

Dr. S. Sohail H. Naqvi

Summary

Twenty years of visionary, leading from the front, leadership in academia, industry and Government, achieving ambitious growth targets with huge socio-economic impact on society. Proven highly successful record of spearheading massive reform, enhancement of quality and growth of academic organizations in the public and private sectors. Globally recognized by International Multilaterals and Pakistani public and private sector for bringing about a paradigm change in the national system of higher education of over 150 Institutions, 300,000 students and 13,000 faculty members, across the entire country. A thought leader, innovator and global expert in Telecommunications and Microelectronics sectors, with several ideas to market products, both in the USA and Pakistan

Experience Highlights

Executive Leadership

- ☞ Chief Executive of HEC (Higher Education Commission of Pakistan) a statutory Constitutional body, overseeing projects over US\$ 5 Billion and an annual turnover of US\$ 500 million.
- ☞ Successfully finalized and obtained approval for a US\$300 Million Loan from the World Bank for Tertiary Education Support for Pakistan
- ☞ “Highly Satisfactory” implementation of US\$100 Million Loan for Higher Education Support Program for Pakistan
- ☞ Regular reporting to and consultations with the President, Prime Minister, Cabinet and Legislature
- ☞ Diverse leadership experience of establishment, nurturing and management of growth to leadership position of new academic faculties as well as startup companies along with transformation of existing government legacy organizations

Change Management

- ☞ Successful introduction of research focus in Institutions leading to quadrupling in international research publications from the country, and international recognition of future research potential of Pakistan
- ☞ Management of 240% growth of students over 5 years in universities to over 300,000 in current year
- ☞ University academic staff association negotiations for implementation of higher education reform measures along with performance driven faculty appointment criteria
- ☞ Design and Implementation of formula-based financial allocations to Institutions based on performance and need

Strategy Development & Implementation

- ☞ Strategy and vision plan development for the Commission and Universities, respectively
- ☞ Results oriented strategy implementation along with system of tracking and monitoring against quantifiable targets
- ☞ Restructuring of undergraduate and post-graduate education system to ensure standardization and international compatibility
- ☞ International recognition of implementation by the World Bank and other Institutions

Technical Innovation & Entrepreneurship

- ☞ International track record of teaching, industry driven research, presentations and publication in conferences and journals
- ☞ 3 US patents in novel measurement technique (Scatterometry) for semiconductor dimensional metrology. Scatterometry remains applicable even today 20 years hence!
- ☞ Successful start-up company with metrology technique, prototype development and commercial sale to Bio-Rad Inc. USA
- ☞ Development and deployment in PTCL of voice over packet based call center solution based on a custom designed chip & board developed by a startup company

Education

1988	Ph.D. Electrical Eng., Purdue University, USA, GPA (6.0/6.0)
1986	M.Sc. Electrical Eng., Purdue University, USA, GPA (6.0/6.0)
1984	B.Sc. Electrical Eng. (<i>With Highest Distinction</i>), Purdue University, USA, GPA (6.0/6.0)
1980	Certificado de Suficiencia en Lengua Espanola (Curso Intermedio), Universidad Complutense de Madrid, Spain

Work Experience

1/13 – 6/13	Higher Education Consultant on projects with the World Bank and Asian Development Bank
10/04 – 12/12	Executive Director, Higher Education Commission, Government of Pakistan, Islamabad
02/03 – 10/04	Member Human Resource Development, Higher Education Commission, Islamabad
10/02 - 02/03	Member Human Resource Development, Ministry of IT&T, Islamabad
01/00 - 10/02	Vice President Operations, Communications Enabling Technologies, Islamabad
01/99 - 12/99	Professor & Dean, Faculty of Electronics, GIK Institute of Technology, Topi, Pakistan.
02/98 - 12/98	Staff Scientist, Bio-Rad CD Systems, Albuquerque, USA. On leave from GIK Institute.
08/95 - 12/97	Associate Professor & Interim Dean, Faculty of Electronics, GIK Institute of Technology, Topi, Pakistan.
08/94 - 07/95	Associate Professor, Electrical and Computer Engineering, University of New Mexico, Albuquerque, USA.
08/88 - 08/94	Assistant Professor, Electrical and Computer Engineering, University of New Mexico, Albuquerque, USA.

Consulting

- ☞ World Bank, Modernizing Higher Education in Uzbekistan (Ongoing project since Feb. 2013)
- ☞ Asian Development Bank, Strengthening Quality Assurance and Inclusive Education in Kyrgyzstan (Ongoing project since Feb. 2013); University of Central Asia (University of Central Asia Establishment and assessment of Kyrgyz Republic, Kazakhstan and Tajikistan higher education systems), 2012; Review of Sri Lankan Higher Education System, Sri Lanka Sep. 2011
- ☞ Bio-Rad Inc., Hercules CA, USA (1996-2004)
- ☞ Sandia Systems Inc., Albuquerque, NM, USA (1993-1996)
- ☞ AT&T Bell Laboratories, Murray Hill, NJ, USA (1992-1995)

Professional Activities, Honours & Awards

- ☞ Lifetime Academic Achievement Award, 2012, Inter University Consortium on Social Sciences, Pakistan
 - ☞ Order of the 'Palme Académiques' with rank of Chevalier, awarded by the French Government
 - ☞ Member Steering Committee on Higher Education constituted by President of Pakistan
 - ☞ Founding Member of Engineering Education Trust, Islamabad that has established the Center for Advanced Studies in Engineering
 - ☞ 3 SEMATECH Inventor Recognition Awards
 - ☞ Reviewer, Journal of the Optical Society of America, Optics Letters, IEEE Transactions on Antennas & Signal Processing, Applied Optics.
 - ☞ Graduated first in the Department of Electrical Engineering, Purdue University, USA
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Professional Accomplishments

- ☞ As Executive Director of the Higher Education Commission, Islamabad, developed and implemented a strategy for the uplift of the higher education sector in Pakistan. Managed the transformation of the University Grants Commission having an annual development budget of Rs. 0.3Billion to a vibrant Higher Education Commission managing an active portfolio of more than 500 projects worth more than Rs. 300Billion with an annual outlay of Rs. 18Billion. Guided all public sector universities with the development and implementation of a long term vision that has dramatically transformed the higher education landscape in Pakistan. Worked with the World Bank to create a comprehensive 10 year higher education strategy for Pakistan culminating in a 3-year US\$300 Million Tertiary Education Support Project for HEC. The project implementation is expected to bring the quality of education on par with international standards, ensure alignment of teaching and research with national development objectives, strengthen governance and management, improve communication with stakeholders, enhance equity and add over 1 million students into the sector with a financial outlay of more than Rs. 1 Trillion
- ☞ As Member Human Resource Development and Strategic Planning of the Higher Education Commission oversaw development and implementation of over Rs. 25 Billion worth of higher education programs
- ☞ Member Steering Committee on Higher Education formed by the President, Islamic Republic of Pakistan. Helped with the transformation of the University Grants Commission into the Higher Education Commission. Co-authored the vision document for programs of the Higher Education Commission
- ☞ Founding member of Engineering Education Trust (EET), a not-for-profit organization dedicated to the development of higher education in Pakistan. The Center for Advanced Studies in Engineering (CASE: www.case.edu.pk) is the first project of EET that, in the space of one year, became the largest post-graduate engineering program in Pakistan
- ☞ Managed growth of Communications Enabling Technologies in Pakistan from a 20 person project funded entity operating from a house to a 150 man+ Silicon Valley Venture Capital funded product company operating in a 13,000 sq. ft. facility
- ☞ Project Director for \$1.1 Million task to design, prototype, assemble and install a computerized networked, state-of-the-art, toll collection system on the Lahore-Islamabad (330km long) Motorway.
- ☞ Established the Faculty of Electronics at the GIK Institute of Technology as one of the premier Electrical Engineering Department in South East Asia
- ☞ Founding member of ISTEAC (Ibero-American Science and Technology Education Consortium, www.istec.org) ISTEAC, a non-profit organization comprised of educational, research, and industrial institutions to foster scientific, engineering, and technology education, joint international research and development efforts among its members
- ☞ Co-developed scatterometry as a metrology technique and process sensor for micro-electronic and opto-electronic fabrication and transferred to Bio-Rad Laboratories. The commercial metrology tool (CDS-2 Scatterometer) is now available for sale and is considered a key tool for future sub quarter micron (i.e. Pentium IV-V) generation microprocessors

Technical Interests

- ☞ Voice over Packet telecommunication technology
 - ☞ Communication systems
 - ☞ Critical dimension metrology of semiconductor devices
 - ☞ Scattering and diffraction of electromagnetic waves
 - ☞ Signal & Image processing
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University Teaching

- ☞ Information Theory, Digital Communications, Probability Theory
 - ☞ Electromagnetics, Electrodynamics, Electro-Optics
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Patents & Publications

- ☞ 3 Patents Issued
 - ☞ 18 Refereed Publications in International Journals
 - ☞ 10 Invited Publications in Journals & Conference Proceedings
 - ☞ > 60 Publications & Presentation of Conference Papers
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Higher Education Conference/Seminar Presentations (International)

- ☞ *Funding Mechanisms at National and Institutional Level in Pakistan*, presented at The World Bank-Iraq Education Study Tour for the Knowledge Economy (ESTKE), June 16-17, 2011 Penang, Malaysia
 - ☞ *Higher Education Governance in Pakistan*, presented at Transforming Tertiary Education for Innovation and Competitiveness, June 6-9, 2011, Bali, Indonesia, World Bank Institute Course
 - ☞ *Rankings: A Pakistani Perspective*, presented at the UNESCO Global Forum on Rankings and Accountability in Higher Education: Uses and Misuses, May 16-17, 2011, Paris, France
 - ☞ *Higher Education Governance in Pakistan*, presented at the World Bank Conference on Governance and Financing of Higher Education in Asia, October 18-20, 2010, Phuket, Thailand
 - ☞ *Concretizing Proposed Reforms*, presented at the Asia Development Bank International Forum on Higher Education in Asia, 26-27 July 2011, Manila, Philippines
 - ☞ *Governance and Financing Challenges Involved in Building a High Performing Higher Education System*, presented at a High-level Roundtable on education quality organized by the World Bank for the Egyptian Cabinet, March 19-20, 2010, Luxor, Egypt
 - ☞ *Country Report on Pakistan*, presented at the Sub-Regional Conference of South, South-West and Central Asia on Higher Education, “Facing Global and Local Challenges The New Dynamics of Higher Education”, February 25-26, 2009 New Delhi, India
 - ☞ *International university links: A one-way street?*, presented at Going Global 3 organized by the British Council, December 3 – 5, 2008, London, England
 - ☞ *Building Innovative Higher Education Partnerships* presented at the Asia Regional Higher Education Summit, “Higher Education’s Response to Global Challenges”, October 6 - 8, 2008, Dhaka, Bangladesh
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Personal

- ☞ Married with three children
- ☞ US Citizen

References

- ☞ Prof. Dr. Atta ur Rahman
 - Former Minister for Science & Technology and former Chairman Higher Education Commission
 - Email: ibne_sina@hotmail.com
- ☞ Dr. Shamsh Kassim-Lakha
 - Former Minister for Education and Founding President of Aga Khan University. Former Co-Chairman of the Higher Education Task Force
 - Email: skassim.lakha@gmail.com
- ☞ Dr. Benoit Millot
 - Former Lead Education Specialist, World Bank
 - Email: Bmillot@worldbank.org

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Others available on request

Dr. S. Sohail H. Naqvi

RESUME DETAILS

1. **RECORD OF FUNDED RESEARCH:** Approximately \$3.5 million

1990 - 1991:	Semiconductor Research Corporation Scatterometry <i>application to</i> Semiconductor Processing Task Leaders: S. S. H. Naqvi and J. R. McNeil	\$249,273
1990-1992:	National Science Foundation <i>Architecture for Multichannel Optical Fiber Communication Arrays of Surface Normal Devices</i> Principal Investigator: J. McInerney, Co-Principal Investigators: K. Malloy, J. Chang and S. S. H. Naqvi	\$600,000
1991-1992:	Semiconductor Research Corporation Scatterometry <i>application to</i> Semiconductor Processing Task Leaders: S. S. H. Naqvi and J. R. McNeil	\$250,000
1990-1991:	Semiconductor Research Corporation <i>Alignment/ Temperature measurement using Moire gratings</i> Co-task leader with Dr. Steven R. J. Brueck	\$80,000
1991-1992:	Sandia National Laboratory <i>Optical Scatter Modeling for Grating Line Shape Characterization</i> Principal Investigator: S. Sohail H. Naqvi	\$40,000
1992-1993:	Semiconductor Research Corporation Scatterometry <i>application to</i> Semiconductor Processing Task Leaders: S. S. H. Naqvi and J. R. McNeil	\$250,000
1991-1992:	Sandia National Laboratory <i>Massively parallel solution of Inverse Scattering Problem for Integrated Circuit Quality Control</i> Principal Investigator: S. S. H. Naqvi	\$ 52,249
1993-1996	Air Force Office of Scientific Research \$185,028 <i>Instrumentation to enhance optical scatterometry-y for semiconductor- metrology</i> development Principal Investigators: S. S. H. Naqvi and J. R. McNeil.	\$185,028
1993-1994:	Semiconductor Research Corporation Scatterometry <i>application to</i> Semiconductor Processing Task Leaders: S. S. H. Naqvi and J. R. McNeil	\$200,000
1993-1995:	Sandia National Laboratory <i>Development of Scatterometry Metrology Sensors</i> Principal Investigators: S. S. H. Naqvi and J. R. McNeil.	\$164,340
1994-1995:	Semiconductor Research Corporation New Mexico SEMA TECH Center of Excellence for Metrology and on-line analysis for Semiconductor Manufacturing - Scatterometry Co-task leader with Dr. John R. McNeil	\$130,000
1997	National Highway Authority, Pakistan <i>Labore Islamabad Motorway Toll Collection System</i> (\$ 1. 1 Million) Project Director: S. S. H. Naqvi	Rs. 50 Million (\$1.1 Million)

2. CREATIVE WORKS:

A. Patents Awarded:

1. Patent 5,164,790 *Simple CD Measurement of Periodic Structures on Photomasks*, S. S. H. Naqvi, J. R. McNeil, S. M. Gaspar*.
2. Patent 5,674,652, issued Oct. 7, 1997, *Diffraction Light from Latent Images in Photoresist for Exposure Control*, K. P. Bishop*, S. R. J. Brueck, S. M. Gaspar*, K. C. Hickman*, J. R. McNeil, S. S. H. Naqvi, B. R. Stallard.
3. Patent 5,703,692, issued Dec. 30, 1997, *Lens Scatterometer System Employing Source Light Beam Scanning Means*, J. R. McNeil, S. S. H. Naqvi, and S. R. Wilson.

B. Refereed Journal Papers, Communications and Technical Notes:

* Indicates Graduate Students

1. S. S. H. Naqvi and N. C. Gallagher, *Comments on Electromagnetic Wave Scattering by an Infinite Plane Metallic Grating in Case of Oblique Incidence and Arbitrary polarization*, IEEE Trans. on Antennas and Propagation, pp. 414-415, Mar. 1990.
2. S. S. H. Naqvi, *A Comment on the Use of TE/TM Polarization Notation, Metallic Grating in Case of Oblique Incidence and Arbitrary Polarization*, IEEE Trans. on Antennas and Propagation, p. 584, Apr. 1990.
3. S. S. H. Naqvi and N. C. Gallagher, *A General Solution to the Scattering of Electromagnetic Waves From a Strip Grating*, Journal of Modern Optics, **37(10)**, pp. 1629-1643, Oct. 1990.
4. S. S. H. Naqvi and N. C. Gallagher, *Analysis of Strip Grating Twist Reflector*, Journal of Optical Society of America, 7(9), 1723-1729, Sep. 1990.
5. S. S. H. Naqvi, S. Gaspar*, K. Hickman*, K. Bishop*, J. R. McNeil, *A Simple Technique for Line width Measurement of Gratings on Photomask*, **31(10)**, 1 Apr. 1992, pp. 1377-1384.
6. K. C. Hickman*, S. M. Gaspar*, S. S. H. Naqvi, K. P. Bishop*, J. R. McNeil, G. D. Tipton, B. Draper, and B. R. Stallard, *Use of Diffraction From Latent Images to Improve Lithography Control*, Journal of Vacuum Science and Technology B, 10(5), Sept./Oct. 1992, pp. 2259-2266.
7. L. M. Milner*, P. Bishop*, S. S. H. Naqvi and J. R. McNeil, *Stepper Focus Characterization Using Diffraction From Latent Images*, Journal of Vacuum Science and Technology B, Jul./Aug. 1993, pp. 1258-1266.
8. J. A. Gregus, C. A. Green, E. Yoon, F. W. Ostermayer, T. R. Hayes, R. Pawelek, R. A. Gottscho and S. S. H. Naqvi, *Real-time Latent Image Monitoring During Holographic Fabrication of Sub-micron Diffraction Gratings*, Journal of Vacuum Science & Technology B, 11(6), Nov./Dec. 1993, pp. 2468-247.
9. S. S. H. Naqvi, R. H. Krukar*, J. R. McNeil, J. E. Franke, T. M. Niemczyk, D. M. Haaland, R. Gottscho, A. Kornblit, *Etch Depth Estimation of Large Period Silicon Gratings Using Multivariate Calibration of Rigorously Simulated Diffraction Profiles*, Journal of the Optical Society of America A, 11(9), Sep. 1994, pp. 2485-2493.
10. S. S. H. Naqvi, S. H. Zaidi, S. R. J. Brueck, *Diffraction Techniques for Lithographic Process Monitoring and Control*, J. Vac. Sci. Technol. B, vol. 12(6) Nov/Dec 1994, pp. 3600-3606.
11. Z. R. Hatab*, J. R. McNeil, S. S. H. Naqvi, *16MB DRAM Bench Depth Characterization Using Two Dimensional Diffraction Analysis*, J. Vac. Sci. Technol. B, vol. 13(2) Mar/Apr 1995, pp. 174-182.
12. P. Blattner, H-P Herzig, S. S. H. Naqvi, *Scanning Spot Metrology for Testing of Photolithography Masks*, Optical Engineering, **34(8)**, 1995, pp. 2425-2427.
13. C. J. Raymond*, M. R. Murnane*, S. S. H. Naqvi, J. R. McNeil, *Metrology of Sub-wavelength Photoresist Gratings using Optical Scatterometry*, J. Vac. Sci. Technol. B, vol. 13(4) Jul/Aug 1995, pp. 1484-1495.

14. P. Blattner, S. S. H. Naqvi, P. Ehbets, and H. P. Herzig, *Diffraction Structures for Testing Nano-meter Technology*, *Microelectronic Engineering* **27**, 1995, 543-546.
15. Z. R. Hatab*, S. L. Prins*, S. S. H. Naqvi, J. R. McNeil, *16MB DRAM Trench Depth Characterization using Dome Scatterometry*, *Applied Surface Science* **86**, 1995, pp. 597-599.
16. C. J. Raymond*, J. R. McNeil, S. S. H. Naqvi, *Multiparameter Grating Metrology using Scatterometry*, *Journal of Vacuum Science and Technology, B*, pp. 361-368 Mar/Apr 1997.
17. S. A. Coulombe, B. K. Minhas*, C. J. Raymond*, S. S. H. Naqvi, J. R. McNeil, *Scatterometry Measurements of Sub-0.1 μ m Line width Gratings* *J. Vac. Sci. Technology B* Vol. 16 No. 1, 1998, pp. 80-87.
18. B. K. Minhas*, S. A. Coulombe, S. S. H. Naqvi, J. R. McNeil, *Ellipsometric Scatterometry for the Metrology of Sub-0.1 μ m Linewidth Structures*, *Applied Optics*, 37(22), August 1998, pp. 5112-5115.

C. Invited Papers:

1. J. R. McNeil, S. Gaspar*, K. Hickman*, K. Bishop*, S. S. H. Naqvi, and S. Brueck, *Applications of Optical Scatterometry to Microelectronic Material Processing*, presented at IEEE LEOS 90 Conf. Nov. 3-8, 1990, Boston, MA.
2. J. R. McNeil, S. S. H. Naqvi, S. M. Gaspar*, R. C. Hickman*, K. P. Bishop*, L. M. Milner*, R. H. Krukar*, G. A. Peterson, *Scatterometry Applied to Microelectronics Processing*, *Microolithography World*, pp. 16-22, Nov/Dec 1992.
3. S. S. H. Naqvi, J. R. McNeil, R. Krukar*, K. P. Bishop*, *Scatterometry and the Simulation of Diffraction-based Metrology*, *Microolithography World*, Jul/Aug/Sep 1993, **2(3)**.
4. S. S. H. Naqvi, J. R. McNeil, R. H. Krukar*, Z. R. Hatab*, *Grating Parameter Estimation Using Scatterometry*, *Miniature Micro-Optics and Micromechanics*, Neal C. Gallagher and Chandrashekar Roychoudri Ed.'s, *Proc. SPIE* **1992**, 1993, pp. 170-180.
5. R. H. Krukar*, S. L. Prins*, G. X. Peterson, S. M. Gaspar*, J. R. McNeil, S. S. H. Naqvi, D. R. Hush, *Using Scattered Light Modeling for Semiconductor Critical Dimension Metrology and Calibration*, *Integrated Circuit Metrology, Inspection, and Process Control VII*, *Proc. SPIE* **1926**, Mar. 1993.
6. S. S. H. Naqvi, S. H. Zaidi, S. R. J. Brueck, 1)' R. McNeil, *Diffraction Techniques for Lithographic Process Monitoring and Control* presented at time 38th Annual Electron, Ion, and Photon Beam Symposium, May 1994.
7. J. R. McNeil, S. Prins*, C. J. Raymond*, S. S. H. Naqvi, *Scatterometry as a Metrology Tool for Semiconductor and Flat Panel Display Processing*, presented at the International Conference on Metallurgical Coatings and Thin Films, San Diego, CA, April 1997
8. J. R. McNeil, S. A. Coulombe, P. C. Logofatu, C. J. Raymond*, S. S. H. Naqvi, G. J. Collins, *Application of optical scatterometry to microelectronic and flat panel display manufacturing Scattering and Surface Roughness*, *Proc. SPIE* **3426**, pp. 202-212, *Scattering and Surface Roughness II*, Zu-Han Gu, Alexei A. Maradudin Eds. 1998.
9. J. R. McNeil, S. A. Coulombe, P. C. Logofatu, C. J. Raymond*, S. S. H. Naqvi, *Application of optical scatterometry to microelectronics processing*, presented at Conference on Lasers and Electro-Optics CLEO '98 May 1998.
10. S. S. H. Naqvi, J. R. McNeil, *Optical scatterometry for process metrology*, *Proc. SPIE CR72*, pp. 129-144, *Optical Metrology*, Ghanim A. Al-Jumaily Ed. 1999.

D. Conference Papers:

1. S. S. H. Naqvi, N. C. Gallagher, and E. J. Coyle, *An Application of Median Filters to Digital Television*, *Proceedings of the IEEE International Conference on ASSP*, Tokyo, Japan, Apr. 1987.

2. N. C. Gallagher and S. S. H. Naqvi, *Diffraction Optics: Scalar and Nonscalar Design Analysis*, Holographic Optics: Optically and Computer Generated, I. N. Cindrich and S. H. Lee, Editors, Proc. SPIE **1052**, pp. 32-40, 1989.
3. S. S. H. Naqvi, S. Gaspar*, K. Hickman* and J. R. McNeil, *A Simple Technique for Linewidth Measurement of Gratings on Photomasks*, SPIE's 1990 Symposium on Microlithography, San Jose, California, Williams H. Arnold Ed., Proc. SPIE **1261** pp. 495-504, 1990.
4. S. S. H. Naqvi, *Scattering from a Strip Grating Placed on a Multilayer Dielectric Sheet*, IEEE AP-S International Symposium, Digest vol. 1, pp. 410-413, Dallas, Texas, May 1990.
5. S. H. Zaidi, S. S. H. Naqvi, S. R. J. Brueck, *Submicrometer Lithographic Alignment and Overlay Strategies*, X-Ray/EUV Optics for Astronomy, Microscopy, Polarimetry, Proc. SPIE **1343**, pp. 245-255, 1991.
6. K. C. Hickman*, S. M. Gaspar*, S. S. H. Naqvi, K. P. Bishop*, J. R. McNeil, G. D. Tipton, B. H. Draper, and B. R. Stallard, *Use of Diffraction from Latent Images to Improve Lithography Control*, Integrated Circuit Metrology, Inspection, and Process Control, W. H. Arnold, Editor, Proc. SPIE **1464**, pp. 145-257, 1991.
7. K.P. Bishop*, S. M. Gaspar*, L. M. Milner*, S. S. H. Naqvi and J. R. McNeil, *Grating Line Shape Characterization Using Scatterometry*, International Conference on the Application and Theory of Periodic Structures, J. M. Lerner, W. R. McKinney, Editors, Proc. SPIE **1545**, pp. 64-73, 1991.
8. K. P. Bishop*, L. M. Milner*, S. S. H. Naqvi, J. R. McNeil and B. L. Draper, *Use of Scatterometry for Resist Process Control*, Integrated Circuit Metrology and Process Control VI, B. J. Lin, Editor, Proc. SPIE **1673**, pp. 441-452, 1992.
9. L. M. Milner*, K. C. Hickman*, S. M. Gaspar*, K. P. Bishop*, S. S. H. Naqvi, J. R. McNeil, M. Blain and B. L. Draper, *Use of Scatterometry for Resist Process Control*, Integrated Circuit Metrology and Process Control VI, B. J. Lin, Editor, Proc., SPIE **1673**, pp. 274-283, 1992.
10. S. M. Gaspar*, K. C. Hickman*, K. D. Bishop*, S. S. Naqvi, J. R. McNeil, S. Wilson*, V. E. Shaursen, R. A. Gottscho, Akornbilt, *Laser Scattering for Process Characterization*, presented at the 2nd Intl. Meeting on Advanced Processing and Characterization Technologies, May 8-10, 1991, Clearwater Beach, Fla.
11. R. H. Krukar*, S. M. Gaspar*, and J. R. McNeil, S. S. H. Naqvi, *Wafer Examination and Critical Dimension Estimation Using Scattered Light*, Machine Vision Applications In Character Recognition and Industrial Inspection, Donald P. D'Amato, Wolf-Ekkehard Blanz, Byron E. Dom, Sasrgur N. Srihari, Editors, Proc. SPIE **1661**, pp. 323-332, 1992.
12. S. M. G. Wilson*, G. A. Petersen, S. S. H. Naqvi, J. R. McNeil, *Application of Laser Scatterometry to Characterize Phase Shifting Masks*, 12th Annual BACUS Symposium, Proc. SPIE **1809**, Sep. 1992.
13. R. H. Krukar*, S. L. Prins*, J. R. McNeil*, S. S. Naqvi, D. R. Hush, J. E. Franke, T. Niemczyk, R. A. Gottscho, and A. Kornblit, *Analyzing Simulated and Measured Optical Scatter for Semiconductor Process Verification*, in Machine Vision Applications in Character Recognition and Industrial Inspection, Proc. SPIE **1907**, pp. 238-249, 1993.
14. L. M. Milner*, K. P. Bishop*, S. S. H. Naqvi, J. R. McNeil, "Lithography Process Monitor Using Light Diffracted from a latent Image," in Integrated Circuit Metrology, Inspection, and Process Control VII, Proc. SPIE **1926**, pp. 274-283, 1993.
15. S. W. Farrer*, S. S. H. Naqvi*, J. Cheng, K. J. Malloy, J. G. M. McInerney, *Numerical Modeling of a novel TDM Digital Optical Fiber Communication Link*, Multigigabit Fiber Communication Systems, Leonid G. Kazovsky and Karen Liu Ed.'s, Proc. SPIE, **2024**, pp. 365-373, 1993
16. Z. R. Hatab*, S. L. Prins*, J. R. McNeil, S. S. -H. Naqvi, *Two-dimensional Diffraction Based Technique for Deep Trench Depth Measurement*, SRC TECHCON'93 Extended Abstracts, pp. 90-92, 1993.
17. S. H. Zaidi*, S. L. Prins*, J. R. McNeil, S. S. H. Naqvi, *Metrology Sensors for Advanced Resists*, in Integrated Circuit Metrology and Process Control VIII, Michael T. Postek, Ed., Proc. SPIE **2196**, pp. 341-351, 1994.

18. Z. R. Hatab*, S. L. Prins*, J. R. McNeil, S. S. H. Naqvi, *16MB DRAM Etch depth Characterization Using Dome Scatterometry*, Integrated Circuit Metrology and Process Control VIII, Michael T. Postek, Ed., Proc. SPIE **2196**, pp. 2-13, 1994.
19. M. Murnane*, C. Raymond*, S. G. Wilson*, S. S. H. Naqvi, J. R. McNeil, *Developed Photoresist Lineshape Metrology Using Scatterometry*, in Integrated Circuit Metrology and Process Control VIII, Michael T. Postek, Ed., Proc. SPIE **2196**, pp. 47-59, 1994.
20. S. L. Prins*, L. M. Milner*, S. Zaidi*, S. S. H. Naqvi, J. R. McNeil, *Scatterometry Employed to Monitor Focus and Exposure in Microlithography*, SRC TECHCON'93 Extended Abstracts, pp. 447, 1994.
21. C. J. Raymond*, M. Murnane*, S. S. H. Naqvi, J. R. McNeil, *A Scatterometric Sensor for Lithography, Manufacturing Process Control for Microelectronic Devices and Circuits*, Proc. SPIE **2336**, pp. 37-49, 1994.
22. S. M. G. Wilson*, S. S. H. Naqvi, B. K. Minhas*, J. R. McNeil *Phase Shift Mask Metrology Using Scatterometry*, "Digest Series (Optical Society of America, Washington, DC 1994) pp. 342-345, 1994.
23. S. M. G. Wilson*, H. M. Marchman, S. S. H. Naqvi, J. R. McNeil, *Phase Shift Mask Metrology Using Scatterometry*, 14th Annual BACUS Symposium on Photomask Technology, pp. 305315, Proc. SPIE **2327**, 1994.
24. C. J. Raymond*, M. Murnane*, S. L. Prins*, S. S. H. Naqvi, J. R. McNeil, *Scatterometry for 0.24- μ m to 0.70- μ m Developed Photoresist Metrology*, Integrated Circuit Metrology, Inspection and Process Control IX, Proc. SPIE **2439**, pp. 427-436, 1995.
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E. Technical Conference Presentations

1. S. S. H. Naqvi and N. C. Gallagher, A General Solution to the Scattering of Electromagnetic Waves From a Strip Grating, presented at Optical Society of America, Annual Conference, Rochester, New York, Oct. 1987.
2. S. S. H. Naqvi and N. C. Gallagher, Electromagnetic Wave Scattering from Planar Periodic Metallic Surfaces, presented at Optical Society of America, Annual Conference, Santa Clara, California, Oct. 1988.
3. S. S. H. Naqvi and N. C. Gallagher, *Strip Grating Twist Reflector, Part 1: Analysis*, presented at Optical Society of America, Annual Conference, Orlando, Florida, Oct. 1989.
4. R. Jordan, H. Pollard, C. T. Abdallah, and S. S. H. Naqvi, An International Education Project, Presented at the UPADI Pan American Federation of Engineering Societies, XXI Convention, Washington, D.C., Aug. 1990.
5. S. M. Gaspar*, K. C. Hickman*, R. H. Krukar*, K. P. Bishop*, S. S. Naqvi, J. R. McNeil, G. Tipton, B. R. Stallard, B. L. Draper and R. P. Jacobsen, *Application of Optical Scatter Techniques for Microelectronics Processing Control*, presented at SPIE's Optical Engineering South Central 91, Dallas Texas, 8-10 May 1991.
6. P. R. G. Franco* and S. S. H. -Naqvi, *Near-Field Observations of a Strip Grating Illuminated with a Plane Monochromatic Wave*, in OSA Annual Meeting Technical Digest, 1991, (Optical Society of America, Washington, DC, 1991), vol. 17, pp. 56.
7. K. P. Bishop*, S. M. Gaspar*, K. C. Hickman* and S. S. H. Naqvi and J. R. McNeil *Use of Rigorous Diffraction Analysis for Characterization of Latent Image Gratings*, in OSA Annual Meeting Technical Digest, 1991, (Optical Society of America, Washington, DC, 1991), **17**, pp. 220.
8. K. C. Hickman, S. M. Gaspar*, K. P. Bishop*, S. S. H. Naqvi and J. R. McNeil, *Photoresist Exposure Control Using Light Scatter*, in OSA Annual Meeting Technical Digest, 1991, (Optical Society of America, Washington, DC, 1991), **17**, pp. 220-221.
9. K. P. Bishop*, S. S. H. Naqvi, L. M. Milner*, and J. R. McNeil, *Advances in the Modeling of Diffraction from Latent Image Grating*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 57.
10. L. M. Milner*, K. P. Bishop*, S. S. H. Naqvi, and J. R. McNeil, *Latent Image Characterization Using Diffracted Light*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 66,20
11. S. M. Gaspar*, R. H. Krukar*, G. L. Peterson, S. R. Wilson, J. R. McNeil, and S. S. H. Naqvi, *Use of Scatterometry in Photomask Metrology*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 66.
12. P. R. G. Franco*, R. Jordan, and S. S. H. Naqvi, *Spectral Analysis Algorithms for Measurements of Critical Dimensions*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 66.

13. S. W. Farrer*, J. Cheng, K. J. Malloy, J. G. McInerney, and S. S. H. Naqvi ' Simulation of a Novel OTDM Fiber Link, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, P. 116.
14. S. S. H. Naqvi and R. Leland, *Massively Parallel Solution of Scattering from Doubly Periodic Structures*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 182.
15. T. Sze, J. Cheng, S. D. Hersee, J. McInerney, S. Z. Sun, S. Naqvi, and K. J. Malloy, *MOCVD Grown Vertical-Cavity Surface-Emitting Laser Arrays with Spatially Graded Lasing Spectra*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 194.
16. R. H. Krukar*, S. S. H. Naqvi*, J. R. McNeil, J. E. Franke, T. M. Niemczyk and D. R. Hush, *Novel Diffraction Techniques for Metrology of Etched Silicon Grating*, in OSA Annual Meeting Technical Digest, 1992 (Optical Society of America, Washington, D.C., 1992), **23**, p. 204.
17. B. K. Minhas*, S. S. H. Naqvi, R. Leland, *Study of Eigenvalue Behavior in Rigorous Coupled Wave Analysis*, OSA Annual Meeting Technical Digest, 1993 (Optical Society of America, Washington, DC, 1993), **16**, p. 25.
18. S. S. H. Naqvi, B. K. Minhas*, R. Krukar*, R. Leland, *Electromagnetic Inverse Scattering Analysis of Diffraction Grating*, OSA Annual Meeting Technical Digest, 1993 (Optical Society of America, Washington, DC, 1993), **16**, p. 26.
19. S. Zaidi*, J. R. McNeil*, S. S. H. Naqvi, *Scatterometric Process Monitoring of Silylation*, OSA Annual Meeting Technical Digest, 1993 (Optical Society of America, Washington, DC, 1993), **16**, p. 62.
20. S. S. H. Naqvi, J. R. McNeil, C. J. Raymond*, M. Murnane*¹ *Stepper Setup Using Scatterometry*, IEEE Lithograph_y Workshop, Quebec City, Aug. 1994.
21. C. J. Raymond*, M. Murnane*, S. S. H. Naqvi, J. R. McNeil, *Parametric Inverse Diffraction Analysis of Diffraction Gratings*, OSA Annual Meeting Technical Digest, 1994 (Optical Society of America, Washington, DC, 1994).

4. **PROFESSIONAL DEVELOPMENT AND SERVICE:**

Graduate student advisement. The bulk of my research has been in the area of Scatterometry where late Prof. John R. McNeil and myself jointly advised a group of students. Students of the scatterometry group are indicated by *

Ph.D. Students:

- ☞ Richard Krukar*, A Methodology for the use of Diffracted Scatter Analysis to Measure the Critical Dimension of Periodic Structures.
- ☞ Paulo R. G. Franco, Optical Microscopy - Simulation and Application of Signal Processing Techniques to Improve Measurement of Critical Dimensions.
- ☞ Shoab H. Zaidi*, Scatterometric Monitoring of Silylation.
- ☞ Susan M. Gaspar*, Light Scatter Metrology of Phase-Shifting Photomasks.
- ☞ Steven L. Prins*, Monitoring the Post-Exposure Bake Process for Chemically Amplified Resists using a Scatterometric Sensor.
- ☞ Chris J. Raymond *, Measurement and Analysis of Semiconductor Materials using 2-q Scatterometry.