

**CURRICULUM VITAE**  
**H. Kumar Wickramasinghe**  
**The Henry Samueli Endowed Chair**  
**Professor of Electrical Engineering and Computer Science**  
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**Areas of Expertise**

Current Research Areas: Novel scanning probe microscopes, bio sensors, ultra-fast sequencing, live cell genomics, x-ray nanoscopy, ultra-sensitive measurements in nanoscience

Past Research: scanning probe microscopy, in-situ sensors for manufacturing, silicon micromechanics, optics, acoustics, photothermal techniques, thermal microscopy, photoacoustics, scanning acoustic microscopy and confocal optical microscopy

**Professional Summary**

-Ph.D Engineer/Physicist with 23 years experience at IBM Research in various capacities from Researcher to Department Mgr. to Sr Department Mgr (responsible for technical direction of up to 50 scientists and engineers) and finally CTO Almaden Research Center (500 employees). Five years as tenured faculty at University College, University of London. Currently, Sue and Nicholas Alexopoulos Presidential Chair of EECS Department and the Henry Samueli Endowed Chair in Engineering at UCI

-Introduced the vibrating probe (dynamic mode or non-contact) AFM – the AFM of choice today and an essential tool in nanotechnology

-Initiated and led a team that developed and moved AFM's from IBM to the external world and also to productive use in IBM development and manufacturing lines. Many of the Scanning Probe Microscopy (SPM) techniques (such as Magnetic Force Microscope, Kelvin Probe Force Microscope, Electrostatic Force Microscope, Scattering Scanning Near Field Optical Microscope, Scanning Thermal Microscope etc) originated in my lab and are widely used in nanotechnology research today

-Initiated and led teams that moved several technologies from concept to productive use (see below)

-Author of **181 publications**, **107 US patents** and **148 invited presentations** (including many keynotes),

-Chair or co-Chair for several international scientific conferences

-Fellow, IEEE, APS, Inst. of Physics, Royal Microscopical Society

-Several major external awards

-Member National Academy of Engineering, 1998

- Fellow National Academy of Inventors, 2013

-IBM Fellow (CEO Appointment), 2000 -

**Citizenship**

USA

Married , Two Children

**EMPLOYMENT**

- 2014- Sue and Nicholas Alexopoulos Presidential Chair of Electrical Engineering and Computer Science Department
- 2006- The Henry Samueli Endowed Chair in Engineering and Professor of Electrical Engineering and Computer Science, Chemical Engineering and Materials Science and Biomedical Engineering, The Henry Samueli School of Engineering, University of California, Irvine
- 2005-06 IBM Fellow and CTO Science and Technology, IBM Almaden Research Center, San Jose CA
- 2002-05 IBM Fellow & Senior Department Mgr, Nanoscale Science & Technology, IBM Almaden Research Center, San Jose, CA
- 1996-02 Physical Science Dept., IBM T.J. Watson Research Center, Yorktown Heights, NY  
-Manager, Imaging Science and Measurement Technology
- 1984-96 Manufacturing Research Dept., IBM T.J. Watson Res Ctr
- 1984-96 - Manager, Physical Measurements
- 1992-94 - Chief Scientist, Manufacturing Res. Dept.
- 1978-83 Lecturer (tenured) in Electronic and Electrical Engineering, University College London (roughly equiv to Assoc Prof)
- 1975-78 Research Associate, E.L.Ginzton Laboratory, Stanford University, CA (under Prof. Calvin Quate)
- 1974-75 Associate Research Assistant, Department of Electronic and Electrical Engineering, University College London

**EDUCATION**

- 1974 Ph.D University College, University of London  
Electronic and Electrical Engineering (advisor Sir Eric A. Ash)
- 1970 B.Sc (Eng), Kings College, University of London – Summa Cum Laude  
Electronic and Electrical Engineering

**AWARDS/HONORS****External**

- Member, National Academy of Engineering, 1998 (youngest member elected that year)
- Fellow National Academy of Inventors, 2013

- 1992 IEEE Field Award (IEEE Morris E. Leeds Award)- for "pioneering contributions to electrical techniques for nanometer-scale measurement of magnetic, electrostatic, thermal and optical properties of surfaces"
- 1983, Vladimir K. Zworykin Premium of IEE (UK) for “Contributions to Scanning Acoustic Microscopy”
- 1982, IEEE Trans Sonics & Ultrasonics Group Best Paper Award (shared with I.R.Smith)
- 1998 Distinguished Corporate Inventor Award, National Inventors Hall of Fame
- 2000 APS Joseph F. Keithley Award – for “pioneering contributions to nanoscale measurement science through their leadership in the development of a range of nanoscale force microscopes that have had a major impact in many areas of Physics” (shared with C.F.Quate)
- 2006 Scientific American 50 award for devising a technique for ultra-fast electrophoresis using an Atomic Force Microscope (top 50 contributions to research, business and policy)
- 2006 Micro/Nano 25 Award, R & D Magazine for one of the 25 most innovative products for 2006
- 2008 IBM Faculty Award – a competitive world wide program intended to foster collaboration between researchers at leading universities world wide and those in IBM research, development and services organizations
- 2014 IBM faculty Award
- 2014-2015 UCI Senate Distinguished Faculty Award for Research (Top award for research across all of UCI)
- 2014 Sri Lanka American of the Year Award, Sri Lanka Foundation
- 2016 OCEC Distinguished Educator Award
- 2017 Distinguished Scholar, Faculty of Engineering, Chinese University of Hong Kong
- Who’s who in Science and Engineering
- Who’s who in America
- Who’s who in the World

### **IBM Major Honors and Awards**

- Appointed IBM Fellow by IBM Chairman and CEO Lou Gerstner (company’s highest technical honor) – June 2000 (less than 300 appointed in the history of IBM)
- Elected to IBM Academy of Technology (1993) - for "leadership in transfer of high precision metrology tools to IBM" (total of approximately 300 members in the company)

- 1991 IBM Outstanding Innovation Award for "first dynamic mode AFM with laser sensing of scanning probe"
- 1991 Designated "Top IBM Inventor", among top thirteen in the Corporation
- 1992 IBM Outstanding Technical Achievement Award for "design, development, and production of manufacturing qualified AFM's"
- 1992 IBM Outstanding Technical Achievement Award for "fundamental contribution to latent image measurement system"
- 1992 IBM Research Division Award for "contributions to liquid particle detector"
- 1997 Designated "Top IBM Inventor" again
- Research Division Master Inventor (1994-2006)
- 21 IBM Invention Achievement Award Plateau's

## Societies

Fellow, Institute of Electronic and Electrical Engineering  
 Fellow, American Physical Society  
 Fellow, Royal Microscopical Society  
 Fellow, Institute of Physics  
 Honorary Member, Materials Research Society of India

## Patents/Publications (see below)

**-HOLDER OF OVER 100 US PATENTS** in areas of nanotechnology, scanning probe microscopy (SPM), metrology, thermal physics, storage, ultra-sensitive measurements and biological sensors. Several of my SPM patents were a key part of the sale of the AFM business to Veeco Inc. The Thermally Assisted Recording Patents were a key part of the negotiations in the sale of the Hard Disk Drive business to Hitachi – they are used in all of today's disk drives. Inventions relating to AFM's, Phase Change Memory and Thermally Assisted Magnetic Recording drove major strategic directions involving large groups within IBM.

**-Author/co-author of over 175 publications** covering the areas of nano photonics, scanning probe microscopy, storage, scanning optical microscopy, acoustics, optics, thermal waves, non-destructive evaluation, in-situ sensors for manufacturing and single cell genomics (see publication list at the end of this document)

**-Editor/co-editor of five books**

**- 144 invited presentations**

## Some Key Publications and Contributions

-Initiated and led the team that moved AFM's from IBM to the external world; this was achieved through both internal development and working with external companies (Digital Instruments and Veeco). When we started, AFM's were based on millimeter size samples and tunnel sensors for detection. The work which involved collaborations across three IBM sites resulted in many new inventions including the introduction of the first vibrating tip AFM's for attractive mode imaging (increasing force sensitivity by 100,000), introduction of first all silicon cantilevers and tips, introduction of laser sensing and the early introduction of a range of "Scanning Probe Microscopes" that have become basic tools for nanotechnology. My group and I coined the name SPM and SXM (see "Scanning Probe Microscopy", Scientific American, Vol.260(10), October 1989, p.98-105) for the range of scanning tip microscopes based on AFM-like feedback. Several of the SPM technologies in use today originated in my group. I was also the first to identify and drive key industrial applications of AFM's such as CD AFM's, dopant profiling in semiconductors magnetic force microscopy (MFM for magnetic characterization of heads and disks and AFM's for disk roughness measurement- all the way from the lab to fully qualified tools in Manufacturing lines. CD AFM's are now firmly on the SIA roadmap for semiconductor technology.

**I initiated and led the following key contributions. Many of the scanning probe microscopy contributions cited below are all commercially available and used world-wide.**

-Introduced the first attractive mode (vibrating mode) AFM, including laser sensing. The technology – which increased detection sensitivity by 100,000x has become the preferred mode for most AFM applications. Worked with Digital Instruments to get this implemented externally and also worked with internal units to drive it toward a metrology tool and other applications. (35,500 google scholar hits)

"Atomic Force Microscope -- Force Mapping and Profiling on a sub-100 Angstrom Scale", J. Appl. Physics, 61(10), May 1987, p.4723.

-Introduced the Magnetic Force Microscope and its application to nanoscale imaging of surface magnetism ; this has become an essential tool for anyone doing surface magnetism (1,700.000 google scholar hits)

"Magnetic Imaging by Force Microscopy with 1000 Angstrom Resolution", Appl. Phys. Letters, 50(20), May 1987, p.1455.

"High Resolution Imaging of Domains in TbFe by Force Microscopy", Appl. Phys. Letters, 52(3), January 1988, p.244.

-Introduced the Scanning Thermal Microscope and its application to thermal imaging of surfaces; this has become a key tool for the study of nanometer scale thermal phenomena

"Scanning Thermal Profiler", Applied Physics Letters, 49(23), December 1986, p.1587.

"High Resolution Thermal Microscopy", Proceedings of IEEE Ultrasonics Symposium 1986, P.393.(Invited).

-Introduced the Electrostatic Force Microscope for potential & dielectric measurements ; a key technology used by many groups world wide

"High Resolution Capacitance Imaging and Potentiometry by Force Microscopy", Appl. Phys. Letters, 52(13), March 1988, p.1103.

-Introduced the Scanning Capacitance Microscope for Dopant Profiling

"Lateral Dopant Profiling with 200nm Resolution by Scanning Capacitance Microscopy", Appl. Phys. Lett., 55 (16) October 1989, p.1662

-Introduced the Kelvin Probe Force Microscope for Contact Potential Difference (CPD) measurements on the nanometer scale – this has become an important tool for studying surface potential distributions of biological and semiconductor surfaces. The CPD signal allows one to differentiate materials through their work function differences (39,600 google scholar hits)

"Kelvin Probe Force Microscopy", Appl. Phys. Letters, 58(25), June 1991, p.2921-2923.

-Introduced the Apertureless Near-Field Optical Microscope; based on local light scattering and interferometric detection and optical field enhancement at the end of a probe tip this approach to near-field optical microscopy overcomes the resolution limitation imposed by conventional aperture based near-field microscopes. It is an active area of research today and the same concept has been applied to fluorescence, Raman and other forms of nanoscale near-field microscopy

"Apertureless Near-Field Optical Microscope", U.S. No. 4 947 034, August 1990.

"Apertureless Near-Field Optical Microscope", Appl. Phys. Lett., 65(13), Sept 1994, p.1623.

"Scanning Interferometric Apertureless Microscopy: Optical Imaging at 10 Angstrom Resolution", Science, Vol.269, August 1995, p.1083

"Strength of Electric Field in Apertureless Near-Field Optical Microscopy"  
J. Appl. Phys. 89 (10), May 2001 p.5774

"Scattering Spectroscopy of Molecules at Nanometer Resolution", Appl. Phys. Lett., 68(18), April 1996, p.2475

-Introduced the Photoacoustic Microscope; based on using focused light pulses to generate microwave acoustics, which were detected using acoustic microscope lenses, the technique provided a new contrast mechanism and initiated a new field.

“Photoacoustics on a Microscopic Scale”, Appl. Phys. Lett., 33(11), Dec 1978, p.923

-Made key contributions to Acoustic Microscopy. Modeled the complete imaging system - transducer - lens - sample interaction which helped elucidated the key contrast mechanisms in Acoustic Microscopy

“Phase Imaging in Reflection with the Acoustic Microscope”, Appl. Phys. Lett, 31(12), Dec 1977, p.791

“Acoustic Microscopy”, Concise Encyclopedia of Biological and Biomedical Imaging Systems (1991), Ed. P.A.Payne, Pergamon Press, p. 7-15

“Acoustic Microscopy”, Advances in Optical and Electron Microscopy, Academic Press, Ed. C.J. Sheppard, 1989, p.153-182

“Contrast and Imaging Performance in the Scanning Acoustic Microscope”, J. Appl. Phys., 50(2), Feb 1979, p.664

-Led the recent work that focuses on the limits of nanoscale magnetic recording demonstrating a world record for magnetic recording density. Worked with 25 scientists and engineers in the Storage Technology Division to transfer this technology into development. The work and associated patents were a key part of the IBM portfolio in the sale of the disk-drive business to Hitachi. The technology was adopted as a part of the Hitachi product plan, driving a new technology direction aimed at substantial increases in storage density - by almost an order of magnitude.

“Thermally Assisted Recording Beyond Traditional Limits”, Appl. Phys., Lett., 84(5) Feb 2004, p.1 (**front cover**)

## **Service Related Activities**

### EDITORIAL BOARDS

-Review of Scientific Instruments, 1996 - 1999

-Member of Exec Editorial Board, Nanotechnology, 1991 - 1996

-Member of Editorial Board, Inst. of Phys. book series, "Advances in Nanoscale Physics, Electronics and Engineering"

### COMMITTEE WORK

-Executive Committee, Meas. Sci. & Instr. Topical Group, APS, 1997 – 2000

-Nominating Committee, Meas. Sci. & Instr. Topical Group, APS, 1999

### ORGANIZING SCIENTIFIC CONFERENCES

- Co-Organizer, MRS Symposium on Scanning Probe Microscopy for Imaging Functionality on the Nanoscale, San Francisco, 2013
- International Program Committee, SPIE Conference on Nanofabrication Technologies, San Diego, August, 2003
- Co-Chairman, SPIE Conference on "Controlling and Manipulating Photons on the Nanoscale", August 2-3, 2001
- International Advisory Board, 5th Int. Conf. on Atomically Controlled Surfaces and Interfaces, France, 1999
- Member, Organizing Committee, Fourth International Meeting on Near- Field Opics, NFO4, Jerusalem, Israel, February 1997
- Member, International Program Committee, NANO4, Beijing, Sept. 1996
- Chairman, "Non-Contact Atomic Force Microscopy for Critical Dimension Metrology", Semicon Southwest, Austin, Texas, Oct. 1995
- Co-Chairman, MRS Symposium on "Determining Nanoscale Physical Properties of Materials by Microscopy and Spectroscopy" Boston, November 1993
- Co-Chairman, First International Conference on Near-Field Optical Microscopy, Besancon, France, 1992.
- Chairman, Engineering Foundation Conference on "Scanning Probe Microscopy – STM and Beyond", January 6-11, CA, 1991.
- Member, IEEE Awards Committee (Sonics & Ultrasonics Group), 1985-1993.
- Member, Technical Program Committee, IEEE, Ultrasonics Symposium, 1984-1993.
- Organizing Committee, 6th International Topical Meeting on Photoacoustic, Thermal and Related Science, Md., 1989.
- Member, NIH Site Visit Panel to Brookhaven National Laboratory on STEM and STM Applications to Biology, 1988.
- Co-Chairman, SPIE Conference on Scanning Microscopy - Technology and Applications, CA, 1988.
- Member, Organizing Committee, Office of Science & Technology Policy/NBS Conference, "National Forum on Role of Sensors for Automated Materials Processing", Santa Barbara, CA., 1985
- Technical Program Committee, 3rd International Topical Meeting on Photoacoustic and Photothermal Spectroscopy, Paris, April 1983.



-Organizing Committee, 12th International Symposium on Acoustical Imaging, July 1982.

-Steering Committee, SIRA Symposium on Microscopy: Techniques and Capabilities, London, September 1982.

#### CHAIRING OF SCIENTIFIC CONFERENCES

-Session Chairman, Acoustic Microscopy, 12th International Symposium on Acoustical Imaging, London, July 1982.

-Session Chairman, Acoustic Microscopy, Symposium on Microscopy – Techniques and Capabilities, Royal Society, Sept. 1982.

-Session Chairman, X-Ray Studies, 3rd Oxford Conference on Microscopy of Semiconducting Materials, March 1983.

-Session Chairman at NATO Advanced Study Institute on Optical Metrology, Portugal, 1984.

-Session Chairman, 4th International Topical Meeting on Photoacoustic, Thermal and Related Sciences, Montreal, 1985.

-Session Chairman, UNESCO International Workshop on Acoustic NDE, China 1985.

-Session Chairman, IEEE Ultrasonic Symposium, 1985,86,87,89

-Organized and Chaired Session at International Meeting on Review of Progress in Quantitative NDE, 1985-89.

-Session Chairman at SPIE Conference on Scanning Microscopy- Technology and Applications, CA., 1988.

-Session Chairman at SPIE Lithography Symposium, CA.,1988.

-Discussion Leader, International Conference on Ultrasonic Micro- Spectroscopy for Material Characterization, Japan, 1988.

-Session Chairman at 6th International Photoacoustics Meeting, MD.,1989

-Session Chairman, SPIE Meeting Scanning Microscopy Instrumentation, San Diego, 1991

-Discussion Leader, Gordon Conference on Non-Destructive Evaluation, Los Angeles, 1992

-Session Chairman, SEM 90, Chicago, 1990

- Session Chairman, SPIE meeting, San Diego, 1991
- Session Chairman, APS March Meeting, Indianapolis, 1992
- Discussion Leader, Gordon Conference on Photoacoustic, Thermal & Related Techniques, New Hampshire, June 1992
- Session Chairman at MRS fall meeting, "Determining Nanoscale Physical Properties of Materials by Microscopy and Spectroscopy", Boston, Nov. 1993
- Session Chairman, "Non-Contact Atomic Force Microscopy for Critical Dimension Metrology", Semicon Southwest, Austin, Texas, Oct. 1995
- Session Chairman, Microanalysis 1, 117th Meeting of Japan Institute of Metals, Honolulu, December 1995
- External Review Panel, NIST National Advanced Manufacturing Testbed, Gaithersburg, MD, 1996
- Session Chairman, Fourth International Meeting on Near-Field Optics, Jerusalem, Israel, February 1997
- Panel Leader, Electronics and Telecommunications Track, World Nano Economic Congress, Washington DC, September 2003
- Panel Leader, Nanotechnology Track, COMDEX, Las Vegas, November, 2003

### **Keynote/Plenary Lectures**

- “TERS and Photo Induced Force Microscopy”, TERS5, 5<sup>th</sup> International Conference on Tip Enhanced Raman Spectroscopy, Osaka, Japan September 2015. **Plenary**
- “Development of the Atomic Force Microscope, International Conference on Micro Manufacturing, Tokyo, March, 2012 . **Keynote**
- ”Near Field Optical Microscopy – Past, Present and Future”, International Conference on Tip Enhanced Raman Spectroscopy – TERS 2, National Physical Laboratory, Teddington, UK, July 2011. **Keynote**
- "Probing the Nanoscale in Biology and Medicine", **Keynote**, Global Technology Forum, Sri Lanka, Dec. 2011. **Keynote**
- ”Raman Probe Force Microscope”, Near Field Optics 12, International Conference, **Keynote**, Sept. 2012. **Keynote**
- “Scanning Probe Microscopy- an Enabler for Future Nanotechnology, Semiconductor and Storage Technology”, Royal Microscopical Society Meeting, Lancaster, UK, April 2002. **Keynote**
- “Scanning Probe Microscopies”, International Dielectric Society Meeting,

Canterbury, UK, April, 2000. **Keynote**

“Electrostatic Force Microscopy”, Electrostatics 99, Cambridge, UK, 1999. **Keynote**

“Scanning Probe Microscopy” – APS Centennial Lecturer – 1999 (throughout year)

“Recent Advances in Apertureless Near-Field Optical Microscopy”, Near-Field Nano-Optics Conference, Osaka, Japan, 1999. **Keynote**

"Scanning Probe Microscopy - From Birth to Adolescence", Annual Review of Quantitative NDE, San Diego, CA, July 1997. **Keynote**

"Optical Microscopy Near Atomic Resolution", Electron, Photon and Ion Beam meeting, Atlanta, May 1996. **Keynote**

"Scanning Probe Techniques", 5th International Scanning Probe Microscopy Symposium, Rudkers, NJ, September 1995. **Keynote**

"Scanning Probe Microscopy - A Historical Perspective", Keynote Speaker, International Symposium on Non-Contact Atomic Force Microscopy for Critical Dimension Metrology, Semicon Southwest, Austin, TX, Oct 1995. **Keynote**

"Toward Accurate Metrology with Scanning Force Microscopes", International Conference on Electron, Ion and Photon Beam Technology, Scottsdale, AZ, May 1995. **Keynote**

"Scanning Probe Microscopy Overview", Annual Meeting of Swiss Society of Biologists, Fribourg, Switzerland, March 1995. **Keynote**

### **Other Professional Activities:**

#### **CONSULTANCIES**

- Veeco Inc., Technical Advisory Board, 2007 – 2009

-United Kingdom Atomic Energy Authority, Harwell, on Acoustic Microscopy, October 1980 - December 1982.

-The General Electric Company Ltd., Hirst Research Center, U.K., August 1980 – 1983 on Acoustic/Photoacoustic Microscopy.

-IBM, T.J.Watson Research Center, Yorktown Heights, New York on "Optical Heterodyne Detection as Applied to Novel Imaging Systems", Oct.-Dec.1983.

### **Details of Work Experience**

**UNIVERSITY OF CALIFORNIA, IRVINE, CALIFORNIA, 2006 –**

The Henry Samueli Endowed Chair in Engineering  
 Chairman EECS Department  
 Professor of Electrical Engineering and Computer Science  
 Professor of Biomedical Engineering  
 Professor of Chemical Engineering and Materials Science

#### RESEARCH GRANTS HELD:

Principle Investigator, NIH Award HG-04025 "DNA Size Separation Using an Atomic Force Microscope" funded by PHS Natl Human Genome Research Inst, October 2006 –May 2008 - \$152K

Principle Investigator, NIH R01 "High throughput low cost DNA sequencing using probe tip arrays" August 2007 – August 2010 - \$2.18M

Principle Investigator, NIH R21, "Rapid DNA Sizing and Haplotyping Using Probe Electrophoresis" June 2008 – June 2010 - \$ 420,000

IBM Faculty Award (IBM Foundation) 2008 - \$40K

Principle Investigator, (NSF Sub Award) UIUC Center for Nano-Chemical-Electrical-Mechanical Manufacturing Systems "Macromolecular Manipulation and Synthesis with AFM's" September 2008 - September 2013 - \$550K (**2010 – 2013 amount is \$330K**)

Agilent Foundation Faculty Award 2010 - **\$48 K**

Keck Foundation 2012 - **\$ 1.573 M** - Platform for Live Cell Genomics

IBM Faculty Award (IBM Foundation) 2014 - **\$50 K**

Keck Foundation - Optical Frequency Magnetic Nanoprobe 2015 - \$ 3.028 M - (my share is **\$757,000**)

Principle Investigator, (NSF Sub-Award) UCI Center for Chemistry at the Space Time Limit – CaSTL 2011, 2012, 2013, 2014,2015 - **\$ 1.48 M**

**Total 2010-2015 Funding is \$ 4,964,666**

#### Research Students:

Undergraduate: Jay Zandazad  
 Robert Kennedy  
 Milad Nazari

Masters: Loic Derely  
 Scott Roset  
 Mohammad Almajhadi

- Ph.D:           Indrajith Rajapakse (graduated- now Sr Engineer at Intel)  
                   Ganesh Varadarajalu (graduated - now at Applied Materials Inc)  
                   Elaheh Shekaramiz (graduated , now post doc)  
                   Ying Lie Tao (graduated, now post-doc)  
                   Fei Huang (graduated – now at Brucker)  
                   Zahra Mamaghani (advanced to candidacy)  
                   Rathi Anmol (started September 2016)  
                   Mohsen Rajai (started September 2016)  
                   Mohammad Almajhadi (started September 2016)
- Post Doctoral: Kerem Uenal (Executive Director, Operations at Castleton Commodities)  
                   Sinan Balci ( Professor, Turkish Aeronautical Association (UTAA)  
                   Liyun Lin  
                   Hadi Jebori  
                   Dharmakeerthi Nawarathna (Asst Prof, North Dakota State)  
                   Jonathan Burdett (Regional Manager Craic Technology Inc)  
                   Ananth Tamma (Philips Research)  
                   Jinwei Zeng (current post doc)  
                   Sina Hamian (current post-doc)

## **IBM RESEARCH DIVISION , 1984 - 2006**

### **IBM, T.J.WATSON RESEARCH CENTER, YORKTOWN HEIGHTS, NEW YORK, 1984 – 2001**

#### TEACHING ACTIVITY:

- Adjunct Professor, Polytechnic Institute of New York (formerly Brooklyn Polytechnic), 1985,86, 87 ; taught graduate course in EM Field Theory.

#### RANKING:

- **Ranked #1** in the organization (about 100 Scientists) while I was a Research Staff Member over the past eight years before appointment as an IBM Fellow (IBM Executive Position). I am ranked in the top tier of current IBM Fellows

#### PHYSICAL SCIENCES DEPARTMENT (appr. 100 HC), 1997 - 2001

- Manager, Imaging Science and Measurement Technology

#### MANUFACTURING RESEARCH DEPARTMENT (appr. 180 HC), 1984 - 1996

- Manager, Physical Measurements

-Established new group in Micro-Measurements

-Provided Technical Leadership in Micro-Measurements and Sensors to IBM Manufacturing

- Managed Scientists and Engineers
- Transferred Technology from Research into IBM Sites
- Chief Scientist, Manufacturing Research Department (1992 - 1994)
  - Managed base technology (Science) portfolio for Manufacturing Res.
  - Defined interactions with Universities, Research Labs etc.
- Senior Leadership Council -one of six members- (1992- 1994)

Shared Responsibilities:

- Provided leadership to Manufacturing Research Department
- Responsible for funding projects
- Responsible for reviewing new staff requisitions
- Initiated, guided and phased out projects
- Responsible for getting together appropriate part of division plan
- Made sure that technical teams communicated at all levels
- Represented MR capabilities and impact
- Member Micromechanics Council, IBM, 1991-93
  - Kept Director of Research informed about Internal and External Activity in Micromechanics - Suggested New Opportunities for IBM

ACCOMPLISHMENTS:

. The following projects of mine made the list of accomplishments at the division level

Thermal Microprobe

Magnetic Force Microscope

SXM Thermomagnetic Storage

Absorption Spectroscopy on a Nanometer Scale

AFM Workstation (among the top ten accomplishments in Research Division)

Flat Top Sensor for Lithography Alignment

## Scanning Apertureless Near Field Microscope

### Interferometric Measurement of Trench Depth and End-Point

#### **Significant Research Accomplishments**

Many of the scanning probe sensor technologies that I initiated and led at IBM (Non-Contact AFM, Magnetic Force Microscope, Electrostatic Force Microscope, Kelvin Probe Force Microscopy, Scanning Thermal Probe etc) are now commercially available and used widely around the world for visualizing the nanoscale. Magnetic Force Microscopes account for about a third of the scanning probe microscopes sold today.

- Invented Scanning Thermal Profiler; first scanned probe microscope to profile insulators. Based on nanometer scale measurement of temperature variations, it preceded the atomic force microscope. It is being used by several groups to measure local phase transitions (differential calorimetry), local thermal conductivity, hot spots and leakage currents in semiconductors etc.
- Initiated and led the development of the AFM from being a scientific instrument to a fully hardened manufacturing tool for Silicon manufacturing lines in IBM. This has now become a common instrument in all semiconductor FAB's. The work which lasted five years, involved a multi-site collaboration (Sindelfingen, Boca Raton and Yorktown Heights) and required several innovations including the development of the first silicon micro-mechanical cantilevers, oscillating probe mode operation and new optical sensing technology .
- Introduced the first oscillating probe, (non-contact) attractive mode force microscope; this gave 100,000x improvement in force sensitivity over earlier contact mode atomic force microscopes - this is the preferred mode of operation today
- Introduced the Magnetic Force Microscope (MFM); this enabled 200 Angstrom resolution magnetic imaging. First to demonstrate MFM application to head magnetic imaging and disk domain imaging, both vertical (magneto-optic TbFe) and horizontal (magnetic thin-film CoCr). The MFM has become a standard tool for nanoscale magnetic imaging world-wide. All disk drive manufacturers use MFM's for magnetic characterization of their heads and disks.
- Introduced the electrostatic force microscope for potential measurements; the new technique provided increased sensitivity in detection of charge and potential (sensitivity down to single electron).

- Demonstrated chemical potential measurement with an STM - thermal emf's were measured on the atomic scale. This technique also initiated activity outside - for example, a Princeton molecular biology group showed that they can distinguish the bases in DNA through differences in their thermal emf's and a group at UT Austin is using this technique for dopant profiling on the atomic scale.
- Invented and demonstrated a method for nanoscale dopant profiling by local capacitance/voltage measurement. The technology was demonstrated both with force microscopes and electrical capacitance microscopes and can perform dopant profiling with 100 nm resolution. This technique has been widely used by other groups.
- Demonstrated Kelvin probe force microscope; the technique is able to measure local variations in Kelvin potential with a sensitivity better than 1 mV. The technique can locally identify the different metals on an integrated circuit through their differences in work function. The technique has been widely used by others to map nanoscale potential variations in biological surfaces and in working semiconductor devices. IBM has used the technique to detect trapped charges in failed devices.
- Demonstrated local thermal conductivity measurements and sub-surface imaging on the nanometer scale using scanning force microscopy. This has become a widely used technique for studying nanoscale thermal transport.
- First to elucidate the resolution limitations of aperture based near-field optical microscopes. Invented and demonstrated a new technique for bringing the resolution of optical microscopes near the atomic level. Apertureless Near-Field Microscopy, is based on measuring the modulation of the localized light from a sharp tip as it scans in close proximity to a sample. It overcomes the resolution limitation of conventional aperture based near-field microscopes. A resolution of 10 angstrom, was demonstrated. We applied the technique to spectroscopy of single molecules and high density storage. The concept of apertureless microscopy (or sSNOM) has stimulated a great deal of interest from many groups around the world, who have advanced the concept in many different directions
- Invented and demonstrated a concept called Thermally Assisted Magnetic Recording where a local resistive heater is used to extend (by up to 10x) the superparamagnetic limit of magnetic recording media. Demonstrated a world record for magnetic storage density in perpendicular recording media. Worked with the Storage Technology Division to transfer this technology into IBM development and manufacturing.
- Developed and transferred into manufacturing an infra-red technology for non-destructively measuring -within seconds- the depth of 256 Mbit DRAM trenches in silicon manufacturing lines. Previously, the wafers had to be cross-sectioned to make such measurements which took upto six hours - both costly and time consuming. These systems have been commercialized by Biorad Inc.
- Developed and transferred to manufacturing, an in-situ monitor for etch-rate in reactive ion etch (RIE) chambers. The technique is able to monitor the etch rate of shallow (1 micron deep) trenches that are only 0.25 micron wide. In-situ monitoring eliminates costly downstream measurements, thereby increasing throughput.



- Co-invented and transferred a technology called Thermal Protrusion Control to thermally control the fly height in magnetic recording disk drives; the technology is used in today's disk drives.
- Developed and transferred an in-situ monitor for real-time measurement and control of film thickness in a Chemical Mechanical Polishing (CMP) tool. This new sensor reduced the wafer to wafer film thickness variation by 10x and also significantly improved throughput
- Introduced ultra-sensitive optical differential phase microscopy techniques to IBM resulting in the following two co-inventions being transferred to manufacturing.
  - Liquid Particle Detector; over 100 units installed in IBM liquid lines - can detect and count particles down to 100 angstrom diameter.(commercialized by Particle Measurement Systems) – won IR 100 award
  - In-situ interferometric overlay control technique applied to exposure tools in IBM, resulting in a 25% reduction of the overall processing time in the photosector. The technique measures latent images in photoresist and uses them to register one chip level with respect to the next. Previously, send-ahead wafers were used to check the mis-alignment of registration resulting in significant processing delays.

**IBM, ALMADEN RESEARCH CENTER, SAN JOSE, CA, JUNE 2001– JUNE 2006**

SCIENCE AND TECHNOLOGY DEPARTMENT, JUNE 2001- 2006

- Manager, Thermally Assisted Recording, June 2001- December 2002
  - worked with a team of 25 scientist and engineers to transfer a technology which I invented that extends the super-paramagnetic limit in magnetic recording by 10x . It changed the strategic direction of the storage division. The thermal technology is now in all current disk drives

- Senior Department Manager, Nanoscale Science and Technology 2002-2006

Responsible for directing the research of several groups focused on nanoscale science and technology

- initiated projects on Storage Class Memory (a nanoscale solid state memory which is aimed at replacing disk drives) – a major strategic thrust in the Science & Technology area
- initiated projects on nano-imprint lithography for low cost manufacturing
- responsible for overseeing research in other areas of nanoscale science such as magnetic resonance force microscopy, spin flip spectroscopy with STM's , single photon detectors for

quantum cryptography, lithography limits of photoresists, materials for non-volatile embedded memory , etc.

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### **UNIVERSITY COLLEGE, UNIVERSITY OF LONDON 1978-1983**

- Lecturer - Tenured - (Roughly Equivalent to Associate Professor), University College London, Oct. 78 - Dec. 83
- Courses Taught:
  - B.Sc.(Engineering) degree:
    - First Year Instrumentation
    - Second Year Electromagnetic Field Theory
    - Final Year Physical Electronics
  - M.Sc. in Microwaves and Modern Optics:
    - Course in Microwave Networks and Components
- Ph.D. Projects Supervised:
  1. Gas Medium Acoustic Microscopy and Photothermal Imaging
  2. Photothermal Spectroscopy
  3. Acoustic Microscopy in High Pressure Gases
  4. Broadband Laser Heterodyne Probe-Use in SAW Diagnostics and Surface Analysis
  5. Photodisplacement Imaging
  6. Differential Phase Contrast Optical Microscopy
- Research Grants Held:
  1. "Photoacoustic Microscope", Science Research Council, June 79-June 81; Principal Investigator
  2. "Analysis Techniques for SAW Devices", DCVD, Ministry of Defence, June 80 – Dec.83; Co-Investigator

3. "Gas Medium Acoustic Microscope", National Research Development Corporation, June 80 - July 82; Principal Investigator
  4. "Surface Acoustic Waves and Acoustic Microscopy for N.D.T", European Office of the U.S.Army, Oct.78-Dec.83; Co-Investigator
  5. "Scanning Acoustic Microscopy for Microelectronics", U.K. Post Office Research Centre, April 80-Dec.83; Co-Investigator
  6. "Saw Techniques for Surface Characterization", Rockwell Science Center, U.S.A., Jan 79 - Jan 80; Principal Investigator
  7. "Study of Mode Structure in SAW Resonators Using Laser Probes", Rockwell Science Center, U.S.A., Nov.80 - Nov.81; Principal Investigator
  8. "Differential Phase Contrast Optical Microscope with Sub-Angstrom Depth Resolution", Science and Engineering Research Council, April 83- Dec. 83 ; Principal Investigator
- Administrative Duties:
    - Physical Electronics Group Seminar Organizer 1979-1983
    - Compilation of Departmental Book List, Oct.80 - Dec.83
    - Library Sub-Committee, University College London, 1980-1983.
    - Member, Board of Studies in Electrical Engineering, University of London, 1981-1983.
    - Member, Board of Examiners for M.Sc in Microwaves and Modern Optics, 1981-1983

### **Significant Research Accomplishments**

- First work on high frequency (i.e. above 50 MHz) acoustic microscopy in high pressure gases; enabled 5x improvement in resolution over former water coupled systems at same frequency.
- First to demonstrate differential phase contrast acoustic microscopy; this allowed very sensitive acoustic phase difference measurements on the microscopic scale - awarded IEEE Best Paper Award for this work.
- Invented dithered differential phase contrast optical microscopy with ultra-high phase resolution ( $10^{-8}$  rad/sqrt Hz) and applied it to latent image measurement in photoresist, growth step imaging on single crystals, LB film measurement and dopant pattern imaging on

semiconductors - this has been the basis of many ultra-sensitive optical measurements that followed, at IBM and outside.

### **E.L.GINZTON LABORATORY, STANFORD UNIVERSITY 1975-1978**

- Research Associate working for Prof.C.F.Quate and the late Prof.R.Kompfner
- Research into Scanning Acoustic and Optical Microscopy
- Supervision of graduate students in the fields of Scanning Optical and Scanning Acoustic Microscopy

### **Significant Research Accomplishments**

- First to model (with C.F.Quate and A.Atalar) the contrast and imaging performance in the scanning acoustic microscope ; it defined the key contrast mechanism - commonly known as the V(z) effect;
- Performed first experiments on photoacoustic microscopy; this initiated a new field which is still active today.

### **UNIVERSITY COLLEGE, UNIVERSITY OF LONDON 1970-75**

- Ph.D in Electronic and Electrical Engineering, 1970-74 Thesis on "Two and Three Dimensional Acoustic Holography in Solids" (Supervisor Professor Sir Eric A. Ash)
- Research into Acoustic Holography in Solids
- Associate Research Assistant, Department of Electronic and Electrical Engineering, 1975 (Post-Doctoral Position)
- Harold Barlow Prize 1972-73, University College for "most original contribution to research in the field of Electronic and Electrical Engineering - (best Ph.d project)
- Mary Scharlieb Open Research Scholarship, University of London, 1971-74
- Offices Held: Post Graduate Representative in the Department of Electronic and Electrical Engineering 1971-72

### **KINGS COLLEGE, UNIVERSITY OF LONDON 1967-1970**

- B.Sc.(Engineering) (Hons) - Summa Cum Laude - in Electronic and Electrical Engineering, 1970

### INVITED PRESENTATIONS

- C1. "Recent Progress in High Resolution Ultrasonic Microscopy", Cavendish Physical Society Lecture, Cambridge University, November 1980.
- C2. "Recent Advances in Acoustic Microscopy", 6th Electronics Update Colloquium, Institute of Mechanical Engineers, London, October 1980.
- C3. "Photoacoustic Microscopy- A New Technique in Microscopy", Recent Advances in Photoacoustic Spectroscopy-Photoacoustic Microscopy, Scientific Conference Services, London, December 1981.
- C4. "Acoustic Microscopy", Royal Signals and Radar Establishment, Malvern, UK, January 1981.
- C5. "Photoacoustic Microscopy"-Colloquium on Scanning Optical Microscopy, IEE, London, December 1981.
- C6. "Acoustic Microscopy", Light Microscopy '81- The State of the Art, Imperial College London, July 1981.
- C7. "Acoustic and Optical Techniques for Micro-NDE", Standard Telecommunications Laboratories, Harlow, UK, January 1982.
- C8. "Application of Scanning Differential Phase Contrast Microscopy to Silicon Inspection", 1984 Gordon NDE Conference, New Hampshire.
- C9. "Recent Advances in Acoustic Microscopy", MICRO 84, London, UK.
- C10. "Laser Probes", NATO Advanced Study Institute on Optical Metrology, Portugal, 1984.
- C11. "Application of Heterodyne Techniques to Metrology", NATO Advanced Study Institute on Optical Metrology, Portugal, 1984.
- C12. "Application of Laser Heterodyne Probes to NDE, UNESCO International Workshop on Acoustic NDE", China, 1985.
- C13. "Dimensional Metrology", OSTP-NBS meeting on National Forum on the Future of Automated Materials Processing in US Industry-Role of Sensors, California 1985.
- C14. "Absolute Laser Ranging with Micron Precision", American Society of Precision Engineering, Dallas, TX., 1986.
- C15. "Acoustic Microscopy", Gordon Conference on Interfaces, NH., 1986.
- C16. "Laser Heterodyne Force Microscope", Adriatico STM Conference, Trieste, Italy, 1987.

C17. "Technology and Application of Scanning Near-Field Microscopy", American Physical Society Spring Meeting, MD., 1988.

C18. "Novel Scanned Tip Microscopy", American Physical Society, March Meeting, LA., 1988.

C19. "Some History and Technology of Scanning Microscopy", Sigma Xi Lecture, Northern Westchester Chapter, IBM Yorktown Heights, NY., March 31st 1988.

C20. "Novel Scanned Tip Microscopy", ALCOA Centennial Meeting on Sensor Technology, PA., 1988.

C21. "High Resolution Scanned Tip Microscopies", Annual Meeting of Electron Microscopy Society of America, WI, 1988.

C22. "High Resolution Magnetic Imaging by Force Microscopy", Magnetism and Magnetic Materials Conference, Chicago, 1987.

C23. "Thermal and Photothermal Imaging of 100 Nanometer Structures", Annual American Vacuum Society Meeting, Atlanta, Georgia, Oct. 1988.

C24. "Scanning Probe Microscopy & Their Applications", American Physical Society, Annual Meeting, CA., Jan. 1989

C25. "Nanometer Scale Force, Thermal & Magnetic Microscopies", American Physical Society Fall Meeting, NY., Oct. 1989.

C26. "High Resolution Magnetic Imaging by Force Microscopy", IEEE Magnetics Society Meeting, Boston, 1989

C27. "Magnetic, Thermal and Capacitance Microscopy on a Nanometer Scale" 5th Precision Engineering Conference, California, September 1989.

C28. "Thermal and Other Near-Field Non-Contact Microscopies", IBM Europe Institute, SXM Ultramicroscopy, FRG, August 1989.

C29. "Near-Field Scanning Probe Microscopy", AVS Annual Meeting, MA, October 1989.

C30. "Near-Field Scanning Probe Microscopy", Symposium on Scanning Microscopy Techniques, Max Planck Institute fur Biochemie, Munich, November 1989.

C31. "STM and AFM Extensions", IMO Symposium, Wetzlar, FRG, October 1990.

C32. "Scanning Probe Microscopy", Materials Science Seminar, Cornell University, February 1990.

C33. "Scanning Probe Microscopy", Scanning 90, Washington, April 1990.

C34. "New Directions in Nanometer Scale Microscopy", Electron Microscopical Society Meeting, New York, March 1990

- C35. "Nanometer Scale Scanning Microscopy" Philips Research Lab., March 1990.
- C36. "Atomic Force Microscopy", Minerals, Metals and Materials Conference, February 1990.
- C37. "Scanning Probes with Possible Biological Applications", Biophysics Seminar, Cornell University, April 1990.
- C38. "Scanning Probe Microscopy", NIST, Boulder, April 1990.
- C39. "Nanometer Resolution Photoacoustic and Photothermal Imaging with STM", IEEE Ultrasonics Symposium, December 1990.
- C40. "Near-Field Scanning Microscopy", Kodak Research Lab., NY, March 1990
- C41. "Scanning Probe Microscopy and Manipulation", Second Foresight Conference, CA, Nov. 1991.
- C42. "Absorption Microscopy with Picosecond Acoustic Pulses", SPIE, Scanning Microscopy, San Diego, 1991.
- C43. "STM and Related Atomic Scale Surface Probes", APS Spring Meeting, Rochester, NY, April 1991.
- C44. "Optical Absorption Spectroscopy on the Nanometer Scale", SPIE, Los Angeles, CA, Jan 1991.
- C45. "Advances in Dopant Profiling by Atomic Force Microscopy", Symposium on Characterization of Ultra-Shallow Dopant Profiles, Microelectronics Center, Univ. of North Carolina, 1991.
- C46. "Tunneling Microscopy and Manufacturing", IBM Europe Meeting on Grand Challenges in Materials Science, Caen, France, Oct. 1991
- C47. "STM and AFM Extensions", American Chemical Society Annual Meeting, NY, August, 1991.
- C48. "Scanning Probe Microscopy", Physics and Chemistry Seminar, Brown University, March, 1991.
- C49. "Thermal, Optical, Dielectric and Magnetic Scanning Tip Microscopy", Princeton Materials Institute Seminar, May 1991.
- C50. "STM and Related Probe Techniques", Physics Seminar at Brookhaven National Laboratory, June 1991.
- C51. "Recent Progress in Scanning Probe Microscopy", SPIE, January 1992.

- C52. "Material Property Measurement on the Nanoscale", Princeton Materials Seminar, February 1992
- C53. "Scanning Probe Microscopy", Scanning '92, Atlantic City, March 1992.
- C54. "Nanometer Scale Measurement of Physical Properties", NIST, Gaithersburg, May 1992.
- C55. "Nanometer Scale Investigation of Surface Chemical Properties", Gordon Conference on Corrosion, New Hampshire, July 1992.
- C56. "Other Scanned Probe Microscopies", EMSA Workshop on Future Directions in Microscopy and Imaging, Massachusetts, August 1992.
- C57. "Metrology Needs in Semiconductor Industry", **Plenary talk**, NIST Workshop on Metrology Issues in Precision Tolerance Manufacturing, Gaithersburg, August 1992.
- C58. "Surface Topography Using Tip Techniques", 11th Pfefferkorn Conference, Massachusetts, August 1992.
- C59. "Characterization of Non-Crystalline Materials by Scanning Probe Techniques", 112nd TMS Annual Meeting, Denver, Co., February 1993
- C60. "Scanning Probe Microscopy-Current Status & Future Trends" 67th Joint AVS/ACS Colloid & Surface Science Symposium, Toronto, June 1993.
- C61. "Scanned Probes for Metrology", APS March Meeting, Seattle, WA., 1993
- C62. "Scanning Probe Microscopy - Technology & Applications, Princeton Materials Science Seminar, April 1993.
- C63. "Scanning Probe Microscopy and its Applications", Joint AVS/ECS Symposium, Austin, TX., June 1993.
- C64. "Characterization by Scanning Probe Methods", Materials Science Center, University of Minnesota, November 1993.
- C65. "Scanning Probe Microscopy of Physical and Chemical Properties", Johns Hopkins Materials Science Seminar, March, 1994
- C66. "STM's, AFM's and SXM's", Department of Applied Physics, University of Geneva, April 1993.
- C67. "Apertureless Near-Field Optical Microscope", NATO, ASI on Forces in Scanning Probe Methods, Black Forrest, Germany, March 1994
- C68. "Magnetic Force Microscopy and Related Probe Techniques", Advances in Measurement Techniques and Instrumentation for Magnetic Property Determination, Ames, Iowa, May 1994



- C69. "Application of Probe Techniques for Imaging Polymer Surfaces", Polymer Outreach Program, Cornell University Materials Science Center, May 1994
- C70. "Recent Developments in Scanning Probe Microscopy", International Scanning Probe Microscopy Symposium, Cambridge University, June 1994
- C71. "At Line Process Control Using SPM's", IEEE Lithography Workshop, Quebec, Canada, August 1994
- C72. "Scanning Probe Microscopy - Techniques and Applications", Applied Biosystems, San Francisco, October 1994
- C73. "Scanning Probe Microscopy Overview", **Keynote** Speaker, Annual Meeting of Swiss Society of Biologists, Fribourg, Switzerland, March 1995
- C74. "Apertureless Near-Field Optical Microscopy", Annual Meeting of American Chemical Society, Anaheim, CA, April 1995
- C75. "Toward Accurate Metrology with Scanning Force Microscopes", International Conference on Electron, Ion and Photon Beam Technology, Scottsdale, AZ, May 1995
- C76. "Atomic Microprobes", School of Advanced Sensors for Process Control, Banff, Canada, June 1995
- C77. "Scanning Interferometric Apertureless Microscope", NATO Advanced Study Institute on Near-Field Optics, Spain, September 1995
- C78. "Scanning Probe Techniques", **Keynote** Speaker, 5th International Scanning Probe Microscopy Symposium, Rudkers, NJ, September 1995
- C79. "Scanning Probe Microscopy - A Historical Perspective", **Keynote** Speaker, International Symposium on Non-Contact Atomic Force Microscopy for Critical Dimension Metrology, Semicon Southwest, Austin, TX, Oct 1995
- C80. "STM and Related Methods", Symposium 1, 117th Meeting of Japan Institute of Metals, Honolulu, December 1995
- C81. "Optical Microscopy at 10 angstrom Resolution", Physics/Applied Physics Colloquium, Stanford University, March 1996
- C82. "Optical Microscopy and Spectroscopy Near Atomic Resolution", Quantum Electronics and Optics Seminar at MIT, March 1996
- C83. "Optical Microscopy at 10 angstrom Resolution", CALTEC Applied Physics Seminar, May 1996
- C84. "Optical Microscopy Near Atomic Resolution", **Plenary** Talk at Electron, Photon and Ion Beam meeting, Atlanta, May 1996

- C85. "Optical Microscopy and Spectroscopy Near Atomic Resolution", Science Colloquium, IBM Almaden Research Laboratory, October 1996
- C86. "Scanning Interferometric Apertureless Microscopy - Optical Imaging at 10 angstrom Resolution", NANO4 Beijing, September 1996
- C87. "Optical Microscopy Near Atomic Resolution", RPI Physics Colloquium, November 1996
- C88. "Optical Microscopy Near Atomic Resolution", DARPA/DSRC workshop on Future of Massive Memories, San Diego, CA, 1996
- C89. "Optical Microscopy and Spectroscopy Near Atomic Resolution by Scanning Interferometric Apertureless Microscopy", Physics and Chemistry of Small Scale Structures, Albuquerque, NM, February 1997
- C90. "Ultra High Density Storage Concepts using SIAM", IBM Zurich Research Laboratory, Rushlicon, Switzerland, January 1997
- C91. "Optical Microscopy and Spectroscopy Near Atomic Resolution", Royal Society / CIBA Meeting on Advances in Quantum Electronics in Biology and Medicine, London, January 1997.
- C92. "Optical Microscopy Near Atomic Resolution", Physics and Chemistry of Semiconductor Interfaces, Raleigh, NC, January 1997
- C93. "Optical Imaging Near Atomic Resolution", OSA Connecticut Chapter, Danbury, CT, April 1997
- C94. "Scanning Interferometric Apertureless Microscopy", STM 97, Hamburg, Germany, July, 1997
- C95. "Apertureless Near-Field Optical Microscope", International Near-Field Optics Conference NFO4, Jerusalem, February 1997
- C96. "Optical Microscopy Near Atomic Resolution", International Conference on Atomically Controlled Surfaces and Interfaces (ACSI-4), Tokyo, October, 1997
- C97. "Optical Storage Read-Out at 256 Gbits/Sq inch- a Proposal, International Symposium on Optical Memory, Ibaraki, Japan, October, 1998
- C98. "Quest for Optical Microscopy Near Atomic Resolution", APS Annual Meeting, 1998
- C99. "Resolution Limits of Near-Field Optical Microscopy", JILA/NIST, Boulder CO, 1998
- C100. "Recent Advances in Apertureless Near-Field Optical Microscopy", Near-Field Nano-Optics Conference, Osaka, Japan, 1999 (Keynote)
- C101. "Scanning Probe Microscopy – from Birth to Adolescence", APS Centennial Lecture, Physics Department, Queens College, NY, 1999

- C102. “Micro Metrology with Scanning Probes”, AVS 46<sup>th</sup> Annual Meeting Seattle, 1999
- C103. “Electrostatic Force Microscopy”, Electrostatics 99, Cambridge, UK, 1999
- C104. “Development of Magnetic Force Microscopy”, APS March Meeting, 1999
- C105. “Scanning Probe Microscopy-Tools for Manufacturing and Development”, Keithley Award Presentation, APS March Meeting, Minneapolis, 2000
- C106. “Near-Field Optical Microscopy”, Optical Society of America Annual Meeting, Providence, RI, October 2000
- C107. “Scanning Probes and Biophotonics”, Biophotonics Workshop, Case Western Reserve University, 2000
- C108. “Scanning Probe Microscopies”, International Dielectric Society Meeting, Canterbury, UK, April, 2000
- C109. “Scanning Probe Microscopy- an Enabler for Future Nanotechnology, Semiconductor and Storage Technology”, Royal Microscopical Society Meeting, Lancaster, UK, April 2002.
- C110. “Scanning Probe Microscopy – Tools for Nanotechnology”, UC Davis Inter Departmental Colloquium, April 2003
- C111. “IT Opportunities for Nanotechnology”- COMDEX 2003, Las Vegas, November 2003
- C112. “Nanotechnology – Opportunities in Silicon Technology”, World Nano Economic Congress, Washington DC, September 2003
- C113. “Scanning Probe Microscopy Evolution and their Applications in Nanotechnology”, UC Berkeley, Inter Departmental Colloquium, May 2004
- C114. “ Probing The Nanoscale”, 6<sup>th</sup> International Workshop on Micro Factories , Evanston, Il, October 2008 (**Keynote**)
- C115. “Probe Based Electrophoresis”, American Institute of Chemical Engineers Annual Meeting, San Francisco, CA, November 2006 (**Keynote**)
- C116. “AFM Jet Device for Molecular Sorting and Delivery”, International Conference Seeing at the Nanoscale V, Santa Barbara, CA, June 2007
- C117. “Manufacturing at the Nanoscale”, Summer Workshop on Advanced and Futuristic Manufacturing, Evanston, Il, June 2007
- C118. “ Imaging the Nanoscale from Technology to Biology”, Orange County Engineering Council National Engineers Week Awards Banquet, Irvine, February 2007, CA, (**Keynote**)
- C119. “Manipulating Molecules using the AFM”, Nanotechnology 2008, Boston, MA

- C120. “Probing the Gene Expression within a Single Living Cell”, Royal Society London, June 2009
- C121.”Single Cell Chemistry and other Biological Applications of AFM” UCI Center for Complex Biological Systems Retreat, March 2010
- C122. “High Throughput Low Cost DNA Sequencing Using Probe Tip Arrays”, NIH Advanced Sequencing Technology Development Meeting, La Jolly, CA, March 2008
- C123. “High Throughput Low Cost DNA Sequencing by Probe Tip Arrays”, NIH Advanced Sequencing Technology Development Meeting, La Jolly, CA, March 2009
- C124. “Probe Based DNA Sequencing “, NIH Advanced Sequencing Technology Development Meeting, Chapel Hill, NC, March 2010
- C125. “Ultrafast Low Cost DNA Sequencing by Surface Electrophoresis India”, Indo-US Workshop, IIT Kanpur, October 2007
- C126. “Three Dimensional Nanoscale Imaging with X-rays”, Indo-US Workshop, IIT Kanpur, October 2007
- C127. “DNA Probe Electrophoresis”, Indo-US Workshop, IIT Kharagpur, India, January 2009
- C128. “Measurement, Manipulation and Understanding Processes at the Single Molecule Level” Indo-US Workshop, Seattle WA, June 2010
- C129. ”Image force microscopy of molecular resonance – a new microscopy principle”, MRS Fall Meeting, Boston, Dec. 2010
- C130.” Near Field Optical Microscopy – Past, Present and Future”, International Conference on Tip Enhanced Raman Spectroscopy – TERS 2, National Physical Laboratory, Teddington, UK, July 2011. **Keynote**
- C131 "Probing the Nanoscale in Biology and Medicine", **Keynote**, Global Technology Forum, Sri Lanka, Dec. 2011
- C.132. “Development of the Atomic Force Microscope, **Keynote**, International Conference on Micro Manufacturing, Tokyo, March, 2012
- C133. “Mechanical Detection of the Raman Effect”, Eight Annual Workshop Stanford Center for Probing the Nanoscale, Stanford, May 2012
- C134. “ Raman microscopy and spectroscopy by force detection”, Nano Measure 2012, Stanford, June 2012
- C135.” Raman Probe Force Microscope”, Near Field Optics 12, International Conference, **Keynote**, Sept. 2012

C136. “Experiments with the Raman Probe Force Microscope”, Physics Colloquium , Cal State Long Beach, Oct. 2012

C137. “Applications of Nanotechnology to Storage and Biology” , Communications 2025, Oct, 2012

C138. “Near Field Opto-Mechanics and Detecting the Raman Effect”, Optical, Electronic and Quantum Systems Seminar, University of Colorado, Nov. 2012

C139. “Measuring and manipulating single molecules for biological applications”, International Medical Innovation Technology 2025, Tel Aviv, Israel, Nov. 2013

C140. “Mechanical Detection of Optical Resonance”, Nano Optics Workshop, Troyes, France, Nov. 2013

C141. “Near Field Opto-Mechanics”, 44<sup>th</sup> Winter Colloquium, Photonics and Quantum Electronics Conference, Utah, Jan, 2014

C142. “From Molecules to Atoms – Development of Scanning Probes for Visualizing the Nanoworld”, The Nelson Lecture , Georgia State University, Atlanta, April 2015

C143. “Photo Induced Force Microscopy – Nanoscale Imaging of Optical Polarizability”, “SPIE Optics and Photonics Conference, August, 2015, San Diego, CA

C144. “TERS and Photo Induced Force Microscopy”, Plenary Speaker , TERS5, 5<sup>th</sup> International Conference on Tip Enhanced Raman Spectroscopy, Osaka, Japan September 2015

C145. “Some History of Tip Based Near Field Optical Microscopy – Past, Present and Future”, Invited Talk at Nano Korea 2016, July 2016

C146. “Nanotechnology for Detecting Molecular Optical Resonances and Tracking Chemistry of Living Cells”, Invited Talk at Physical Chemistry Seminar, UCLA  
Nov. 2016

C147. “From atoms to molecules – development of scanning probes for visualizing the nanoworld”, Public Lecture, Chinese University of Hong Kong, June 12<sup>th</sup>, 2017

C.148. “Tip Based Near Field Optical Spectroscopy – Past , Present , Future”, Invited Talk at Center for Nano Materials, Chinese University of Hong Kong, June 13<sup>th</sup>, 2017

**PATENTS**

P1. "Differential Phase Contrast Microscope", U.K. No. 212 8734, October 1982, Euro. No. 010 8497, U.S. No. 4 741 620

P2. "Improved Acoustic Coupling Device", U.K. No. 211 0052, June 1981, U.S. No. 4 435 985

P3. "Irradiative Probe System", U.S. Patent No. 4 471 620, May 1988

P4. "Improved Scanning Acoustic Microscope", U.K. No. 205 1363, May 1979, U.S. Patent No. 4 378 699, Japan No. 146 3888

P5. "Scanning Thermal Profiler", U.S. No. 4 747 698, May 1988.

P6. "Particulate Inspection of Fluids", US Patent 5 061 070, Oct. 1991, Euro. Pub. No. 338288 Oct. 1989, Japan Feb. 1989.

P7. "Absorption Microscopy and/or Spectroscopy with Scanning Tunneling Microscopy Control", U.S. Patent No.4 ,941,753, July 1990.

P8. "Apertureless Near-Field Optical Microscope", U.S. Patent No. 4 947 034, August 1990.

P9. "Near-Field Lorentz Force Microscopy", U.S. Patent No. 4 992 659, February 1991.

P10. "Methods for Producing Ultrafine Silicon Tips for AFM/STM Profilometry", U.S. Patent No. 5,242,541, September 1993, Euro. Pub. No. 039506, December 1992.

P11. "Atomic Photo-Absorption Microscope", U.S. Patent No. 5 003 815, April 1991.

P12. "Scanning Capacitance-Voltage Microscopy", U.S. Patent No. 5 065 103, November 1991.

P13. "Multi-Wavelength Optical Thermometry", U.S. Patent No. 5 263 776, November 1993.

P14. "Sample Carriage for Scanning Probe Microscope", U.S.Patent No. 5 260 577, November 1993.

P15. "Feedback Controlled Differential Fiber Interferometer", U.S. Patent No. 5 280 341, January 1994.

P16. "Surface Profiling Using Scanning Force Microscopy", U.S.Patent No. 5 283 442, February 1994.

P17. "Two Dimensional Profiling with a Contact Force Atomic Force Microscope", U.S.Patent No. 5 347 854, September 1994.

P18. "Combined Scanning Force Microscope and Optical Metrology Tool", U.S.Patent No. 5 298 975, March 1994.

- P19. "Method for Measuring the Trench Depth Parameter of a Material", U.S.Patent No. 5 392 118, February 1995.
- P20. "Depth Measurement of High Aspect Ratio Structures", U.S.Patent No. 5 384 639, January 1995.
- P21. "Ultrafine Silicon Tips for AFM/STM Profilometry", U.S.Patent No. 5 382 795, January 1995.
- P22. "A Method Suitable for Identifying a Code Sequence of a Biomolecule", U.S.Patent No. 5 538 898, July 1996.
- P23. "Method and Apparatus for Detecting Asperities on Magnetic Disks Using Thermal Proximity Imaging", U.S.Patent No. 5 527 110, June 1996.
- P24. "Method and Apparatus for Mass Data Storage", U.S.Patent No.5 602 820 February 1997.
- P25. "Interferometric Detection/Imaging Method Based on Multipole Sensing", U.S.Patent No. 5 646 731, July 1997.
- P26. "Interferometric Measuring Method Based on Multipole Sensing", U.S.Patent No.5 623 339, April 1997.
- P27. "Assembly Suitable for Identifying a Code-Sequence of a Biomolecule in a Gel Embodiment", U.S.Patent No. 5 609 744, March 1997.
- P28. "Assembly Suitable for Identifying a Code-Sequence of a Biomolecule in a Free-Solution Embodiment", U.S.Patent No. 5 607 568, March 1997.
- P29. "Interferometric Near-Field Apparatus Based on Multipole Sensing", U.S.Patent No. 5 623 338, April 1997.
- P30. "Assembly and Method for Making In-Process Thin Film Thickness Measurements", U.S.Patent No. 5 640 242, June 1997.
- P31. "Assembly for Measuring the Trench Depth Parameter of a Workpiece", U.S.Patent No. 5 691 540, November 1997.
- P32. "Assembly and Method Suitable for Identifying a Code Sequence of a Biomolecule", U.S.Patent No. 5 624 845, April 1997.
- P33. "Method and Apparatus for Data Storage Using the Thermal Response of a Magnetoresistive Head", U.S.Patent No..5 850 374, December 1998.
- P34. "Method and Apparatus for Data Storage Using Thermal Proximity Imaging", U.S.Patent No..6 052 249, April 2000.
- P35. "Method and Apparatus for Separating Magnetic and Thermal Components from an MR Read Signal", U.S. Patent No. 6,088,176, July 2000

- P36. "Self-Assembled Nanodevices Using DNA", U.S. Patent No.6 656 693, December 2003.
- P37. "Nano Devices using Block Copolymers", US. Patent No. 6,218,175, April 2001
- P38. "Nano-Devices using Block-Copolymers", U.S. Patent No. 6 403 321, June 2002.
- P39. "Ferroelectric Storage Read-Write Memory", U.S. Patent No. 6 548 843, April 2003
- P40. "Support and Alignment Device for Enabling Chemical Mechanical Polish Rinse and Film Measurements", U.S. Patent No. 6 579 149, June 2003.
- P41. "Chemical Mechanical Polishing System and Method for Integrated Spin Dry-Film Thickness Measurement", U.S. Patent No. 6 532 125, March 2003.
- P42. "Apparatus and Method Suitable for Magnetic Thermal Recording", U.S. Patent No. 6 532 125, March 2003.
- P43. "System and Multipass Probe for Optical Interference Measurements", U.S. Patent No. 567 172, May 2003.
- P44. "High Density Magnetic Thermal Recording and Reproducing Assembly", U.S. Patent No. 6 233 206, May 2001.
- P45. "Chemical Mechanical Polishing in-situ End Point System", U.S. Patent No. 6 334 807, Jan 2002
- P46. "Chemical-Mechanical Polishing System and Method for Integrated Spin-Dry Film Thickness Measurement", U.S. Patent No. 6 319 093, November 2001
- P47. "Method of Forming a Patterned Magnetic Recording Medium", U.S. Patent No. 6 733 764, August 2004
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