

# TANGALI S. SUDARSHAN

Carolina Distinguished Professor Emeritus of Electrical Engineering and Fellow of IEEE

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## EDUCATIONAL RECORD

1. Ph.D.                      Electrical Engineering (High Voltage Electrical Engineering)  
October 1974              University of Waterloo, Ontario, Canada  
Thesis title:              *Flashover of Solid Insulators in Vacuum*
2. M.A.Sc.                    Electrical Engineering (High Voltage Engineering)  
August 1972              University of Waterloo, Ontario, Canada  
Thesis title:              *Field Enhancement due to Solid Insulators Subjected to High DC Stresses in Vacuum*
3. M.Sc.                      Physics (Solid state)  
June, 1970                University of Mysore, Mysore, India
4. B.Sc.                      Physics, Mathematics, and Chemistry  
May 1968                 University of Bangalore, Bangalore, India

## SPECIALIZATIONS AND RESEARCH INTERESTS

Novel techniques of growth of silicon carbide (SiC) bulk and epitaxial films; surface modification to produce porous SiC; SiC material and device processing – wafering, surface polishing, oxidation, mask technology, dopant diffusion, implant activation, and metallization; fabrication and characterization of SiC high power Diodes and Transistors; novel defect characterization methods for wide bandgap semiconductors; novel methods of Graphene growth by CVD; high field effects in SiC-based electronic materials and devices; high power solid-state switches; electron emission from thin films, as cold cathodes, for applications in field emission displays; microspacer insulation for flat panel displays; solid, liquid and gas insulated systems for high voltage power apparatus, underground power cable, overhead transmission systems and pulsed power systems; surface flashover of solid dielectrics and photoconducting materials in high vacuum and compressed gas systems; fast high voltage and current diagnostics, and low light level imaging; electric field studies using numerical techniques; insulator degradation and aging, coronas and arcs, power system protection.

*Special Interests in Humanitarian Engineering and Rural Science & Technology Education:* In the developing world, develop and install inexpensive, easy to assemble-on-site, and easy to maintain Water Purification Units independent of the power grid that can remove turbidity, sterilize water, and remove harmful dissolved metals, fluorides, nitrates, etc. In village schools and community centers, provide solar lighting for children to study when the Sun sets. Assist village schools with Science & Technology education by providing easy to use instruments such as Microscopes, Telescopes, Lenses & Prisms; provide Science & Engineering project kits to facilitate hands-on learning in the areas of Physics (electricity, magnetism, etc.), Chemistry (chemical reactions), Biology (plant and animal). With support from Charitable Organizations, work with NGOs, Social Workers (including College Students), and Social Entrepreneurs to install Water Purification units, Solar Lighting, and to enhance Science & Technology literacy in rural parts of India.

**EXPERIENCE**

**September 2006 to August 2012 :** *Department Chair, Department of Electrical Engineering*  
University of South Carolina

**1987 to 2014 :** *Carolina Distinguished Professor, Department of Electrical Engineering, University of South Carolina*

Research activity in the areas of (1) SiC bulk growth, wafering, and surface preparation; defect characterization; CVD film growth; defect characterization; porous SiC; SiC material and device processing; device fabrication and characterization, (2) Surface flashover mechanisms along insulators and photoconducting materials in high vacuum for nanosecond excitations, (3) Insulator surface flashover mechanisms in vacuum and compressed gases for DC, 60 Hz and slow pulsed excitations, (4) High field insulation relevant to vacuum microelectronics, (5) Design of high current, high voltage crowbar switch for fusion applications, (6) Study of the characteristics of high vacuum and compressed gas gaps used as high voltage, high current switching elements, (7) Coating of metal surfaces with liquid metals for applications in high power switches, (8) Application of plasmas to metal surface coatings and alloying, and (9) Characterization of the degradation of Barium Titanate insulated capacitors.

**1982 - 1987:** *Associate Professor, Department of Electrical and Computer Engineering*  
University of South Carolina

**1979 – 1982:** *Assistant Professor, Department of Electrical and Computer Engineering,*  
*University of South Carolina.*

**1974 - 1979:** *Research Officer in the Electrical Engineering Division*  
National Research Council of Canada, Ottawa

Responsible for (1) the study of the deterioration of polymeric materials used in underground power cables, (2) developing additives to retard the degradation of polyethylene, to improve the overall reliability of the power system, (3) developing techniques to test insulating materials for resistance to discharges, (4) studying accelerated aging of insulating materials, and (5) studying the characteristics of insulating materials at cryogenic temperatures.

**1971 - 1974:** *Research Assistant, University of Waterloo, Ontario, Canada*

Research work included study of mechanisms involved in the flashover of insulators in vacuum subject to high stresses. Measurement of electric fields was made in the proximity of insulators due to positive charging caused by HV stress. Suitable insulator coatings, which reduced the charging, were developed, improving breakdown performance by nearly 300%. The study also involved high-speed photography of electric arcs along insulator surfaces using an image converter camera, electron microprobe analysis of microparticles, and computer simulation of prebreakdown phenomena.

**HONORS AND AWARDS**

- William G. Dunbar ‘High Voltage Award’ by 2012 IEEE Intl Power Modulator and High Voltage Conference (IEEE Dielectrics and Electrical Insulation Society) 2012
- Russell Research Award awarded by USC for innovative research 2010
- USC International Advocate award for student outreach to international students 2010
- Carolina Trustee Professorship awarded by USC Board of Trustees 2009
- Governor’s Distinguished Professor award by the Commission on Higher Education 2007
- Carolina Distinguished Professor reappointment in May 2007 for five years (continuous appointment from 1987 to 2012) 2007
- Irons Endowed Distinguished Lecturer, Rutgers University, the State University Of New Jersey 2007
- Michael J. Mungo Distinguished Professor of the Year award 2006

- Governor's Distinguished Professor Award 2006
- Fellow of the Institute of Electrical & Electronic Engineers (IEEE) 2005
- College of Engineering and Information Technology Research Achievement Award 2001
- Carolina Distinguished Professor 1995 to present
- Carolina Research Professor 1986 to 1994
- Alpha chapter of Mortar Board Excellence in Teaching Award Nov. 1991
- College of Engineering Research Achievement Award 1991
- Carolina Education Foundation Award for Research in Science and Engineering 1990
- Sigma Chi Outstanding Teacher of the Year 1985
- Outstanding Young Men of America 1982
- Who is Who in Technology 1980
- Council of Scientific and Industrial Research Fellowship 1970-1971
- India National Merit Scholarship 1968-1970

### PROFESSIONAL AND HONOR ORGANIZATION MEMBERSHIPS, ACTIVITIES

- Fellow, Institute of Electrical and Electronics Engineering, Inc. (IEEE)
- Eta Kappa Nu, national Electrical and Computer Engineering Honor Society
- Tau Beta Pi, Engineering Honor Society
- Sigma Xi, Scientific Research Society
- Reviewer of proposals to NSF and member of NSF panel review of SBIR proposals.
- Materials Research Society (MRS)
- Electrical and Computer Engineering Department Heads Association (ECEDHA)
- Southeast Electrical and Computer Engineering Department Heads Association (SECEDHA)
- American Society for Engineering Education (ASEE)

### KEY RESEARCH ACCOMPLISHMENTS

- 1976 Development of Cr<sub>2</sub>O<sub>3</sub> coatings to inhibit failure of insulators at high voltages. This coating is extensively used in electron accelerators, X-ray tubes, e-beam lithography equipment, and in faint object spectrograph in the Hubble space telescope. *IEEE Trans. on Electrical Insulation*
- 1984 Wetting of metal surfaces with a liquid metal. Widely used in high current switches. *J. Appl. Phys*
- 1987 Novel insulator designs. Widely used in high energy particle accelerators. *IEEE Trans. on Electrical Insulation*
- 1989 Novel design of high voltage feedthrough. Used in INTELSAT traveling wave tubes. *IEEE Trans. on Electrical Insulation*
- 1993 First ultra high voltage Si photoconducting Switch. *IEEE Trans. on Electrical Insulation*
- 1999 Development of High Field micro-spacer for Flat Panel Emitter Displays. *SPIE Electronic Imaging*
- 2000 First to perform selective doping of SiC by boron diffusion. *Mat. Sci. Forum*
- 2001 Produced defect-free SiC by local epitaxy. *J. Crystal Growth*
- 2002 Developed vacuum gap design rules for vacuum microelectronic applications. *IEEE-DEI*
- 2002 Developed a non-destructive wafer-scale method of delineating defects in SiC. *APL* (Patent issued)
- 2003 Demonstrated formation of nano-porous structures in SiC wafers. *Electrochemical and Solid State Letters*
- 2003 Demonstrated non-degradable SiC pin diodes; patent awarded June 2006.
- 2005 Developed basal plane dislocation-free epitaxial growth of SiC, *APL*
- 2006 Development of new method of forming a graded junction termination extension (JTE) for high voltage SiC devices (up to 10 kV) using high temperature diffusion of boron; Novel Method of Forming Junction Termination Extension for SiC Power Devices, USCRF 000619, Patent submitted with Cree, Inc. 2009
- 2007 Demonstrated extremely high carrier lifetime (~10 us) in thin epilayers (~20-30 um); A method to increase and control carrier lifetime in SiC, USCRF 694

- 2008 Demonstrated step-bunch free epilayers in 4 degree off-cut substrates; optimized the epilayer growth for reduction of triangular defects from  $850 \text{ cm}^{-2}$  to  $5 \text{ cm}^{-2}$ ; Optimized the epilayer growth for reduction of triangular defects from  $850 \text{ cm}^{-2}$  to  $5 \text{ cm}^{-2}$
- 2008 Demonstrated high growth rate ( $>50 \text{ um/hr}$ ) using Dichlorosilane in 8 degree off substrates, J. of Crystal Growth
- 2009 Developed a method to grow semi-insulating SiC films with significant applications in SiC power devices including photo-conducting switches, J. of Crystal Growth
- 2010 Developed “growth-etch-regrowth” process to investigate the dislocation evolution in SiC epitaxial growth on eutectic etched surface, *Journal of Crystal Growth*
- 2010 Demonstrate homoepitaxial growth on  $1^\circ$  off 6H and  $4^\circ$  off 4H-SiC substrates, *EMC*
- 2010 Demonstrated reduction of in-grown stacking fault density in the SiC epilayer from  $\sim 10^4$  to  $<10 \text{ cm}^{-2}$ , *ICSCRM 2011*
- 2011 Developed an innovative split tube gas delivery system to analyze gas decomposition, parasitic deposition and particle formation in the CVD reactor for growth study and optimization. *ICSCRM 2011*
- 2011 Evidence of carbon depletion in SiC epitaxy is provided for the first time; relative losses of carbon source and silicon source determines the effective C/Si ratio and hence the doping. *ICSCRM 2011*
- 2011 Invented non-destructive eutectic pretreatment of the substrate to reduce/eliminate basal plane dislocations in SiC epitaxial growth, *ICSCRM 2011, USC disclosure, and US patent*

## PATENTS

14. “Methods of Growing a Silicon Carbide Epitaxial layer on a substrate to increase and control carrier lifetime,” Tangali S. Sudarshan and Amitesh Srivastava, U.S. Patent US 8,574,528 B2. Issued: Nov. 5, 2013. (<http://www.google.com/patents/US8574528>)
13. “Method of growing high quality epitaxial graphene with thickness controllability”, TS Sudarshan, T Rana, MVS Chandrashekar, (US 61,850,414, pending)
12. “Method of growing high quality, thick SiC epitaxial films by eliminating silicon gas phase nucleation and suppressing parasitic deposition”, Tangali S. Sudarshan, Tawhid Rana, Haizheng Song, International Patent, Publication No. WO 2013/078219 A1, Publication Date: May 30, 2013. (Pending) (<https://www.google.com/patents/WO2013078219A1>)
11. “Pretreatment method for reduction and/or elimination of basal plane dislocations close to epilayer/substrate interface in growth of SiC epitaxial films”, Tangali S. Sudarshan, Haizheng Song, Tawhid Rana, U.S. patent, Publication No. US 20130143396 A1, Publication Date: June 6, 2013. (Pending) (<https://www.google.com/patents/US20130143396A1>)
10. “Methods, Wires, and Apparatus for Slicing Hard Materials”, Tangali Sudarshan, Igor Agafonov, Robert Kennedy, U.S. Patent, US8291895 B2, Issued: Oct. 23, 2012. (<https://www.google.com/patents/US8291895>)
9. “System and method for detecting defects in semiconductor wafers,” Xianyun Ma, Tangali S. Sudarshan, U.S. Patent, US7220978 B2, Issued: May 22, 2007. (<https://www.google.com/patents/US7220978>)
8. “Method for Elimination of Basal Plane Dislocation and In-Grown Stacking Fault with No Surface Degradation for High Quality SiC Epitaxial Films”, Tangali S. Sudarshan, Haizheng Song, US Provisional Patent, Filing Date: October 19, 2012, Application No. 61/716,020.
7. “Method of eliminating silicon gas phase nucleation for high quality homoepitaxy”, T. S. Sudarshan, T. Rana, US Provisional Patent, Filing Date: April 26, 2012, Application No. 61/638,770.
6. “Substrate Pretreatment Method for Reduction/Elimination of Basal Plane Dislocations and In-Grown Stacking Faults with No Surface Degradation for High Quality SiC Epitaxial Films”, Tangali S. Sudarshan, Haizheng Song, US Provisional Patent, Filing Date: November 23, 2011, Application No. 61/563,250.
5. “Diffused junction termination structures for silicon carbide devices and methods of fabricating silicon carbide devices incorporating same”, Qingchun Zhang, Anant K. Agarwal, Tangali S. Sudarshan, Alexander Bolotnikov, U.S. Patent, US8637386 B2, Issued: Jan 28, 2014. (<https://www.google.com/patents/US8637386>)
4. “Silicon Carbide and Related Wide Bandgap Semiconductor Based Optically-Controlled Power Switching Devices”, Feng Zhao, Tangali S. Sudarshan, U.S. Patent, US20100276699 A1, Publication date: Nov 4, 2010.

- (Pending) (<https://www.google.com/patents/US20100276699>)
3. U. S. Patent Application, "Novel JTE Formation Technique for Use in Silicon Carbide Power Devices, T. S. Sudarshan, A. Bolotnikov, Q. Zhang, and A. Agarwal. Submitted for filing by Cree, Inc., December 2009.
  2. "System and Method for Fabricating Diodes", Tangali S. Sudarshan, Stanislav Soloviev, Ying Gao, U.S. Patent, No. US7061021 B2, Issued: June 13, 2006. (<https://www.google.com/patents/US7061021>)
  1. "Method of wetting metals", Tangali S. Sudarshan, Larry Park, Meng H. Lim, James E. Thompson, U.S. Patent No. US4780176 A, Issued: October 25, 1988. (<https://www.google.com/patents/US4780176>)

## DISCLOSURES TO USC INTELLECTUAL PROPERTY OFFICE

1. "A Novel Method of Rapid Epitaxial Growth of Silicon Carbide (SiC) that Heals Micropipes in Commercial SiC Substrates," T.S. Sudarshan, Y. Khlebnikov, and I. Khlebnikov, disclosure #98171, Jan. 14, 1998.
2. "Local Epitaxy, Diffusion, and Etching Related to Silicon Carbide and Other Wide Bandgap Semiconductors," T.S. Sudarshan, Y. Khlebnikov, and I. Khlebnikov, disclosure #98174, May 1, 1998.
3. "Bulk Silicon Carbide Crystal Growth by a Modified Vapor Transport Technique," T.S. Sudarshan, Y. Khlebnikov, and I. Khlebnikov, disclosure #98175, May 1, 1998.
4. "An Electrochemical Polishing Technique for the Surface Preparation of SiC," T.S. Sudarshan, Y. Khlebnikov, and I. Khlebnikov, disclosure #99207, Dec. 1998.
5. "High Power Large Area Schottky Diode," Q. Zhang, T.S. Sudarshan, and V. Madangarli, disclosure #99204, April 26, 1999.
6. "Thick Oxide Film Deposition on Silicon Carbide," T.S. Sudarshan, Q. Zhang, and I. Khlebnikov, disclosure #99205, April 26, 1999.
7. "Rapid Anodic Oxidation of Silicon Carbide," T.S. Sudarshan, Y. Khlebnikov, and I. Khlebnikov, disclosure #99206, April 26, 1999.
8. "A Novel Base Design for High Power Transistors, Thyristors, and Other Devices," Q. Zhang and T.S. Sudarshan, disclosure #99230, Jan. 2000.
9. "Silicon Carbide Wafer Design for High Power Device Fabrication," Q. Zhang and T.S. Sudarshan, disclosure #99208, May, 1999.
10. "A Technique to Eliminate Premature Breakdown at the Edge of Thin Film Electrodes," X. Ma and T.S. Sudarshan, disclosure #20239, Jan. 2000.
11. "A Technique for Alleviating Spacer Triple Junction-Initiated Breakdown," X. Ma and T.S. Sudarshan, disclosure #20250, May 2000.
12. "A Novel Schottky Diode Structure with Low On-State Resistance," Q. Zhang and T.S. Sudarshan, June 27, 2001.
13. "A Novel JFET Structure for High Power, High Frequency Applications," Q. Zhang and T.S. Sudarshan, June 27, 2001.
14. "Novel Schottky Diode Structure for High Power Applications," Q. Zhang and T.S. Sudarshan, Oct. 2001.
15. "Nondestructive Defect Delineation in SiC Wafers Using the Optical Stress Technique," X. Ma and T.S. Sudarshan, #00367, April 2002.
16. "Development of Interfaces to Facilitate the Implantation of Biosensor Based Deveices," N. Sethuraman and T.S. Sudarshan, Dec. 2002.
17. "A Method of Eliminating Forward Voltage Drift in SiC PiN and PN Diodes," S. Soloviev, Y. Gao, and T.S. Sudarshan, March 2003.
18. "New Biomaterial for Bone Implant Applications," N. Sethuraman, T.S. Sudarshan, and J. Morris, Sep. 2003.
19. "Abrasive Wire Used for Slicing Semiconductor Boules", T.S.Sudarshan, I.Agafanov, Y.Khlebnikov and M.Parker USCRF 446, June 2004.
20. "Method and Apparatus for Slicing Hard Brittle Materials", T.S.Sudarshan and I.Agafanov, USCRF Ref 465, Provisional Patent – 2/11/2005.

21. "Epitaxial Growth of Basal Plane Dislocations-Free Silicon Carbide Films", T.S.Sudarshan and Z.Zhang, USCRF Ref 464, Provisional Patent – 11/17/04.
22. "Growth of Low Basal Plane Dislocation Epilayers of SiC with Minimized Surface Depressions", T.S.Sudarshan, Z.Zhang, USCRF Ref 540, Nov 2005.
23. "Mask Design for Low Defect Density Lateral Epitaxially Overgrown SiC Films", T.S.Sudarshan, A.Bolotnikov and S.Soloviev(GE), Jan 2006.
24. "Novel Method of Forming Junction Termination Extension for SiC Power Devices," T. S. Sudarshan and A. Bolotnikov, USCRF #000619, 10/20/2006.
25. "A method to increase and control carrier lifetime in SiC Epilayers," T. S. Sudarshan and Amitesh Shrivastava, disclosed and submitted to Intellectual Property Office, USC, October 3, 2007.
26. "Silicon Carbide and Related Wide Bandgap Semiconductor Based Optically-Controlled Power Switching Devices," Feng Zhao and Tangali S. Sudarshan, disclosed and submitted to USC Intellectual Property Office, January 20, 2009.
27. "Silicon Carbide and Related Wide Bandgap Semiconductor Based Optically-Controlled Power Switching Devices", T. Sudarshan and F. Zhao., Application Serial No. 12/773,369.

## BOOK CHAPTERS

5. S. I. Soloviev and T. S. Sudarshan, "Processing Porous SiC: Diffusion, Oxidation, Contact Formation," *Porous Silicon Carbide and Gallium Nitride: Epitaxy, Catalysts, and Biotechnology Applications*, edited by R. M. Feenstra and C.E.C. Wood, John Wiley & Sons, Ltd., 2008.
4. T.S. Sudarshan, D. Cherednichenko, and R. Yakimova, "Growth of Silicon Carbide," in: *Bulk Crystal Growth of Electronic, Optical and Optoelectronic Materials*, ed. Dr. P. Capper, Wiley and Sons, **invited chapter**, pp. 433-449, 2004.
3. T.S. Sudarshan, "Materials Science and Engineering of Bulk Silicon Carbides" in: *SiC Power Materials*, ed. Dr. Z.C. Feng, Springer-Verlag **invited chapter**, pp. 1-61, 2004.
2. Khlebnikov, D. Cherednichenko, Y. Khlebnikov, and T.S. Sudarshan, "Silicon Carbide Technology: Status and Future," *International School on Crystal Growth of Technologically Important Electronic Materials (ISCGTIEM)*, Mysore, India January 2003.
1. T.S. Sudarshan, "Vacuum Insulation," *Wiley Encyclopedia of Electrical and Electronic Engineering*, **invited chapter**, 1999.

## RESEARCH PUBLICATIONS

### A.1. ARCHIVAL REVIEWED PUBLICATIONS – Recent Publications 2004-2016

#### 2016

237. "4H-SiC homoepitaxy on nearly on-axis substrates using TFS- towards high quality epitaxial growth", Anusha Balachandran, Haizheng Song, T.S. Sudarshan, M.V.S. Chandrashekhar, *Journal of Crystal Growth* (in print).
236. "Evidence of minority carrier injection efficiency > 90% in an epitaxial graphene/SiC Schottky emitter bipolar junction phototransistor for ultraviolet detection.", Venkata S. N. Chava, Sabih U. Omar, Gabriel Brown, Shamaita S. Shetu, J. Andrews, T. S. Sudarshan, and M. V. S. Chandrashekhar, *Applied Physics Letters* 108.4 (2016): 043502.

#### 2015

235. "SiC homoepitaxy, etching and graphene epitaxial growth on SiC substrates using a novel fluorinated Si precursor gas (SiF<sub>4</sub>)", Tawhid Rana, M.V.S. Chandrashekhar, Kevin Daniels, and Tangali Sudarshan, *Journal of Electronic Materials*, pp.1-6

234. "Study of SiC Epitaxial Growth Using Tetrafluorosilane and Dichlorosilane in Vertical Hotwall CVD Furnace", A. Balachandran, H. Z. Song, T.S. Sudarshan, S. S. Shetu, M.V.S. Chandrashekhar, *Materials Science Forum*, Vols. 821-823, pp. 137-140, Jun. 2015
233. "Effect of C/Si ratio and nitrogen doping on 4H-SiC epitaxial growth using dichlorosilane precursor", H. Z. Song, M.V.S. Chandrashekhar, T.S. Sudarshan, *Materials Science Forum*, Vols. 821-823, pp. 129-132, Jun. 2015
232. "Epitaxial growth of graphene on SiC by Si selective etching using SiF<sub>4</sub> in an inert ambient", T. Rana, M.V.S. Chandrashekhar, K. Daniels, T. Sudarshan, *Japanese Journal of Applied Physics* 54 (3), 030304 (2015).
231. "Study of Surface Morphology, Impurity Incorporation and Defect Generation during Homoepitaxial Growth of 4H- SiC Using Dichlorosilane", H. Song, M.V.S. Chandrashekhar, and T. S. Sudarshan, *ECS Journal of Solid State Science and Technology*, 4(3) P71-P76 (2015).
230. "Glide of threading edge dislocations after basal plane dislocation conversion during 4H-SiC epitaxial Growth", M. Abadier, H. Song, T.S. Sudarshan, Y.N. Picard, and M. Skowronski, *Journal of Crystal Growth* 418, pp. 7-14 (2015).
229. "Interface Trap-Induced Nonideality in as-Deposited Ni/4H-SiC Schottky Barrier Diode", S.U. Omar, T.S. Sudarshan, T.A. Rana, H. Song, and M.V.S. Chandrashekhar, *IEEE Transactions on Electron Devices*, Vol.62, pp. 615-621, February 2015.
228. "Mechanism of Electrochemical Hydrogenation of Epitaxial Graphene", K.M. Daniels, S. Shetu, J. Staser, J. Weidner, C. Williams, T.S. Sudarshan, and M.V. S. Chandrashekhar, *Journal of Electrochemical Society*, 162 (4), E37-E42 (2015).

## 2014

227. "Large Barrier, Highly Uniform and Reproducible Ni-Si/4H-SiC Forward Schottky Diode Characteristics: Testing the Limits of Tung's Model", Sabih U. Omar, Tangali S. Sudarshan, Tawhid A. Rana, Haizheng Song, M.V.S. Chandrashekhar, *Journal of Physics D: Applied Physics*, 47 (2014) 295102 (9pp).
226. "Nanoparticle functionalized graphene/Si schottky diode for hydrogen sensing," Muhammad Ahsan Uddin, Amol Kumar Singh, Tangali S. Sudarshan and Goutam Koley, *Nanotechnology* 25, 125501 (2014).
225. "Tunable reverse-biased graphene/Si heterojunction Schottky diode sensor," Amol Kumar Singh, Muhammad Ahsan Uddin, Tangali S. Sudarshan and Goutam Koley, *Small* 10, 1555 (2014).

## 2013

224. "Si-adatom kinetics in defect mediated growth of multilayer epitaxial graphene films on 6H-SiC", Shamaita Shetu, Sabih. U. Omar, K.M. Daniels, Joseph Andrews, B.K. Daas, T.S. Sudarshan, MVS Chandrashekhar, *J. Appl. Phys.*, 114, 164903 (2013).
223. "Electrically tunable molecular doping of Graphene," A. K. Singh, M. A. Uddin, J. T. Tolson, H. Maire-Afeli, N. Sbrockey, G. S. Tompa, M. G. Spencer, T. Vogt, T. S. Sudarshan and G. Koley, *Applied Physics Letters* 102, 043101 (2013).
222. "Nucleation of In-grown Stacking Faults and Dislocation Half-loops in 4H-SiC Epitaxy", M. Abadier, R. L. Myers-Ward, N. A. Mahadik, R. E. Stahlbush, V. D. Wheeler, L. O. Nyakiti, C. R. Eddy, Jr., D. K. Gaskill, H. Song, T. S. Sudarshan, Y. N. Picard, M. Skowronski, *J. Appl. Phys.* 114, 123502 (2013).
221. "Comparison of SiC Epitaxial Growth from Dichlorosilane and Tetrafluorosilane Precursors", Haizheng Song,

- Tawhid Rana, M.V.S. Chandrashekhar, Sabih U. Omar, Tangali S. Sudarshan, *ECS Transactions* 58 (2013) 97-109.
220. “Trade-Off between Parasitic Deposition and SiC Homoepitaxial Growth Rate Using Halogenated Si-Precursors”, Tangali S. Sudarshan, Tawhid Rana, Haizheng Song, M.V.S. Chandrashekhar, *ECS Journal of Solid State Science and Technology*, 2 (2013) N3079-N3086. **(invited)**
219. “Vapor phase surface preparation (etching) of 4H-SiC substrates using tetrafluorosilane (SiF<sub>4</sub>) in a hydrogen ambient for SiC epitaxy”, T. Rana, M.V.S. Chandrashekhar, Tangali S. Sudarshan, *Journal of Crystal Growth*, 380 (2013) 61-67.
218. “Step dynamics in the homoepitaxial growth of 6H-SiC by chemical vapor deposition on 1o offcut substrate using dichlorosilane as Si precursor”, Sabih U. Omar, M. V. S. Chandrashekhar, Iftekhar A. Chowdhury, Tawhid A. Rana, Tangali S. Sudarshan, *Journal of Applied Physics*, 113, 184904 (2013).
217. “Basal Plane Dislocation Conversion Near the Epilayer/substrate Interference in Epitaxial growth of 4 deg off-axis 4H-SiC”, Haizheng Song, Tangali S. Sudarshan, *Journal of Crystal Growth*, 371 (2013) 94-101.
216. “Electrically Tunable Molecular Doping of Graphene”, A. K. Singh, M. A. Uddin, J. T. Tolson, H. Maire-Afeli, N. Sbrockey, G. S. Tompa, M. G. Spencer, T. Vogt, T. S. Sudarshan, and G. Koley, *Applied Physics Letters*, 102, 043101, (2013).

## 2012

215. “Elimination of silicon gas phase nucleation using silicon tetrafluoride (SiF<sub>4</sub>) precursor for high quality thick silicon carbide (SiC) homoepitaxy” Tawhid Rana, M.V.S. Chandrashekhar, T.S. Sudarshan, *Phys. Status Solidi A*, Volume 209, Issue 12, pages 2455–2462, December 2012.
214. “Comparison of Epitaxial Graphene Growth on Polar and Nonpolar 6H-SiC Faces: On the Growth of Multilayer Films”, Daas, B. K. Omar, Sabih U. Shetu, S. Daniels, Kevin M. Ma, S. Sudarshan, T. S. Chandrashekhar, M. V. S., *Crystal Growth & Design*, Volume: 12 Issue: 7 Pages: 3379-3387 Jul 2012.
213. “Evidences of electrochemical graphene functionalization and substrate dependence by Raman and scanning tunneling spectroscopies”, Kevin M. Daniels, B. K. Daas, N. Srivastava, C. Williams, R. M. Feenstra, T.S. Sudarshan, M.V.S Chandrashekhar, *J. Appl. Phys.*, 111, 114306, Jun 2012.
212. “Basal plane dislocation mitigation in SiC epitaxial growth by non-destructive substrate treatment”, Haizheng Song, Tangali S. Sudarshan, *Crystal Growth & Design*, 12, 1703-1707, Apr. 2012.
211. “High Purity Semi-Insulating 4H-SiC Epitaxial Layers by Defect-Competition Epitaxy: Controlling Si Vacancies”, M. V. S. Chandrashekhar, Iftekhar Chowdhury, Pavel Kaminskiĭ, Roman Kozlowskiĭ, P. B. Klein, and Tangali Sudarshan, *Appl. Phys. Express* 5, 025502, Feb. 2012.
210. “Comparison of 4H silicon carbide epitaxial growths at various growth pressures using dichlorosilane and silane gases”, Tawhid Rana, Haizheng Song, M.V.S. Chandrashekhar, and Tangali Sudarshan, *Materials Science Forum*, 717-720, p. 117-120, May 2012.
209. “In-Grown Stacking Faults in SiC-CVD Using Dichlorosilane and Propane as Precursors”, Haizheng Song, Sabih U. Omar, Tawhid Rana, M.V.S. Chandrashekhar, Tangali S. Sudarshan, *Materials Science Forum* 717-720, p. 121-124, May 2012.
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#### **B.1. INTERNATIONAL CONFERENCE PRESENTATIONS – 2004-2015**

##### **2015**

221. "Epitaxial graphene/SiC Schottky Junctions as collector and emitter in a bipolar phototransistor: Towards graphene-based bipolar mode Schottky contacts for UV and radiation detection", Venkata Surya N. Chava, Sabih U. Omar, Gabriel Brown, Shamaita S. Shethu, H Song, T.S. Sudarshan, M.V.S. Chandrashekhar, The 57th Electronic Materials Conference (EMC), Columbus, OH, June 25, 2015.
220. "Comparison of the homo epitaxial growth of 4H-SiC using TFS and DCS precursors: Towards on-axis growth", Anusha Balachandran, Haizheng Song, T.S.Sudarshan, M.V.S. Chandrashekhar, The 57th Electronic Materials Conference (EMC), Columbus, OH, June 25, 2015.
219. "SiC Homoepitaxy, Etching and Graphene Epitaxial Growth on SiC Substrates Using a Novel Fluorinated Si Precursor Gas SiF<sub>4</sub>", Tawhid Rana, MVS Chandrashekhar, Kevin Daniels and T.S.Sudarshan, The 57th Electronic Materials Conference (EMC), Columbus, OH, June 25, 2015.

##### **2014**

218. "Qualitative study of SiC epitaxial growth using TFS and DCS in vertical hotwall CVD furnace", Anusha Balachandran, Haizheng Song, Tangali S Sudarshan, Shamaita S Shetu, MVS Chandrashekhar, 10<sup>th</sup> European Conference on Silicon Carbide and Related Materials, Grenoble, France, September 21-25, 2014.
217. "Glide of Threading Edge Dislocations after Basal Plane Dislocation Conversion during 4H-SiC Epitaxial Growth", M. Abadier, H. Song, T.S. Sudarshan, Y.N. Picard and M. Skowronski, 2014 MRS Fall Meeting & Exhibit, Boston, Massachusetts, November 30 – December 5, 2014.
216. "Study of shift associated with basal plane to threading edge dislocation conversion in SiC epitaxial growth", Haizheng Song, Mina Abadier, Yoosuf N. Picard, Marek Skowronski, MVS Chandrashekhar, Tangali S. Sudarshan, European Conference on Silicon Carbide and Related Materials, Grenoble, France Sep.21-25, 2014.

215. "Effect of C/Si ratio and nitrogen doping on 4H-SiC epitaxial growth using dichlorosilane precursor", Haizheng Song, MVS Chandrashekhar, Tangali S. Sudarshan, European Conference on Silicon Carbide and Related Materials, Grenoble, France, September 21-25, 2014
214. "The limits of Tung's model: On the origin of non-ideality and hysteresis in SiC schottky diodes", Sabih U. Omar, Gabriel Brown, Anusha Balachandran, Tawhid A. Rana, Haizheng Song, Tangali S. Sudarshan, MVS Chandrashekhar, The 56th Electronic Materials Conference (EMC), Santa Barbara, CA, June 25, 2014.
213. "Large Molecular Sensitivity Enhancement by Graphene/Si Chemi-Diodes," Amol K. Singh, Md Ahsan Uddin, Tangali S. Sudarshan, M. V. Chandrashekhar and Goutam Koley, oral presentation at the Electronic Materials Conference, Santa Barbara, CA, June 25, 2014.
212. "Metal Functionalized Graphene/Si Heterojunction Diode for H<sub>2</sub> Sensing," Md Ahsan Uddin, Amol K. Singh, Tangali S. Sudarshan, MVS Chandrashekhar and Goutam Koley, oral presentation at the Electronic Materials Conference, Santa Barbara, CA, June 25, 2014.

### 2013

211. "Tunable Graphene/Si Schottky Diode Sensor," Amol Singh, Md. Ahsan Uddin, Tangali Sudarshan and Goutam Koley, oral presentation at the IEEE Sensors conference, Baltimore, MD, Nov 5, 2013. (Proceedings of the IEEE Sensors conference, pg. 1283-1286, Nov 3-6, Baltimore, MD, 2013.)
210. "Pt-functionalized Graphene/Si Heterostructure for Hydrogen Sensing," Md. Ahsan Uddin, Amol Singh, Tangali Sudarshan and Goutam Koley, oral presentation at the IEEE Sensors conference, Baltimore, MD, Nov 5, 2013. (Proceedings of the IEEE Sensors conference, pg. 1279-1282, Nov 3-6, Baltimore, MD, 2013.)
209. "Selective Multimodal Gas Sensing in Epitaxial Graphene by Fourier Transform Infrared Spectroscopy," Shamaita Shetu, B. K. Daas, Kevin Daniels, Tangali Sudarshan, Goutam Koley, Mvs Chandrashekhar, poster presentation at the IEEE Sensors conference, November 5, 2013.
208. "Controlling Donor and Acceptor Type Molecular Doping of CVD Graphene," A. K. Singh, M. A. Uddin, J. T. Tolson, N. Sbrockey, G. S. Tompa, M. G. Spencer, T. S. Sudarshan and Goutam Koley, oral presentation at the Electronic Materials Conference, Notre Dame, IN, June 26 (2013).
207. "Tuning the Sensitivity of Toxic Gas Detection Using Back Gate Bias in CVD Graphene Field Effect Transistors," Amol K. Singh, Md. Ahsan Uddin, James T. Tolson, G. S. Tompa, N. Sbrockey, M. G. Spencer, Tangali S. Sudarshan and Goutam Koley, oral presentation at the Electronic Materials and Applications Conference, Orlando, Florida, January 23 (2013).
206. "Evidence of Two-Dimensional Nucleation during 4H-SiC Homoepitaxy on 4° off-cut Substrates", R. L. Myers-Ward, N. A. Mahadik, R. E. Stahlbush, V. D. Wheeler, L. O. Nyakiti, C. R. Eddy, Jr., D. K. Gaskill, H. Song, T. S. Sudarshan, Y. N. Picard, M. Skowronski, Int. Conf. Silicon Carbide and Related Materials, Miyazaki, Japan, September 29 – October 4, 2013
205. "Nucleation of In-grown Stacking Faults and Dislocation Half loops during 4H-SiC Epitaxy", M. Abadier, R. L. Myers-Ward, N. A. Mahadik, R. E. Stahlbush, V. D. Wheeler, L. O. Nyakiti, C. R. Eddy, Jr., D. K. Gaskill, H. Song, T. S. Sudarshan, Y. N. Picard, M. Skowronski, 224th Electrochemical Society Meeting, San Francisco, CA, October 27 – November 1, 2013
204. "Comparison of SiC epitaxial growth from dichlorosilane and tetrafluorosilane precursors", Tangali S. Sudarshan, Tawhid Rana, Haizheng Song, MVS Chandrashekhar, 224th ECS Meeting, San Francisco, California, October 27 – November 1, 2013. **(invited talk)**
203. "Epitaxial growth of 4H-SiC using tetrafluorosilane precursor and study of defect evolution", Tawhid Rana, Haizheng Song, MVS Chandrashekhar, Tangali S. Sudarshan, The 55<sup>th</sup> Electronic Materials Conference (EMC

- 2013), University of Notre Dame, Notre Dame, IN, June 26-28, 2013.
202. "Enhancement of Basal Plane Dislocation Conversion in SiC Epitaxial Growth by Mild Substrate Etching", Haizheng Song, Tawhid Rana, Sabih U. Omar, MVS Chandrashekar, Tangali S. Sudarshan, The 55<sup>th</sup> Electronic Materials Conference (EMC 2013), University of Notre Dame, Notre Dame, IN, June 26-28, 2013.
201. "Effect of structural defects on the reverse I-V characteristics of Ni/4H-SiC schottky diodes: establishment of defect-dependent performance metrics", Sabih U. Omar, Haizheng Song, Tawhid A. Rana, Tangali S. Sudarshan, MVS Chandrashekar, The 55<sup>th</sup> Electronic Materials Conference (EMC 2013), University of Notre Dame, Notre Dame, IN, June 26-28, 2013.
200. "Nucleation of in-grown stacking faults and dislocation half loops in 4H-SiC epilayers deposited at high growth rate", M. Abadier, R.L. Myers-Ward, N. Mahadik, R.E. Stahlbush, V.D. Wheeler, L.O. Nyakiti, C.R. Eddy, Jr., D.K. Gaskill, H. Song, T.S. Sudarshan, Y.N. Picard and M. Skowronski, The 55<sup>th</sup> Electronic Materials Conference (EMC 2013), University of Notre Dame, Notre Dame, IN, June 26-28, 2013.

## 2012

199. "Infra-red Reflection of Epitaxial Graphene on Cu and Ni", B.K. Daas, A. Singh, J. Tolson, S. Ma, T.S. Sudarshan, G. Koley, MVS Chandrashekar, 54<sup>th</sup> Annual Electronic Materials Conference (EMC 2012), Pennsylvania State University, State College, PA, June 20 – 22, 2012.
198. "Dispersion Relation of Plasmons at EG/SiC Interface: Tuning the Plasmon", B.K. Daas, S.Ma, T.S. Sudarshan and MVS Chandrashekar, 54<sup>th</sup> Annual Electronic Materials Conference (EMC 2012), Pennsylvania State University, State College, PA, June 20 – 22, 2012.
197. "Biological Sensing Applications of Epitaxial Graphene", Kevin M. Daniels, Nirupam Aich, Kristen P. Miller, Biplob K. Daas, Tangali S. Sudarshan, Navid Saleh, Alan W. Decho, Mvs Chandrashekar, 54<sup>th</sup> Annual Electronic Materials Conference (EMC 2012), Pennsylvania State University, State College, PA, June 20 – 22, 2012.
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137. "Recombination Behavior of Stacking Faults in SiC p-i-n Diodes" with S. Maximenko and P. Pirouz, *ibid.*
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58. "High Voltage/High Field Behavior of SiC for High Power Electronic Device Applications," annual report to ARO, Research Triangle Park, Feb. 2, 1998.
59. "Surface Flashover Characteristics of Single Crystal Diamond," with P. Muzikov and X. Ma, *Diamond Microelectronics Corp. CREDA Workshop*, Nanosystems, Inc., Oxford, CT, Oct. 29, 1998.
60. "High Voltage/High Field Behavior of SiC for High Power Electronic Device Applications," annual report to ARO, Research Triangle Park, Jan. 11, 1999.
61. "Defect Formation during SiC Bulk Crystal Growth," with I. Khlebnikov, *1999 Workshop on Compound Semiconductor Materials and Devices (WOCSEMMAD)*, New Orleans, Feb. 21-24, 1999.
62. "SiC substrate issues - thick film epitaxy for 'filling-up' micropipes," with I. Khlebnikov, *WOCSEMMAD*, New Orleans, Feb. 21-24, 1999.
63. "New device concepts - 1kV Schottky diodes on P-type SiC using thick oxide film for edge termination," with I. Khlebnikov, *WOCSEMMAD*, New Orleans, Feb. 21-24, 1999.
64. "High Voltage Characterization of Type IA Nitrogen Doped Diamond," with P. Muzykov and X. Ma, *Diamond Microelectronics Corp. CREDA Workshop*, MIT Lincoln Lab, March 12, 1999.
65. "Silicon Carbide Film Growth and Processing Issues," Litton Industries, Airtron Dvn, March 17, 1999.
66. "Microspacer Insulation for Field Emission Displays," *DARPA High Definition System (HDS) Information Exchange Conference*, Washington, DC, March 24, 1999.
67. "High Voltage/High Field Behavior of SiC for High Power Electronic Device Applications," final report to ARO, Research Triangle Park, Jan. 2000.
68. "Microspacer Insulation for Field Emission Displays," monthly reports to ONR/DARPA.
69. "Selective Doping in SiC via Diffusion," with Y. Gao and S. Soloviev, *2000 Workshop on Compound Semiconductor Materials and Devices (WOCSEMMAD)*, San Diego, Feb. 19-23, 2000.
70. "SiC Device Modeling using ATLAS," with M. Tarplee and V. Madangarli, *WOCSEMMAD*, San Diego, Feb. 19-23, 2000.
71. "Growth of Porous SiC: Si vs. C Face," with S. Soloviev and T. Das. *ONR Workshop on Challenges in Porous and Amorphous Wide Gap Semiconductors*, Corner Brook, NF, Canada, June 10 - 14, 2001.
72. "Structural & Electrical Characterization of Porous SiC," S. Soloviev and T. S. Sudarshan, *DURINT Workshop on Nanoporous Silicon Carbide and Gallium Nitride*, Tampa, FL, Jan. 3-4, 2002.
73. "Defect Delineation in Silicon Carbide by EBIC," with S. Maximenko and R. Bondokov, *ONR workshop on Extended Defects in Widegap Semiconductors; Electrical and Optical Effects*. January 27-31, 2002, Belize.
74. "Electrical & Optical Effects," **invited talk** at *ONR workshop on Extended Defects in Wide Gap Semiconductors*, Belize, January 2002.
75. "Definition of Usable Area in SiC wafers," with M. Parker, Y. Khlebnikov, X. Ma and P. Muzykov, *2002 Workshop on Compound Semiconductor Materials and Devices (WOCSEMMAD)*, Austin, TX, Feb. 2002.
76. "Non-Destructive SiC Wafer Characterization," with X. Ma, Y. Ma, T. Kuboto, and P. Talekar, *WOCSEMMAD*, Austin, TX, Feb. 2002.
77. "A-Face Silicon Carbide," with Y. Khlebnikov, I. Khlebnikov and P. Muzykov, *WOCSEMMAD*, Austin, TX, Feb. 2002.
78. "An Automated Defect Detection System for Silicon Carbide Wafers," with T. Kubota, P. Talekar, X. Ma, M. Parker, and Y. Ma, *2002 SE Conference*, April 2002.

79. "Silicon Carbide research activity in South Carolina," with I.I. Khlebnikov at the *IV International Seminar on Silicon Carbide and Related Materials, ISSCRM*, Novgorod, Russia, May 2002.
80. "Current Status of SiC Research in the US," with I.I. Khlebnikov at the *IV International Seminar on Silicon Carbide and Related Materials, ISSCRM*, Novgorod, Russia, May 2002.
81. "Si-SiC Bulk Growth: Purity and Doping Issues," with I. Khlebnikov, *ONR workshop on Challenges in Semi-Insulating Nitrides & SiC conference*, Laugarvatn, Iceland, July 14-18, 2002.
82. "Characterization of Semi-Insulating SiC wafers: Electrical and Optical," with P. Muzykov, *ONR workshop on Challenges in Semi-Insulating Nitrides & SiC conference*, Laugarvatn, Iceland, July 14-18, 2002.
83. "Polytype Transformation during SiC Crystal Growth," with Y. Khlebnikov, G. Stratiy, S. Maximenko, I. Khlebnikov, D. Cherednichenko, and R. Bondokov, *MRS Boston*, MA, Dec. 2002.
84. "Formation and characterization of porous SiC," with S. Soloviev, T. Das, J. Bai, P.I. Gouma, Y. Khlebnikov, and I. Khlebnikov, *DURINT Workshop*, Richmond, VA, March 2003.
85. "Hot-Wall CVD Epi-Growth of 4H-SiC using PVT Buffer Layer," with Y. Gao, Z. Zhang, X. Ma, and Y. Khlebnikov, *45<sup>th</sup> Electronic Materials Conference* Salt Lake City, UT, June 2003.
86. "Study of Forward Voltage Drop Degradation in Diffused SiC PIN Diodes," with D. Cherednichenko, S. Soloviev, Y. Gao, Y. Ma, and A. Grekov, *EMC*, Salt Lake City, UT, June 2003.
87. "Nondestructive defect characterization of SiC substrates and epilayers," with X. Ma, *EMC*, Salt Lake City, UT, June 2003.
88. "Nondestructive defect mapping of SiC substrates and epilayers using a PLM system," with X. Ma, *ONR Workshop on Extended Defects in Wide Gap Semiconductors*, Richmond, VA July 2003.
89. "Substrate Defects and III-Nitride Epitaxy," with X. Ma and M.A. Khan, *8<sup>th</sup> Wide-Bandgap III-Nitride Workshop*, Richmond, VA Sept. 2003.
90. "Formation and Structure of Porous Silicon Carbide" with S. Soloviev, *Seminar for the Center for Functional Nanomaterials at Brookhaven National Laboratory* October 2003.
91. "Evaluation of SiC Wafers for Device Fabrication," with X. Ma, **invited** *12<sup>th</sup> International Workshop on the Physics of Semiconductor Devices (IWPSD)* Dec. 2003.
92. "Non-degrading 4H-SiC PIN diodes: fabrication and characterization," with S. Soloviev, *WOCSEMMAD*, Pasadena, CA, Feb. 2004.
93. "Characterization of Defects Generated during Boron Diffusion in SiC," with XF. Lin, S. Smith, X. Ma, L. Wang, Q. Zhang, and H-R. Chang, *2004 MRS Spring Meeting*, San Francisco, CA, April 2004.
94. "The Effect of Doping Concentration and Conductivity Type on Preferential Etching of 4H-SiC by Molten KOH," with Y. Gao, Z. Zhang, R. Bondokov, and S. Soloviev, *2004 MRS Spring Meeting*, San Francisco, CA, April 2004.
95. "Nondestructive Defect Characterization and Its Significance in WBG Material/Device Development," with X. Ma, *DARPA/MTO TriServices*, Monterey, CA, May 2004.
96. "Silicon Carbide Material Characterization, Epitaxy, and Device Fabrication and Testing," with S. Soloviev, *ONR Electronics Division Materials Program Review*, Monterey, CA, August 2004.
97. "Micro robots for harsh environments," with Q. Li, *ARL Advanced Microsystems Workshop*, Jan. 30-31, 2006, Research Triangle Park.
98. "Graphite and BN/AIN Annealing Caps for Ion Implanted SiC," M. C. Wood, K. A. Jones, T. S. Zheleva, K. W. Kirchner, M. A. Derenge, A. Bolonikov, T. S. Sudarshan, R. D. Vispute, S. S. Hullavarad, and S. Dhar, *25<sup>th</sup> Army Science Conference*, November 27-30, 2006, *Orlando, FL*.
99. "Defect-Device Performance Correlation for DOW SiC Epiwafers," *ONR/DOW Corning Known Good Substrates Program Review Meeting*, Dec. 14, 2006, Chicago.
100. "Investigation of epilayer growth on low off axis 4H-SiC substrates," *ONR Electronic Device Material Review*, Washington, DC, August 6-10, 2007.
101. "Study of trap centers in n-type SiC MOS capacitors using thermally stimulated current (TSC) and capacitance voltage (CV) measurements," Peter Muzykov, A.V. Bolotnikov, and Prof. T. S. Sudarshan

Presented at SiC MOS workshop at ARL, 2800 Powder Mill Rd., (Bldg 601), Adelphi, MD 20783, Thursday 21 and Friday 22 August 2008.

102. "SiC Epitaxial Growth: Challenges and Opportunities – Workshop on Energy Efficiency through Wide Bandgap Power Electronics," presented at NRL. T. S. Sudarshan and Peter Muzykov, January 7-8, 2009.
103. "Development of High Quality 4H-SiC Thick Epitaxy for Reliable High Power Electronics Using Chlorinated Precursors," ONR annual report, T. S. Sudarshan, August, 2010.
104. "Development of High Quality 4H-SiC Thick Epitaxy for Reliable High Power Electronics Using Chlorinated Precursors," ONR annual report, T. S. Sudarshan, August, 2011.
105. "Development of High Quality 4H-SiC Thick Epitaxy for Reliable High Power Electronics Using Halogenated Precursors," ONR annual report, T. S. Sudarshan, August, 2012.

## FUNDED GRANTS AND CONTRACTS

- Secured over \$19 million from various private and public funding agencies, in a competitive manner, including:
  - 1) The Naval Surface Warfare center (NSWC)
  - 2) Los Alamos Scientific Laboratory
  - 3) National Science Foundation (NSF)
  - 4) National Bureau of Standards (NIST)
  - 5) Air Force Office of Scientific Research (AFOSR)
  - 6) Office of Naval Research (ONR)
  - 7) Department of Energy (DOE) / Oak Ridge National Laboratory (ORNL)
  - 8) International Telecommunications Satellite Organization (INTELSAT)
  - 9) Strategic Defense Initiative Organization (SDIO) - ONR
  - 10) M.J. Murdock Trust
  - 11) Sandia National Laboratory
  - 12) Pirelli Cable Corporation (Prysmian Cables & Systems Limited)
  - 13) South Carolina Electric & Gas Company (SCE&G)
  - 14) Virginia Electric Power Company / Pirelli Cable
  - 15) ONR- Experimental Program to Stimulate Competitive Research (EPSCoR)
  - 16) D.N.A. University of Texas, Arlington
  - 17) Ballistic Missile Defense Organization (BMDO) - ONR
  - 18) Ballistic Missile Defense Organization (BMDO) – US Army SSDC
  - 19) Army Research Office (ARO)
  - 20) Defense Advanced Research Projects Agency (DARPA)
  - 21) AVX Corporation
  - 22) Litton Corporation
  - 23) CMAT
  - 24) US Army Space and Missile Defense Command (ASMDC)
  - 25) General Electric (GE) Global Research
  - 26) DOW Corning Corporation
  - 27) CREE Inc.
  - 28) SINMAT Inc. (NIST and Air Force)

## RESEARCH SUPERVISION

- Number of post-doctoral associates and Research Professors 23
- Number of Ph.D. students 30 (28 Ph.D. students graduated)
- Number of M.S. students 52
- Number of undergraduate research students 129 (As of December, 2013)
- Number of Directed Study (ELCT 499) projects supervised 35
- PhD advisory committees 22 (As of August, 2015)
- Undergraduate engineering special projects supervised 60
- Number of seminars and technical presentations 104

**Collaborated projects with the following visiting professors:**

	<b>Name of the Professor</b>	<b>Name of the Project</b>	<b>Affiliated Institution</b>	<b>Year</b>
(a)	Dr.G. R.Nagabhusana	(i)Prebreakdown current measurements along insulators in vacuum (ii)Analysis of electric fields using analog techniques	Indian Institute of Science, India	1980-81
(b)	Dr.R.L.Boxman	Study of Pulsed Vacuum Gap Breakdown Mechanisms	Tel Avi University	1981-82
(c)	Dr. S. Grzybowski	Partial Discharges in Multi-layered Ceramics	University of Poznan, Poland	1982-83
(d)	Prof. Jung-Dal Kim	Prebreakdown Conduction Micrometric Vacuum Gaps	Kyungnam University, South Korea	1995-96
(e)	Prof. Chengmu Luo	Computation of Electric Fields relevant to FETs and Micrometric Vacuum Gaps	Tsinghua University, China	1996
(f)	Prof. Stanislav Lilov	Growth and investigation of SiC for Device applications in High temperature Electronics	University of Sofia, Bulgaria, Fulbright Fellow	Sept. 1, 2005 - Feb. 1, 2006

**COLLABORATION AND VISITS**

- Continuous Electron Beam Accelerator Facility (CEBAF) - DOE facility in Virginia
- Naval Surface Warfare Center, Dahlgren, VA
- Sandia National Labs, Albuquerque, NM
- Grumman Corporation, Electronics System Division, Princeton, NJ
- Electric Power Research Institute, in both Knoxville, TN, and Palo Alto, CA
- Thomson CSF, France
- Toshiba Corporation, Japan European Space Agency, the Netherlands
- French Atomic Energy Commission, Paris
- Dornier GmbH., Germany
- SI Diamond Technology, Inc.
- Litton Industries, Airtron Division, New Jersey
- General Electric Corporate Research Headquarters, Schenectady, NY
- Rockwell Scientific Co. LLC, Thousand Oaks, CA
- NOVA SiC, France
- SUNY, Stony Brook, NY
- Naval Research Lab, Washington, DC
- Wright Airforce Lab, Dayton, OH
- Army Research Lab, Adelphi, MD
- Case Western Reserve University, Ohio
- European Organization for Nuclear Research (CERN), Geneva

**UNIVERSITY SERVICE**

- Hosted, at the request of the Provost's office, the Duke Energy Executive in Residence Program , a day-long event of meetings, lunch, visits, and seminar; Mr. James Stanley was the Duke Executive participating, October 6, 2011.
- Visited India with American Delegation of International Academic Partnership Program to build linkages between India and the United States, November, 2010.
- Computer Science and Engineering Search Committee Co-Chair, October 2009 to December 2010.
- Focus Carolina, Chairman, Teaching and Learning Committee, Jan. 2009 to 2010
- Completed Memorandum of Understanding Academic and Research Collaboration between USC and

The Indian Institute of Technology (IITM in Madras, India, March 2008.

- Mechanical Engineering Search Committee, Chairman, September 2006 to November, 2007.
- General Education at the University of South Carolina: Team Leader for Scientific Literacy and Technological Skills, Nov. 2006 to December, 2007.
- Michael J. Mungo Distinguished Professor Selection Committee, 2006 – present
- Engineering Dean Search Committee, Co-chairman, May 2005, Feb. 2006
- Search Committee for the nanoelectronics hire for the Nanocenter, Sept. 2005-Mar. 2006
- Search Committee for the Director of USC Nanocenter, Nov. 2004-June 2005
- EE Department Program Committee, Chairman, Feb. 2004, to September 2006
- Southeast Alliance for Graduate Education and the Professoriate (SEAGEP), June 2004 to present
- Dean (White) Review Committee, August-December 2003
- Graduate & Research Committee (1992-present), Chairman (1992-1999), member (2000-September 2006)
- Member of the Provost's Science, Mathematics, and Engineering Faculty Research Award Selection Panel (Russell and USC Educational Foundation Research Awards) (1994-96)
- T&P Committee of the Chemical Engineering Department to evaluate associate professors, 1994-1999.
- ECE representative for the Dean's Research Advisory Committee (1988-June 2000)
- ECE Department, T&P Committee, Chairman (1989-90; April 2000-present)
- Dean's Ad Hoc Committee on Chairs/Professorships (1993-1999)
- ECE Department Mission and Organization Committee (Goals Committee) (1988-95), Chairman (1994-95)
- College-wide Civil Engineering Review Committee (1995-96)
- College of Engineering Academic Affairs Committee (Aug. 99 to May 2000)
- Member of Faculty Advisory Council for the Vice President for Research (September 2000 to August 2002)
- EE Department T&P Committee Chairman (April 2000 to 2002)
- College of Engineering Research Achievement Award Committee (2002)
- COE Carolina Distinguished Professorship Review Committee, Chairman (Dec. 2002-Jan 2003)
- ECE committee member for the Dean's Review Board (Aug. 2003 to 2004)
- Member, Advisory Board, Innoventure, annual forum to support SC companies, Jan. 2006 to 2009