

## **James H. Edgar** (abbreviated Curriculum Vita)

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### **Work Experience**

Kansas State University, Department of Chemical Engineering, Manhattan, KS

Department Head, 2009-  
Interim Department Head, 2003-2004  
Professor, 1997-present.  
Associate Professor, 1993-1997.  
Assistant Professor, 1988-1993.

*Recent undergraduate courses taught:* Engineering Materials, Chemical Engineering Thermodynamics I & II, Separational Process Design, and Unit Operations Laboratory.

*Recent graduate courses taught:* Introduction to Nanotechnology, Advanced Chemical Engineering Thermodynamics, Processing of Materials for Solid State Devices,

Guest Lecturer *Radboud University Nijmegen*, Applied Materials Science Department, Nijmegen, the Netherlands, July 2006-July 2007.

Sabbatical Fellow *Naval Research Laboratory*, Washington, DC, June 1994-May 1995 (Sabbatical Fellow).

Research Fellow *NASA Lewis Research Center*, Cleveland, OH, summers 1990 and 1991 (Research Fellow).

### **Education**

Ph.D., Chemical Engineering, University of Florida, Gainesville, FL, December 1987.  
Dissertation title: *The Selective Deposition of Gallium Arsenide and Aluminum Gallium Arsenide by Laser-Enhanced Metalorganic Chemical Vapor Deposition*. Completed 39 hours of Electrical Engineering courses emphasizing semiconductor and device physics, crystal growth, and processing of electronic materials. Graduate Advisor: T.J. Anderson.

B.S., Chemical Engineering, University of Kansas, Lawrence, KS, 1981, graduation with honors.

### **Honors**

Commerce Bank Distinguished Graduate Faculty Award, Kansas State University, 2007-2008.

Making a Difference Award, Women in Engineering and Science Program, Kansas State University, 2006.

Ervin W. Segebrecht Distinguished Faculty Achievement Award, Kansas State University, 2005.

William H. Honstead Professorship in Chemical Engineering, Kansas State University, 2002-2005.

Outstanding Scientist Award, Kansas State University Chapter of Sigma Xi, 2000.

College of Engineering Research Excellence Award, Kansas State University, 1998/1999.

### **Professional Activities**

*Symposium chair*, Materials Research Society, *Boron and Boron Compounds: From Fundamentals to Applications*, Fall 2010

*NSF Review panelist* for reverse site visits for the 2005 Materials Science and Engineering Centers (MRSECs), Arlington, VA, May 2005.

*Technical advisor*, to Judge James C. Fox, Senior United States District Judge, for the patent infringement lawsuit North Carolina State University and Cree, Inc. V. Nichia Corporation and Nichia America Corporation, 2002.

*NSF review panelist* for the Electronics, Photonics, and Device Technologies program of the Electrical and Communications Systems Division, Arlington, VA, June 2000.

*NSF review panelist* for Engineering Research Centers, preproposals, Arlington, VA, March 1999.

*NSF review panelist* for the Small Business Innovation Research Program, phase II proposals, Arlington, VA, February 1999.

Reviewer of individual proposals for: ACS; Australian Research Council; Civilian Research and Development Foundation; Defense Threat Reduction Agency, Israel Science Foundation; Kansas Technology Center; Nebraska Energy Office; National Academy Research Council; NSF; and South Carolina Commission on Higher Education.

Member Electrochemical Society; American Vacuum Society; Institute of Electrical and Electronic Engineers; American Institute of Chemical Engineers; Materials Research Society; Sigma Xi.

Journal Manuscripts Reviewed (reviewer for 26 different journals): AIChE Journal; Applied Physics Letters; Applied Surface Science; Chemical Engineering Communications; Chemistry of Materials; Diamond and Related Materials; Electrochemical and Solid State Letters; Internation-

al Journal of Heat and Mass Transfer; Journal of Alloys and Compounds; Journal of the American Ceramics Society; Journal of Applied Physics; Journal of Crystal Growth; Journal of the Electrochemical Society; Journal of Materials Research; Journal of Nanotechnology; Journal of Physical Chemistry; Journal of Physics. D, Applied Physics; Material Research Society Symposium Proceedings; Nano Letters; Nanotechnology; Philosophical Magazine; Proceedings of the IEEE; Science; Semiconductor Science and Technology; Surface Science; and Thin Solid Films.

### **Institutional Services**

Academic Affairs Committee, Graduate Council, 2009-  
Integrity in Research and Scholarly Activity Committee, 2008-  
Chemical Engineering Representative to the College of Engineering's Reappointment, Tenure, and Promotion Committee, 2007-2009  
Graduate College Assessment Review Committee, 2004-  
Intellectual Property Advisory Committee, 2003-2006  
Chairman, Chemical Engineering Graduate Students Committee, 1996-present.  
Faculty Search Committee, 1998-2001; 2004-2005  
Faculty Grievance Committee, 2000

### **Research Projects, Grants, and Gifts** (career total of more than \$5.4 million)

#### Current

*High K Oxide Insulating Gate Group III Nitride-Based FETs*, DEPSCoR, 2010-2013, \$452,710.

*MRI: Acquisition of a Field Emission Scanning Electron Microscope for Kansas State University*, NSF (lead P.I., with 14 other KSU faculty), 2009-2012, \$725,400.

*Crystal Growth of Alpha Rhombohedral Boron*, II-VI Incorporated Foundation, 2008-2010, \$127,900

*Boron-Rich semiconductors for Neutron Detectors*, Domestic Nuclear Detection Office/National Science Foundation Academic Research Initiative (ARI), 2008-2010, \$300,000.

*Materials World Network: Collaborative Research: An Investigation into the Properties of  $B_{12}As_2$ ,  $B_4C$  and their Heterostructures*, National Science Foundation, Division of Materials Research - Office of Special Programs, 2006-2009, \$270,000.

#### Completed

*REU Supplements: Materials World Network: Collaborative Research: An Investigation into the Properties of  $B_{12}As_2$ ,  $B_4C$  and Their Heterostructures*, National Science Foundation, 2008 & 2009, \$12,900.

*REU Supplements: Collaborative Research: Analysis of Defects and Their Causes in Bulk Aluminum Nitride Crystals*, National Science Foundation, 2005, 2006 & 2008, \$18,400

*Collaborative Research: Analysis of Defects and Their Causes in Bulk Aluminum Nitride Crystals*, National Science Foundation, 2004-2007, \$219,058, KSU portion.

*High Growth Rate, High Purity Silicon Carbide Epitaxy*, Office of Naval Research, 2006-2007, \$100,000.

*Aquisition of a Hall Effect Measurement System for Characterizing Novel Semiconductors*, National Science Foundation, 2006-2007, \$154,636.

*Bulk Aluminum Nitride Growth Using Silicon Carbide Seed Crystals*, a phase II STTR with Hexatech, Inc., 2004-2006, \$150,000.

*Highly Durable Crucible Materials to Support Large AlN Crystal Growth*, a phase II STTR with the Fox Group, 2004-2006, \$150,000.

*Rapid Growth of Bulk Aluminum Nitride Crystals*, Office of Naval Research, 2002-2005, \$210,000.

*Epitaxial Growth of Icosahedral Boride Semiconductors for Novel Energy Conversion Devices*, Department of Energy - Kansas Technology Enterprise Corporation, 2002-2005, \$505,000.

*Growth of Large Area, Single Crystalline AlN substrates*, with Hexatech, Inc., an STTR phase I grant, 2002-2003, \$21,000.

*Highly Durable Crucible Materials to Support Large AlN crystal growth*, with the Fox Group, Inc., an STTR phase I grant, 2002-2003, \$21,000.

*Establishment of an Advanced Semiconductor Research Group in the State of Kansas*, (with 8 other faculty at Kansas universities), National Science Foundation, 1999-2001, \$500,000.

*A Study of Growth Morphology and Defect Generation in Aluminum Nitride Crystals Grown by Sublimation*, Office of Naval Research, 1998-2001, \$210,000.

*Nitride Semiconductor Substrates*, A small business technology transfer (STTR) phase I grant in collaboration with Astralux, Office of Naval Research, 2000, \$35,000 (KSU portion).

*An Induction Furnace For Aluminum Nitride Crystal Growth*, Department of Defense University Research Program (DURIP), 1999 \$238,000.

*A Comprehensive AlN Source Materials, Single Crystal and Substrate Development Program*, A small business technology transfer (STTR) phase II grant in collaboration with American Xtal Technology, Department of Defense, 1999-2000, \$335,000 (KSU portion).

## Publications

### Books

Properties, Processing and Applications of Gallium Nitride and Related Semiconductors, J.H. Edgar, S.S. Strite, I. Akasaki, H. Amano and C. Wetzel eds. (INSPEC, The Institution of Electrical Engineers, Stevenage, UK 1999).

Properties of Group III Nitrides, J.H. Edgar ed., (INSPEC, The Institution of Electrical Engineers, Stevenage, UK 1994).

### Refereed Journal Articles (Career total of 94)

#### *Summary of papers*

<u>Topics</u>	<u>Number of papers</u>
Aluminum nitride sublimation crystal growth	25
Silicon carbide epitaxy	16
Icosahedral boron arsenide epitaxy and characterization	10
Scandium nitride crystal growth and characterization	5
Aluminum nitride oxidation	4
Reviews on semiconductor technologies	4

#### *Representative papers*

*Sublimation growth of titanium nitride crystals*, L.Du, J.H. Edgar, E. Kenik, and H.M. Meyer, in press, *J. Mater. Sci., Mater. Electron.*

*ScAlN nanowires: a cathodoluminescence study*, T. Bohnen, G.R. Yazdi, R. Yakimova, G.W.G. van Dreumel, P.R. Hageman, E. Vlieg, R.E. Algra, M.A. Verheijen, and J.H. Edgar, *J. Cryst. Growth* **311** 3147 (2009).

*Growth of scandium aluminum nitride nanowires on ScN(111) films on 6H-SiC substrates by HVPE*, T. Bohnen, G.W.G. van Dreumel, P.R. Hageman, R.E. Algra, W.J.P. van Enckevort, E. Vlieg, M.A. Verheijen, and J.H. Edgar, in press, *Phys. Stat. Solidi A*

*Photoluminescence properties of AlN homoepilayers with different orientations*, A. Sedhain, N. Nepal, M.L. Nakarmi, T.M. Al Tahtamouni, J.Y. Lin, H.X. Jiang, Z. Gu, and J.H. Edgar, *Appl. Phys. Lett.* **93** 041905 (2008).

*Single-Crystalline B<sub>12</sub>As<sub>2</sub> on m-plane 15R-SiC*, H. Chen, G. Wang, M. Dudley, Z. Xu, J.H. Edgar, T. Batten, M. Kuball, L. Zhang, and Y. Zhu, *Appl. Phys. Lett.* **92** 231917 (2008).

*Defect structures in B<sub>12</sub>As<sub>2</sub> epitaxial layers grown on (0001) 6H-SiC*, H.Chen, Guan Wang, M. Dudley, L. Zhang, Y. Zhu, Z. Xu, J.H. Edgar, and M. Kuball, *J. Appl. Phys.* **103** 123508 (2008).

- Native oxide and hydroxide and their implications for bulk AlN crystal growth*, J.H. Edgar, L. Du, L. Nyakiti, and J. Chaudhuri, *J. Cryst. Growth*. **310** 4002 (2008).
- Self-assembled monolayers of alkylphosphonic acid on GaN surfaces*, T. Ito, S. Forman, C. Cao, F. Li, C.R. Eddy, Jr., M.A. Mastro, R.T. Holm, R.L. Henry, K. Hohn, and J.H. Edgar, *Langmuir* **24** 6630 (2008).
- HVPE of scandium nitride on 6H-SiC(0001)*, J.H. Edgar, T. Bohnen, and P.R. Hageman, *J. Cryst. Growth*. **310** 1075 (2008).
- The effect of Si doping on the electrical properties of  $B_{12}As_2$  thin films on (0001) 6H-SiC substrates*, Z. Xu, J.H. Edgar, D.C. Look, S. Baumann, R.J. Bleiler, S.H. Wang, and S.E. Mohny, *J. Appl. Phys.* **101** 053710 (2007).
- Growth of aluminum nitride crystals by sublimation*, Z. Gu, L. Du, J.H. Edgar, N. Nepal, J.Y. Lin, H.X. Jiang, and R. Witt, *J. Cryst. Growth* **297** 105 (2006).
- Interface properties of an  $AlN/(AlN)_x(SiC)_{1-x}/4H-SiC$  heterostructure*, J.H. Edgar, Z. Gu, L. Gu, and D.J. Smith, *Phys. Stat. Sol. A*. **203** 3720 (2006).
- Thermal oxidation of aluminum nitride powder*, Z. Gu, J.H. Edgar, C.M. Wang, and D.W. Coffey, *J. Am. Ceram. Soc.* **89** 2167 (2006).
- Defect selective etching of scandium nitride crystals*, Z. Gu, J.H. Edgar, D.W. Coffey, J. Chaudhuri, L. Nyakiti, R.G. Lee, and J.G. Wen, *J. Cryst. Growth*, **293** 242 (2006).
- High-speed growth of SiC thin films from methyltrichlorosilane by CVD*, P. Lu, J.H. Edgar, O.J. Glembocki, P. Klein, C. Evan, and J. Chaudhuri, *J. Crystal Growth* **285** 506 (2005).
- Ct/Pt Ohmic contacts to  $B_{12}As_2$* , S.H. Wang, E.M. Lysczek, B. Liu, S.E. Mohny, Z. Xu, R. Nagarajan, and J.H. Edgar, *Appl. Phys. Lett.* **87** 042103 (2005).
- Thermal oxidation of polycrystalline and single crystalline aluminum nitride wafers*, Z. Gu, J.H. Edgar, S.A. Speakman, D. Blom, J. Perrin, and J. Chaudhuri, *J. Electron. Mater.* **34** 1271 (2005).
- Wet etching of GaN, AlN, and SiC: a review*, D. Zhuang and J.H. Edgar, *Mater. Sci. Eng. R.* **48** 1 (2005).
- Crystal growth and properties of scandium nitride*, Z. Gu, J.H. Edgar, J. Pomeroy, M. Kuball, and D.W. Coffey, *J. Mater. Sci., Mater. Electronic.* **15** 555 (2004).
- Defect-selective etching of bulk AlN single crystals in molten KOH/NaOH eutectic alloy*, D.J. Zhuang, J.H. Edgar, B. Strojek, J. Chaudhuri, and Z. Rek, *J. Cryst. Growth* **262** 89 (2004).
- Bulk AlN crystal growth: self-seeding and seeding on 6H-SiC substrates*, J.H. Edgar, L. Liu, B. Liu, D. Zhuang, J. Chaudhuri, M. Kuball and S. Rajasingam, *J. Cryst. Growth* **246** 187 (2002).

*Substrates for GaN epitaxy*, L. Liu and J.H. Edgar, Mater. Sci. Eng. R **37** 61 (2002).

*Polytype controlled SiC epitaxy on on-axis 6H-SiC(0001) by adding HCl during growth*, Z.Y. Xie, S.F. Chen, J. H. Edgar, K. Barghout, and J. Chaudhuri, Electrochem.Solid-State Lett. **3** 381 (2000).

*A global growth rate model for aluminum nitride sublimation*, L.H. Liu and J.H. Edgar, J. Electrochem. Soc. **149** G12 (2002).

*Transport effects in the sublimation growth of aluminum nitride*, L.H. Liu and J.H. Edgar, J. Cryst. Growth **220** 243 (2000).

*Unstable composition region in the wurtzite  $B_{1-x-y}Ga_xAl_yN$  system*, C.H. Wei and J.H. Edgar, J. Cryst. Growth **208** 179 (1999).

*Selective epitaxial growth of silicon carbide on SiO<sub>2</sub> masked Si(100): the effects of temperature*, J.H. Edgar, Y. Gao, J. Chaudhuri, S. Cheema, S.A. Casalnuovo, and P.W. Yip, J. Appl. Phys. **84** 201 (1998).

#### Representative Proceeding Papers (Career total of 41)

*Growth of boron carbide crystals from a copper flux*, Y.Zhang, J.H. Edgar, J. Plummer, C. Whitley, H. Chen, M. Dudley, J. Gray, and M. Kuball, in Nuclear Radiation Detection Materials, D.L. Perry, A. Burger, L. Franks, K. Yasuda, and M. Fiederle eds. (Mater. Res. Soc. Symp. Proc. **1164** Warrendale, PA 2009) paper no. L06-02.

*Characterization and growth mechanism of  $B_{12}As_2$  epitaxial layers grown on (1-100) 15R-SiC*, H. Chen, G. Wang, M. Dudley, Z. Xu, J.H. Edgar, T. Batten, M. Kuball, L. Zhang, and Y. Zhu, Silicon Carbide 2008 (Mater. Res. Soc. Symp. Proc. **1069** Warrendale, PA 2008) paper no. 1069-D08-03.

*Transmission electron microscopy study of interface region of AlN/6H-SiC*, J. Chaudhuri, L.O. Nyakiti, P. Lu, J.H. Edgar, and P. Li, Nitrides and Related Bulk Materials, R. Kniep, F.J. DiSalvo, R. Riedel, and Y. Sugahara, eds. (Mater. Res. Soc. Symp. Proc. **1040** Warrendale, PA 2008) paper no. 1040-Q10-05.

*Defect selective etching of AlN on 6H-SiC – transmission electron microscopy study*, L. Nyakiti, J. Chaudhuri, E.A. Kenik, P. Lu, and J.H. Edgar, Nitrides and Related Bulk Materials, R. Kniep, F.J. DiSalvo, R. Riedel, and Y. Sugahara, eds. (Mater. Res. Soc. Symp. Proc., **1040** Warrendale, PA 2008) paper no. 1040-Q11-03.

*Defect structures of  $B_{12}As_2$  epilayers grown on c-plane and a-plane 6H-SiC substrates*, H. Chen, G. Wang, M. Dudley, L. Zhang, Y. Zhu, Y. Zhang, J.H. Edgar, and M. Kuball, in Semiconductor Defect Engineering – Materials, Synthetic Structures, and Devices II, edited by S. Ashok, J.

Chevallier, P. Kiesel, and T. Ogino, *Mater. Res. Soc. Symp. Proc.* **994**, Warrendale, PA 2007) pp. 29-34.

*High resolution transmission electron microscopy study of thermal oxidation of single crystalline aluminum nitride*, J. Chaudhuri, R.G. Lee, L. Nyakiti, Z. Gu, J.H. Edgar, and P. Li, in *Advances in III-V Nitride Semiconductor Materials and Devices*, C.R. Abernathy, H.X. Jiang, and J.M. Zavada eds. (*Mater. Res. Soc. Symp. Proc.*, **955**, Warrendale, PA 2007) p. 0955-I09-01

*Titanium nitride epitaxy on tungsten (100) by sublimation crystal growth*, L. Mercurio, L. Du, J.H. Edgar, and E.A. Kenik, in *Advances in III-V Nitride Semiconductor Materials and Devices*, C.R. Abernathy, H.X. Jiang, and J.M. Zavada eds. (*Mater. Res. Soc. Symp. Proc.*, **955**, Pittsburgh, PA 2007) p.0955-I07-11.

*Growth of rhombohedral  $B_{12}P_2$  thin films on 6H-SiC(0001) by chemical vapor deposition*, P. Lu, J.H. Edgar, J. Pomeroy, M. Kuball, H.M. Meyer, and T.L. Aselage, in *Progress in Compound Semiconductor Materials III - Electronic and Optoelectronic Applications*, D. Friedman, M.O. Manasreh, I. Buyanova, F.D. Auret, and A. Munkholm eds., (*Mater. Res. Soc. Symp. Proc.*, **799** Pittsburgh, PA 2004) Z2.10.1.

*Growth mode and defects in aluminum nitride sublimed on (0001) 6H-SiC*, L. Liu, B. Liu, Y. Shi, J.H. Edgar, in *GaN and Related Alloys 2000*, U. Mishra, M.S. Shur, C.M. Wetzel, B. Gil, and K. Kishino eds., (*Mater. Res. Soc. Symp. Proc.*, **639** Pittsburgh, PA 2001) G3.40.

*A comparison of aluminum nitride freely nucleated and seeded on 6H-silicon carbide*, J.H. Edgar, L.H. Robins, S.E. Coatney, L. Liu, J. Chaudhuri, K. Ignatiev and Z. Rek, *Materials Science Forum* Vols. 338-342, 1599 (2000).

### **Postdoctorates Advised**

Rajamani Nagarajan, *Epitaxial growth of  $B_{12}As_2$  on silicon carbide* (2001-present).

Ying Shi, *Bulk aluminum nitride crystal growth using silicon carbide seed crystals* (1999-2001).

### **Graduate Students Advised (15 Ph.D., 14 M.S.)**

D. Wei, Ph.D., *High dielectric insulators for GaN-based field effect transistors* (in progress)

C. Whiteley, Ph.D., *Crystal growth of  $B_{12}As_2$  and  $B_{12}P_2$*  (in progress)

W. Gao, M.S., *Boron crystal growth* (in progress)

Y. Zhang, Ph.D., *Epitaxy and characterization of icosahedral boron arsenide* (in progress).

L. Du, Ph.D., *Oxygen incorporation and its effects on AlN crystals* (in progress).

- K.D. Swanson, M.S., *Epitaxial growth of silicon carbide on low angle silicon carbide using methyltrichlorosilane chemical vapor deposition* (2008).
- S. Agarwal, M.S., *Study of crucible materials for sublimation growth of aluminum nitride* (2006).
- K. Taggart, M.S., *Aluminum nitride single crystalline, polycrystalline, and powder oxidation and etching behavior* (2006).
- P. Lu, Ph.D., *Sublimation growth of AlN bulk crystals and high speed CVD growth of SiC epilayers and their characterization* (2006).
- Z. Xu, M.S., *Deposition of icosahedral boron arsenide on 6H-SiC and silicon substrates* (2005).
- Z. Gu, Ph.D., *Sublimation growth of AlN-SiC alloys on SiC substrates, AlN and ScN bulk crystals, and thermal oxidation of AlN* (2006).
- P.Lu, M.S., *Investigation of B<sub>12</sub>P<sub>2</sub> thin films grown on 6H-SiC(0001) substrates by CVD* (2004).
- D.J. Zhuang, Ph.D., *Wet etching studies of AlN bulk crystals their sublimation growth by microwaves* (2004).
- B. Liu, Ph.D., *Growth of aluminum nitride bulk crystals by sublimation* (2004).
- L. Liu, Ph.D., *Growth of AlN bulk crystals by sublimation* (2002).
- W.B. Hageman, M.S., *Optimization of epitaxial GaN on 4H-SiC and 6H-SiC substrates*, co-advised with A. Rys (2002).
- B.K. Burkland, M.S., *Selective silicon carbide epitaxy on silicon and silicon carbide substrates* (2001).
- Z. Xie, Ph.D., *Surface etching of 6H-SiC(0001) and its effects on growth of GaN, AlN by MOCVD, and SiC by APCVD* (2000).
- S.E. Coatney, M.S., *Sublimation growth of aluminum nitride* (1999).
- C.-H. Wei, Ph.D., *Growth and characterization of GaB and B GaN by metal-organic chemical vapor deposition* (1999).

## Recent Collaborators

J. Chaudhuri, Mechanical Engineering Department, Texas Tech University, Lubbock, TX  
M. Dudley, State University of New York, Stony Brook, N.Y.  
C.R. Eddy, Jr., Naval Research Laboratory, Washington, D.C.  
M.A. Fanton, Electro-Optics Center, Pennsylvania State University, PA  
G.C. Farlow, Wright State University, Dayton, OH  
O.J. Glembocki, Naval Research Laboratory, Washington, D.C.  
P.R. Hageman, Radboud University, Nijmegen, the Netherlands  
H. Helava, Fox Systems Inc., Livermore, CA  
T. Ito, Department of Chemistry, Kansas State University, Manhattan, KS  
E.A. Kenik, Oak Ridge National Laboratory, Oak Ridge, TN  
P.B. Klein, Naval Research Laboratory, Washington, DC  
M. Kuball, Wills Physics Laboratory, University of Bristol, UK  
D.C. Look, Semiconductor Research Center, Wright State University, Dayton, OH  
H.M. Meyer, Oak Ridge National Laboratory, Oak Ridge, TN  
S.E. Mohny, Pennsylvania State University, University Park, PA  
Z. Sitar, North Carolina State University and Hexatech, Inc., Raleigh, NC  
D. J. Smith, Cent. for High Resolution Electron Microscopy, Arizona State University  
S.A. Speakman, Oak Ridge National Laboratory, Oak Ridge, TN  
A.J. Steckl, Dept. Electrical and Computer Eng., University of Cincinnati, Cincinnati, OH  
J.L. Weyher, Institute of High Pressure Physics, Warsaw, Poland  
S. Wang, Fairfield Crystal, LLC New Milford, CT