localized surface plasmon resonance to unveil catalytically active sites on Au nanoparticles," Microscopy & Microanalysis Meeting, Portland, OR (2019).
3. Wei-Chang D. Yang *et al.* "Unveiling active sites for localized surface plasmon induced chemical reaction on plasmonic catalysts using electron beam excitation," the 26th North American Catalysis Society Meeting, Chicago, IL (2019).
4. Wei-Chang D. Yang *et al.* "Unveiling Site-Selective CO Disproportionation Mediated by Electron Beam Excited Localized Surface Plasmon Resonance," Materials Research Society Spring Meeting, Phoenix, AZ (2019).
5. Wei-Chang D. Yang *et al.* "Revelation of active sites for room-temperature CO disproportionation on a gold nanoparticle driven by electron-beam-excited localized surface plasmon resonance," Materials Research Society Fall Meeting, Boston, MA (2018).
6. Canhui Wang, Wei-Chang D. Yang *et al.* "Engineering the energy flow in nanoparticles for localized surface plasmon induced catalysis," Microscopy & Microanalysis Meeting, Baltimore, MD (2018).
7. Wei-Chang D. Yang *et al.* "Room temperature CO Dissociation on Selective Edges of Gold Nanoparticles," the 25th North American Catalysis Society Meeting. Denver, CO (2017).
8. Wei-Chang D. Yang *et al.* "Room temperature CO Dissociation on Selective Edges of Gold Nanoparticles," the 8th International Conference on Surface Plasmon Photonics, Taipei, Taiwan (2017).
9. Wei-Chang D. Yang *et al.* "Room temperature CO Dissociation on Selective Edges of Gold Nanoparticles," Microscopy & Microanalysis Meeting, St. Louis, MO (2017).
10. Wei-Chang D. Yang *et al.* "Cathodoluminescence Measurements of CdTe in the Transmission Electron Microscope," Materials Research Society Fall Meeting, Boston, MA (2016).