

Oliver Chyan

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Professional experience

2006-date	Professor	University of North Texas, Denton, Texas
2010	Visiting Professor	National Taiwan University, Taipei, Taiwan
2003-2004	Visiting Associate Research Fellow	Institute of Atomic and Molecular Sciences, Taiwan Academia Sinica, Taipei, Taiwan
2002-2014	Associate Faculty	Materials Science & Engineering Dept., UNT
1998-2006	Associate Professor	University of North Texas, Denton, Texas
1992-1998	Assistant Professor	University of North Texas, Denton, Texas
1990-1992	Postdoctoral Researcher	University of Cincinnati, Ohio
1984-1989	Graduate Research Assistant	Massachusetts Institute of Technology

Education

1989	Ph.D. in Chemistry, Massachusetts Institute of Technology, Cambridge, USA Dissertation: “ <i>Electrochemical Characterization of Conducting Polymers and Fabrication of Microelectrochemical Transistor with Sub-micron Spacing</i> ”. Advisor: Professor Mark S Wrighton
1984	M.S. in Chemistry, University of Texas at Arlington, Texas, USA Thesis: “ <i>Electrochemistry and Photoelectrochemistry at Sn-doped Indium Oxide/Aqueous Electrolyte Interface</i> ”. Advisor: Professor Krishnan Rajeshwar
1982	M.S. in Analytical Chemistry, National Taiwan University, Taipei, Taiwan Thesis: “ <i>Determination of P, Ge and Si Species by Reductive Molybdate Colorimetry using Flow Injection Analysis</i> ”. Advisor: Professor Yin Mou Chen
1980	B.S. in Chemistry, National Chung-Hsing University, Taichung, Taiwan

Awards

2019	UNT College of Science Faculty Award for Research
2000-2004	Certificates of Honor Teacher for meritorious work with science students
1994, 1997	named in the Siemens Westinghouse Science & Technology Competition
1998	University of North Texas Developing Scholar Award

Research Interests

Microelectronic Materials Chemistry, Interfacial Chemistry Design, Advanced IC Packaging, Microelectronic Fabrication and Process Integration, Nano Scale Materials Characterization, Microscopic Corrosion and Prevention, Molecular Electronics, Silicon Wafer Surface Chemistry, Electrocatalysts.

Recent Research & Student Training Focus: Microelectronic Materials Chemistry

- Over 30 years of research expertise in material chemistry and interfacial characterization related to microelectronics fabrication, advanced packaging and process integration.
- Strong partnership with major IC companies: Intel, TSMC, GlobalFoundries, TI, TEL, NXP/Freescale, Lam Research, Cirrus Logics, K&S, MediaTek, ATMI/Entegris, JSR Micro, SCREEN, Mindox Techno, and L-3 Communications.
- Specialized in Interfacial Engineering across whole spectrum of IC fabrication processes: Front End of Line, Middle End of line, Back End of Line and IC Packaging.
- Develop patented novel patented wafer characterization technology employed by major microelectronic companies.
- Mentor outstanding Graduate Student researchers: *Thirty-two (>85% employed by microelectronic company)*

Research Accomplishments

Professor Chyan's research program has an international reputation for successfully exploring critical underlying fundamental science to facilitate microelectronic fabrication technologies and functional nanostructure design development. Since 1992, Chyan established ***the Interfacial Electrochemistry and Materials Research Laboratory*** where he leads an interdisciplinary research team, *with strong collaboration with IC industry*, to investigate multitude of fundamental and applied research projects relevant to advanced microelectronic fabrication and integration, IC packaging, semiconductor materials chemistry and interfacial electrochemistry. Select achievements are highlighted below.

1) Advanced Microelectronic Fabrication and Integration

a) Advanced IC Packaging

(Focused on Fabrication of Next Generation High Density Cu Interconnect and Wire Bonding Reliability)

- Completed pilot production trial with Mindox Techno in Singapore and NXP at Malaysia based on UNT's Cu-selective passivation coating technology to improve wire bonding reliability. **(Mindox Techno, NXP)**
- Invent a Cu-selective passivation coating technology to achieve reliable Copper to Copper thermocompression Bonding with low cost. **(Elektrum Technologies)**
- Invent a Flux-less Cu pillar to solder bonding technology for Flip-chip packaging application **(SRC, TI, Intel)**
- Demonstrated Cu-Cu wedge bonding on Cu lead frame in open air enabled by Cu-selective passivation coating. **(NXP)**
- Demonstrated Cu-Cu ball bonding in open air assisted by Cu-selective passivation coating. **(NXP)**
- Explored a better understanding of fundamental corrosion mechanism of Cu wire bonded Al bond pad to aid the practical packaging process designs for improved reliability. **(NXP, Freescale, TI, SRC)**
- Invented a Cu selective CVD passivation treatment to enhance Cu wire bonded device reliability reaching *ppb* level failure rate. **(NXP, TI, SRC)**

- Identified key Chemical equilibria that enable precise control on the Cu etching rate to achieve high density interconnects fabrication in advanced IC packaging application. **(Intel, SRC)**
- Invention an attenuated total reflection ATR UV-Vis spectroscopic probe, *U.S. Patent 11099131*, 2021, to monitor and control Cu etching process for high-density Cu Interconnect fabrication. **(Intel, SRC)**
- Invented an electromagnetic radiation induced anisotropic Cu etching process, US patent pending, for high-density Cu interconnect fabrication. **(Intel, SRC)**
- Invented a novel phosphonic acid passivation coating for copper and aluminum to enhance IC packaging reliability. *U.S. Provisional Patent 63/886,578*, 2025.

b) Front End of Line Processing for Microelectronic Fabrication

(Focused on Surface Preparation for Advanced Transistor Fabrication)

- Invented FEOL etchants that selectively remove growth defects from MOCVD 2D MoS₂ wafer to facilitate < 2nm transistor fabrication. **(TEL, Intel and SRC)**
- Explore wet chemistry processing mechanisms of 2-D materials for < 2nm transistor node application. **(TEL, Intel and SRC)**
- Established contamination mechanisms of trace inorganic and organic contamination on silicon wafer surfaces in SC1, SC2, BOE, HF wet cleaning processes. **(TI)**
- Invented Si-based Potentiometric Metallic Impurities sensor (U.S. Patent # 6145372) to aid FEOL chemical processing control in SC1, SC2, BOE, HF etching and cleaning. **(TI)**
- Invented Chemical Bonding Mapping Metrology to establish early back-bonded oxide formation on silicon wafer caused by ppb-ppt level of metallic contamination. **(TI, SRC)**
- Identified ppb organic contamination sources in HF by Multiple Internal Reflection Infrared Spectroscopy. **(TI)**

c) Middle end and Back End of Line Processing for Microelectronic Fabrication

(Focused on Nano-Interconnects and Porous Low-k Dielectric Optimization)

- Explore wet/dry etches and cleans mechanism at the extreme confined spaces (1-5nm). **(TEL)**
- Explore interfacial chemistry optimization to achieve nano-interconnects (<15 nm) fabrication using Ru, Mo, Co and selected intermetallic materials. **(SRC)**
- Invented Ru-based liner/diffusion barrier (U.S. Patent # 7247554) that is directly Cu plate-able for advanced Cu interconnect application. **(TI, SRC)**
- Identified/solved fluoride-induced microscopic corrosion disabling defects in fabrication of TI's DLP dynamic mirror structure. **(TI)**
- Developed a rapid corrosion screening metrology relevant to advanced Cu interconnect fabrication processing, identify new corrosion inhibitors tailored to each chemical cleaning formulation. **(SRC, Intel, ATMI)**
- **Achieved UNT's largest-ever tech transfer award via licensing of MIR-IR wafer characterization metrology to Intel.**

- Applied MIR-IR metrology to monitor/optimize flowable Low-K manufacturing process/ **(Intel)**
- Developed a highly sensitive MIR-IR infrared spectroscopic metrology (U.S. Patent # 9366601) to aid RIE-patterned ultra-low k nanostructure with minimum dielectric damages. **(Intel, SRC)**
- Established chemical bonding structure of ultrathin (<1-2 nm) post-etch fluorocarbon polymer residue on low-k nano-drench structure. **(Intel, SRC)**
- Designed a UV-assisted removal mechanism and invented an effective cleaning process to remove hydrophobic post-etch residue to minimize low-k dielectric damages. **(Intel, TEL)**
- Optimized PECVD growth of α -Si:H microbolometer sensor with PI's patented MIR-IR metrology for maximizing night vision camera performance. **(Army, L-3)**

2) Semiconductor Materials Chemistry

- Exploring deep eutectic solvents as environmentally benign post-etch residue removers for IC fabrication.
- Mechanistic and kinetic investigation of hydrogen termination/passivation process on Si(100) and Si(111) wafer surfaces.
- Study of surface morphological transformation induced by trace metal ions deposition on Si and Ge wafer surfaces.
- Developed new environmentally friendly wet cleaning chemistry to achieve ultra-clean silicon wafer surface preparation.
- Invented a novel method to spontaneously deposit metal nanoparticles (such as Ag, Cu, Au, Pd and Pt) on polycrystalline diamond surfaces and identified its detailed deposition mechanism.
- Discovered metal nanoparticle/diamond composite system exhibited significant enhancement of electrocatalytic properties toward hydrogen evolution and formaldehyde oxidation.
- Deposited ultra-fine Pt and RuO₂ nanoparticles on arrayed carbon nanotubes as electrode materials for micro direct methanol fuel cells and supercapacitors applications.

3) Interfacial Electrochemistry

- Electrochemical investigation of the energetics of the semiconductor/solution interface during trace metal deposition led to a discovery of a silicon-based chemical sensor (US patent 6,145,372) for detecting trace metal ion impurities at ppb-ppt levels in ultra-pure IC chemicals.
- Identified strong interfacial bonding between underpotential deposited Cu monolayer and Ru metal that achieved interfacial stability even after annealed over 600 °C
- First to demonstrate that conductive ruthenium oxide surface also exhibits strong interfacial binding between Cu and RuO_x, manifested by the Cu underpotential deposition process observed experimentally.

- Utilized RBS analysis to corroborate with TEM imaging to show that 5 nm Ru can function as a directly plate-able Cu diffusion barrier for Cu interconnects up to 300 °C anneal.
- High-resolution TEM revealed a ~2nm amorphous interlayer Ru_2Si_3 growth at the Ru/Si interface played a key role of blocking the Cu inter-diffusion process.
- Identified, *for the first time*, microscopic hydrogen evolution was the main cathodic process to drive Cu wire bonding corrosion defects, induced by trace chloride ions.
- Established halides (Cl^- , F^- , Br^-) induced Al corrosion mechanisms under Cu/Al bimetallic contact. Applied the new mechanistic insights to demonstrate a novel CVD passivation coating that provided highly effective corrosion inhibition protection.

Research Grants: List of External Funding

PI has acquired over \$6.6 million external grant support into UNT. Total external awards are over \$8 million as PI, co-PI from various sources and Senior Investigators for NSF REU programs. Furthermore, PI received uninterrupted funding (2007-current) from the prestigious *Semiconductor Research Corporation* with active members from all major microelectronic companies including Intel, TEL, TI, NXP, MediaTek, AMD, GlobalFoundries, K&S, Cirrus Logic etc.

1) Externally Funded and Pending Grants Application

Dates	Projects	Funding	PI/ co-PI	Funding Agency
2020-2026	Optimization of Corrosion Prevention Treatments for Cu Wire- Bonded Devices to Achieve High Bonding Reliability	\$557,400	PI	NPX Semiconductors
2024-2027	Interaction Mechanisms of 2D Materials with FEOL Wet Cleans	\$315,000	Co-PI	Semiconductor Research Corporation
2025-2026	STTR Phase I: Ultra-low-cost Additive Manufacture of Transparent Conductive Electrodes	\$305,000	Co-PI	NSF
2025-2026	Explore UNT Passivation Coating on K&S Wafer Samples	\$3,733	PI	K&S
2025-2026	Apply UNT Passivation Coating on Cirrus Logic wafer Samples for Cu-Cu Wirebondin	\$5,940	PI	Cirrus Logic
2024-2026	Exploring Deep Eutectic Solvents as Environmentally Benign Post-etch Residue Removers	\$315,000	Co-PI	Semiconductor Research Corporation
2023-2025	Tunable Biobased Molding Compounds and Die-Attach Adhesives	\$285,000	Co-PI	Semiconductor Research Corporation

2022-2024	Tunable Low-cost Passivation Coating for Facilitating Copper Wafer-level Bonding	\$289,547	PI	Semiconductor Research Corporation
2018-2021	Intel Technology Transfer Agreement on Acquiring UNT Patented Technology (US Patent # 9366601)	\$690,847	PI	Intel
2018-2020	Novel Chemical Approaches to Enhance Copper Etch Anisotropy for Advanced IC Packaging	\$176,000	PI	Intel, Semiconductor Research Corporation
2019-2020	Optimization of Cu-Selective Repassivation Treatments on Cu Redistribution Lines to Achieve Enhanced Reliability	\$88,850	PI	Texas Instruments
2018-2020	REC Inc. Licensed Agreement on UNT Patented IC Packaging Corrosion Prevention Technology	\$220,000	PI	REC Inc.
2017-2018	Protection of Aluminum Oxide and Cobalt Microstructures in Ammonium Fluoride Solution	\$75,000	PI	JSR-Micro
2016-2017	Characterization of Plasma Processed Patterned Wafers by MIR-IR Spectroscopy	\$21,420	PI	Intel
2016-2017	Characterization of Chemical Equilibriums of Cu Etch Bath Samples	\$7,200	PI	Intel
2015-2017	Mechanistic Investigation and Prevention of Al Bond Pad Corrosion in Cu Wire Bonded Device Assembly	\$163,333	PI	Semiconductor Research Corporation
2015-2016	Characterization of Plasma Processed Patterned Wafers by MIR-IR Spectroscopy	\$12,500	PI	Lam Research Inc.
2015-2016	Explore UV treatments for TTCA integrated wafer BEOL polymer removal using MIR-IR Spectroscopy	\$60,000	PI	TEL
2015-2016	Characterization of UV-radiated Post-etch Residue MIR-IR Spectroscopy	\$60,000	PI	TEL
2015-2016	Characterization of Carbon Nanotubes Coating on Wafers using MIR-IR Spectroscopy	\$3,000	PI	Nantero Company
2014-2015	Study of Plasma Processed Patterned Wafers by MIR-IR Spectroscopy	\$14,193	PI	Intel
2012-2014	Optimize Chemical Bonding Structure of PECVD Amorphous Silicon Micobolometer	\$ 10,000	PI	L3 Communication
2014-2015	Investigation of Al Pad Corrosion in the Cu Wire Bonded Semiconductor Device Assembly	\$85,000	PI	Semiconductor Research Corporation

2012-2013	Study of Chemical Bonding Structure of PECVD Amorphous Silicon Micobolometer	\$45,000	PI	Army
2012-2013	Study of Chemical Bonding Structure of PECVD Amorphous Silicon Micobolometer	\$35,000	PI	L3 Communication
2012-2014	Characterization of Plasma-etch-polymers using MIR-IR Spectroscopy	\$252,000	PI	Intel, Semiconductor Research Corporation
2012-2013	Evaluation of ULK Dielectrics Damages by MIR-IR Spectroscopy	\$6,000	PI	TEL
2012-2013	Characterization of Plasma-etched SiC wafers by MIR-IR Spectroscopy	\$6,000	PI	Lam Research Inc.
2011-2012	Characterization of Plasma-Etch-Polymers Using MIR-IR Spectroscopy	\$135,000	PI	Semiconductor Research Corporation
2012-2013	Plasma-etched ULK Patterned wafers Studied by MIR-IR Spectroscopy	\$15,000	PI	ATMI
2011-2012	Characterization of Cu/W/Co Bimetallic Corrosion and Inhibition IC Cleaning Solution Environments	\$48,000	PI	ATMI
2010-2012	Interfacial Study of Cu Bimetallic Corrosion and Inhibition IC Cleaning Solution Environments	\$123,000	PI	ATMI
2010-2012	Hybrid Nanocomposite High-k Dielectric Flexible Films for Semiconductor Applications	\$196,461	PI + 2 co-PIs	Norman Hackerman Advanced Research Program
2010-2012	Electrochemical Investigation of Cu Corrosion in Cu-CMP and Post-CMP Solution Environments	\$150,000	PI	Semiconductor Research Corporation
2007-2008	Study of Organometallic Chemistry and Its Applications to ALD TaN Barrier	\$ 40,000	PI +1 co-PI	Lam Research Inc.
2008-2010	Electrochemical Investigation of Cu Corrosion in Cu-CMP and Post-CMP Solution Environments	\$100,000	PI	Semiconductor Research Corporation
2007-2010	Investigation of Cu Electrodeposition and Patination on Metallic Oxide	\$150,000	PI	Robert A. Welch Foundation
2006-2007	Study of Semiconductor Surface Chemistry and Its Applications to Advanced Interconnects	\$ 40,000	PI	Lam Research Inc.
2004-2007	Corrosion Investigation in a Dynamic Environments for the Next Generation Cu Interconnect Microstructure	\$30,000	PI	Semiconductor Research Corporation
2004-2007	Interfacial Study of Metal Deposition on Metallic Oxide Surfaces	\$150,000	PI	Robert A. Welch Foundation

2004-2007	Bimetallic Corrosion at the Dissimilar Interfaces with Nanometer Dimension	\$150,000	PI	Semiconductor Research Corporation
2002-2004	Developing a new Ruthenium-based Diffusion Barrier for Copper Interconnects	\$264,890	PI + 1 co-PI	Texas Advanced Technology Program
2002-2003	Wet Chemical Cleaning Processes	\$105,337	PI	Texas Instruments
2001-2004	Metal Deposition on Early Group 14 Elements: Diamond, Silicon and Germanium	\$150,000	PI	Robert A. Welch Foundation
2000-2001	Trace Silver Detection in Natural Waters Using Silicon-based Sensor and Ion Exchange Membrane	\$ 20,000	PI	Eastman Kodak
1998-1999	Investigate the Cleaning Conditions for the Cooper Metallization in ULSI Applications	\$24,000	PI	Texas Instruments
1998-2001	Investigation of Discrete Metal Deposition on Semiconductor Surfaces	\$126,000	PI	Robert A. Welch Foundation
1998-1999	Trace Silver Detection in Natural Waters Using Silicon-based Sensor and Matrix Isolation Technique	\$50,000	PI	Eastman Kodak
1996-1998	Scanning Probe Microscopic Studies of Metal Depositions on Dissimilar Metallic Surfaces	\$103,200	PI	Robert A. Welch Foundation
1995-1998	Silicon-based Sensor Assembly for Trace Silver Detection	\$80,000	PI	Eastman Kodak
1997-1998	Detecting Trace Level Organic Contaminations In Microelectronic Processing Chemicals Using ATR-FTIR Techniques	\$5,000	PI	SAMATECH
1996-1997	Characterization of Trace Organics Adsorbed on Silicon Surface by Multiple Internal Reflection FTIR	\$22,000	PI	Texas Instruments
1995-1996	Sensor for Ultra -Trace Level Detection of Metallic Ions in Hydrofluoric Solutions	\$45,000	PI	Texas Instruments
1994-1995	AFM Morphological Studies of Conducting Polymer Films	\$12,500	PI	Gumbs Associates, Inc
1994-1995	High Surface Area Electrode Materials for Advanced Battery and Fuel Cell Applications	\$22,500	PI	Gumbs Associates, Inc
1994-1997	AFM, STM and Electrochemical Characterization of Silicon Surfaces	\$49,000	PI	Texas Instruments
1993-1995	Interfacial Characterization on HF/Silicon Wafer Systems	\$85,959	PI	Texas Instruments

2) Realized Value of Intellectual Property from the PI's IEMR Laboratory

Patented Technology	Funding	Funding Sources	Tech Transfers
#9366601 (2016) <i>MIR-IR Wafer Characterization Technology</i>	\$2,094 K	Intel, SRC, TEL, Lam, TI	Intel (<i>Signed</i> , \$840K) Bruker, Entegris (<i>in negotiation</i>)
#62/511863 (2017) <i>CVD Corrosion Inhibition Treatment</i>	\$3,165 K	SRC, NXP, TI, REC, K&S	REC Microelectronics (<i>Signed</i> , >\$220K)
#11099131 (2021) <i>Light Induced Anisotropic Cu Etching</i>	\$183 K	Intel	Intel, CHEMCUT Inc. (<i>In negotiation</i>)
#7247554 (2007) <i>Ru-based Cu Diffusion Barrier</i>	\$415 K	Intel, TI, SRC, ATMI,	-
#6145372 (2000) <i>Silicon based Chemical Sensor</i>	\$659 K	TI, SRC, Kodak	-
TOTAL	>\$ 6.5 millions		

Publication (Reviewed Articles, Proceeding, Patents and Invention Disclosures)

Summary: Invention and Technology Transfer: Professor Chyan has filed 31 patent disclosures to UNT Research office. Four United States Patents (*US Patent#* 6145372, 7247554, 9366601 and *11099131*) were awarded to professor Chyan's inventions. In addition, six US Provisional Patent #62/432115, #62/511863, #62/897942, #18/674,810, 63/727,186 and 63/886,578 were filed by UNT based on Professor Chyan's inventions.

1) Selected Patent Publications

- "An Apparatus and Method for Detecting Impurities in Wet Chemicals"
Hall, L; Sees, J; Chyan, O.M.R.; *US Patent*, 6,145,372, 2000.
- "Method of Making Integrated Circuits Using Ruthenium and Its Oxides as Cu Diffusion Barrier", Ponnuswamy, T.; Chyan, O.M.R. *U.S. Patent No. 7247554*, 2007.
- "Wafer Fabrication Monitoring/Control System and Method" Chen, J.J.; Chyan, O.M.R.; *U.S. Patent* 9366601, 2016.4. "Systems and Methods for Copper Etch Rate Monitoring and Control", Lambert, A.; Chyan, O.M.R.; *U.S. Provisional Patent* 62432115, 2016.
- "Mechanistic Investigation and Prevention of Al Bonded Pad Corrosion in Cu Wire-bonded Device Assembly", Ross, N.; Chyan, O.M.R.; *U.S. Provisional Patent* 62511863, 2017.

5. "Systems and Methods for Copper Etch Rate Monitoring and Control", Lambert, A.; Chyan, O.M.R.; *U.S. Patent 11099131*, 2021.
6. "Selective Surface Finishing for Corrosion Inhibition via Chemical Vapor Deposition", Asokan, M.; Chyan, O.M.R.; *United States Patent Application, US 2021/0071308*, 2021.
7. "Passivation Coating on Copper Metal Surface for Copper Wire Bonding Application", Chyan, O.M.R.; Alptekin, J.F.; Ashok Kumar, G. I., *United States Patent Application, UNTP.P0037US.P1/1001200335*, 2022
8. "Tunable Low-cost Passivation Coating for Facilitating Flux-less Bonding of Copper Solder Interconnects in Flip Chip Assembly", Antony Jesu Durai, K.; Salunke, A. S.; Kumaravel, D. K. ; Chyan, O.M.R.; *United States Patent Application, US Patent Application 18/674,810*, 2024.
9. " Tunable Low-cost Passivation Coating for Facilitating Copper-to-Copper Bonding in Interconnect Fabrication", Antony Jesu Durai, K.; Kumaravel, D. K. ; Chyan, O.M.R.; *U.S. Provisional Patent 63/727,186*, 2024.
10. " Phosphonic Acid Passivation of Copper and Aluminum for Enhanced Reliability", Dinesh Kumaravel; Shinoj Nair; Chyan, O.M.R.; *U.S. Provisional Patent 63/886,578*, 2025.
11. "Semi-Aqueous Cleaning Compositions, Systems, and Methods for 2-D Transition Metal Dichalcogenide Thin Films in Electronic Devices", Choi, W.; Shinoj Sridharan, S.; Chyan, O.M.R.; *U.S. Provisional Patent 2026*.

2) Selected Publications

1. "Heterojunction Photoelectrodes II. Electrochemistry at Tin-doped Indium Oxide /Aqueous Electrolyte Interfaces", Chyan, O. M. R.; Rajeshwar, K. *J. Electrochem. Soc.*, 1985, *132*, 2109.
2. "Heterojunction Photoelectrodes III. Cyclic Voltammetry at Indium Tin Oxide-coated Silicon / Aqueous Redox Electrolyte Interfaces", Chyan, O. M. R.; Ho, S. I.; Rajeshwar, K. *J. Electrochem. Soc.*, 1986, *133*, 531.
3. "Quantitation of Lens Protein Mixed Disulfides by Ion-Exchange Chromatography", Lou, M. F.; Mckellar, R.; Chyan, O. M. R. *Exp. Eye Res.*, 1986, *42*, 607.
4. "New Conducting Polymers of Some Bithiophene- and Bis-N-Methylpyrrole Polyenes, Their Properties and Their Application in Microelectrochemical Devices", Baeuerle, P.;Wrighton, M. S.; Chyan, O. M. R.; Spangler C. W. *Ber. Bunsenges. Phys. Chem.*, 1987, *91*, 889.
5. "Chemically Modified Microelectrode Arrays: New Kinds of Electronic Devices", Wrighton, M. S.; Chao, S.; Chyan, O. M. R.; Jones, E. T.T.; Lofton, E. P.; Schloh, M. O.; Shu, C. F., in *Chemically Modified Surface in Science and Industry*, D. E. Leyden, W. T. Collins, ed., Gordon and Breach Science Publishes, N.Y., 1988, P. 337.

6. "Preparation and Characterization of Molecule-Based Transistors with a 50 Nanometer source-Drain Separation Using Shadow Deposition Techniques: Toward Faster, More Sensitive Molecule-Based Devices", Jones, E. T. T.; Chyan, O. M. R.; Wrighton, M. S. *J. Am. Chem. Soc.*, 1987, 109, 5526-5528.
7. "Potential Dependence of the Relative Conductivity of Poly (3-Methylthiophene): Electrochemical Reduction in Acetonitrile and Liquid Ammonia", Crooks, R. M.; Chyan, O. M. R.; Wrighton, M. S. *Chem. Mater.*, 1989, 1(1), 2.
8. "Imaging Surface Atomic Structure by Means of Auger Electrons", Hubbard, A. T.; Frank, D. G.; Chyan, O. M. R.; Golden, T. *J. Vac. Sci. Tech.*, 1990, B8, 1329.
9. "Imaging Surface Atomic Layers by Means of Auger Electrons", Batina, N.; Chyan, O. M. R.; Frank, D. G.; Golden, T.; Hubbard, A. T. *Naturwissenschaften*, 1990, 77, 557.
10. "Direct Imaging of Monolayer and Surface Atomic Structure by Angular Distribution Auger Microscopy", Frank, D. G.; Golden, T.; Chyan, O. M. R.; Hubbard, A. T. *J. Vac. Sci. Tech.*, 1991, A9, 1254.
11. "Direct Imaging of Thin Film Atomic Structure by Angular Distribution Auger Microscopy", Frank, D. G.; Golden, T.; Chyan, O. M. R.; Hubbard, A. T. *Appl. Surf. Sci.*, 1991, 48-49, 166.
12. "Imaging Monolayer Structure by Means of Auger Electrons", Frank, D. G.; Chyan, O. M. R.; Golden, T.; Hubbard, A. T. *J. Vac. Sci. Tech.*, 1992, A10, 158.
13. "Probing Three Distinct Iodine Monolayer Structures at Pt(111) by Means of Angular Distribution Auger Microscopy: Results Agree with Scanning Tunneling Microscopy", Frank, D. G.; Chyan, O. M. R.; Golden, T.; Hubbard, A. T. *J. Phys. Chem.*, 1993, 97, 3829.
14. "Auger Electron Angular Distributions from Al(100): Resolution of an Apparent Contradiction" Chyan, O. M. R.; Frank, D. G.; Doyle, C.A.; Hubbard, A. T. *J. Vac. Sci. Tech.*, 1993, A11, 2659.
15. "Auger Emission Angular Distributions from a Silver Monolayer in the presence and Absence of an Iodine Overlayer: Evidence for the Predominance of Inhomogeneous Inelastic Scattering of Auger Electrons by Atoms", Frank, D. G.; Chyan, O. M. R.; Golden, T.; Hubbard, A. T. *J. Phys. Chem.*, 1994, 98, 1895.
16. "Measurement of Complete Auger Electron Emission Angular Distribution from SiC Films on Si(100)" Chyan, O. M. R.; Frank, D. G.; Hubbard, A. T.; Li, J.P.; Steckl, A.T. *J. Vac. Sci. Tech. B*, 1994, B12, 457.
17. "Auger Emission Angular Distributions from Pt(111): the Effect of Adsorbed Iodine Monolayer", Doyle, Charles A.; Chyan, O. M. R.; Frank, D. G.; Golden, T.; Hubbard, A. T. *Surface and Interface Analysis*, 1994, 21(2), 123.
18. "Kinetics and Morphology of Copper Deposition on Hydrogen -Passivated Silicon Surfaces from Dilute HF Solutions", Sees, J.; Hall, L.; Chyan, O. M. R.; Chen, J.J.;

- Chien, H.Y., Proceedings of the Second International Symposium on Ultra-clean Silicon Surfaces, Brugge, Belgium, 1994, p 147.
19. "Electrochemical Aspects of Noble Metals Related to Silicon Wafer Cleaning", Chyan, O. M. R.; Chen, J.J.; Chien, H.Y.; Hall, L.; Sees, J., Proceedings of the Second International Symposium on Ultra-clean Silicon Surfaces, Brugge, Belgium, 1994, p 213.
 20. "High Surface Electrode Materials by Direct Metallization of Porous Substrates", Chyan, O. M. R.; Chen, J.J.; Liu, M.; Richmond, M.G.; Yang, K.; MRS Proceedings of Materials for Electrochemical Energy Storage and Conversion-Batteries, Capacitors and Fuel Cells, *Mater. Res. Soc. Symp. Proc.* 1995, 393, 265.
 21. "Copper Deposition on HF Etched Silicon Surfaces : Morphological and Kinetic Studies", Chyan, O. M. R.; Chen, J.J.; Chien, H.Y.; Sees, J.; Hall, L.; *J. Electrochem. Soc.*, 1996, 143, 92.
 22. "Pulsed Plasma Polymerization of Tetramethyltin: Nanoscale Film Chemistry Composition Control", Chen, X.; Rajeshwar, K.; Timmons, R.B.; Chen, J.J.; Chyan, O. M. R.; *Chem. Mater.*, 1996, 8, 1067.
 23. "A New Potentiometric Sensor For the Detection of Trace Metallic Contaminants in Hydrofluoric Acid", Chyan, O. M. R.; Chen, J.J.; Chien, H.Y.; Wu, J.J.; Liu, M.; Sees, J.; Hall, L., *J. Electrochem. Soc.*, 1996, 143, L235.
 24. "Porous Silicon Coated with Calixarene Carboxylic Acid Derivatives: Effects on Luminescence Quenching Selectivity", Zhang, L.; Coffey, J.L.; Wang, J.; Gutsche, C.D.; Chen, J.J.; Chyan, O. M. R., *J. Am. Chem. Soc.*, 1996, 118, 12840.
 25. "Potentiometric Investigation of Silicon Electrode Immersed in Alkaline Hydrogen Peroxide Solution Containing Trace Level of Iron", Chyan, O. M. R.; Chen, J.J.; L. Chen; F. Xu, *J. Electrochem. Soc.*, 1997, 144, L17.
 26. "Discrete Metal Deposition on Hydrogen Terminated Silicon Surfaces: Kinetics, Morphologies and Sensor Applications", Chyan, O. M. R.; Chen, J.J.; Wu, J.; Chien, H.Y., *Mater. Res. Soc. Symp. Proc.* 1997, 451, 267.
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