Some Highlights of Research Results

1. The first demonstration of near 1000V SiC Schottky barrier diode in 1993 (ICSCRM-93, page II-61, "Near 1,000V Schottky diodes and ECR plasma etching of 6H-SiC")
2. The first demonstration of electron cyclotron resonance plasma dry etching of SiC and identification of ITO as the masking material in 1993 (ICSCRM-93, page II-61, "Near 1,000V Schottky diodes and ECR plasma etching of 6H-SiC"); Smooth ECR dry etching of SiC ("Smooth Etching of Single crystal 6H-SiC in an Electron Cyclotron Resonance Plasma Reactor", *Appl. Phys. Lett*, Vol. 64(17), pp. 2315-2317,1994.); Low damage and residual-free ECR dry etching ("Low damage and residue-free dry etching of 6H-SiC using electron cyclotron resonance plasma", *Appl. Phys. Lett*, Vol. 67(3), pp. 368-370, 1995)
3. The first demonstration of SiC thyristor in 1993 (so did Cree, Inc. in 1993) ("A study of 6H-SiC based diodes and thyristors", Proc. of 6th BMDO/ONR pulse power meeting, pp. 42-48, 1993; 9th IEEE Pulsed Power Conf., Albuquerque, NM; And the then best performing SiC GTO thyristor in IEDM-1994, pp.415-18, as well as the first 300°C SiC thyristor in IEEE EDL No. 3, 1996, pp. 142-144)
4. The first demonstration of SiC optothyristor in 1993 (SPIE Intl. Symp. On photonics for industrial appl., Oct. 31-Nov. 4, 1994)
5. The first demonstration of beneficial effects of Al & C co-implantation in SiC in Feb 1997 ("Characterization of P-type SiC layers created by C and AL co-implantation", 11th Annual LSM, Feb 13, 1997, Piscataway, NJ. Also in Evaluation of ohmic contacts to P-type 6H-SiC created by C and Al co-implantation", IEEE EDL, No. 8, 1997, pp.375-377.)
6. The first demonstration and successful development in 1997 of dry etching of SiC by Inductively-coupled plasma (ICP) with very low subsurface damage and high etching rate ("Inductively coupled plasma etching of SiC for power switching device fabrication", Proc. of ICSCRM-1997, 8/31-9/5, 1997, Sweden, pp.833-836; "Evaluation of damage induced by inductively-coupled plasma etching of 6H-SiC using Au Schottky barrier diodes" in APL, Vol 73(5), pp.653-655, 1998; and "Dry etching of 6H-SiC using inductively coupled plasma", J. Elect. Soc, Vol.145, No.10, pp.3609-3612, Oct. 1998. The SiC ICP system was developed by Unaxis and Rutgers jointly under an NSF-funded New Instrument Development program.)
7. The first systematic study of temperature- and electric field-dependent electron transport properties in 3C-, 6H-SiC and 4H-SiC by Monte Carlo simulations and the first determination of effective masses, electron-phonon coupling constants in 1998 (J. Appl. Phys. Vol83(6), 1998, pp.3161-3167).
8. The first prediction and Gunn effect and microwave power generation at 240GHz in GaN transferred electron devices in 1999 (ICSCRM-1999, Matr. Sci. Forum Vols.338-342(2000), pp.1635-1638).
9. The first prediction of terahertz(THz) Maser based on optical phonon transit time resonance in GaN (IEEE TED, Vol.48(3), 2001, pp.438-443).
10. The first demonstration and development of SiC/SiO_2 PMA (post-metallization annealing) method in various ambient for substantial reduction of interface states and effective oxide charge in 6H- and 4H-SiC/SiO_2 system in 1998 ("Effect of PAM on effective fixed charge in thermally grown oxide on 6H-SiC", IEE Elect. Lett., Vol.34(7), pp.698-700, April, 1998; And "Study of interface state density and effective oxide charge in post-metallization annealed SiO_2-SiC structures", IEEE TED, Vol.46(3), pp.511-519, 1999.

11. The first successful development of multi-step junction-termination extension (MJTE) for high voltage power device edge termination which also enabled the development of the first MJTE-terminated SiC APD with 100% edge termination (“Theoretical and experimental study of 4H-SiC junction edge termination”, ICSCRM-1999, pp. 1375-1378; And “4H-SiC avalanche photodiode with multistep junction extension termination”, Electronics Letters, V. 37, n 17, Aug 16, 2001, p 1080-1081).
12. The first identification and demonstration of the unique fundamental advantages of SiC for avalanche photodiode applications and report of the first SiC APD and Reach-through APDs in 1999 (“4H-SiC visible-blind UV avalanche photodiode”, IEE Elect. Lett. Vol35(11), pp.929-930, 1999, And “Demonstration of the first 4H-SiC avalanche photodiodes”, Solid State Electronics, Vol4292),, pp.341-346, 2000.)
13. The first demonstration of 4H-SiC BJT in 2000 (IEE Elect Lett. Vol36(17), Aug. 2000, pp.1496-1497 (so did Cree, Inc. in 2000).
14. The first demonstration of simultaneous Ni ohmic contacts to both N- and P-type SiC (Nickel ohmic contacts to p and n-type 4H-SiC, IEE Elect. Lett. Vol. 37(17), Aug. 2001, pp. 1092-1093.)
15. The first demonstration of 5,000V 4H-SiC PiN diode (and packaged for 100A) in 2001 (“High performance C plus Al co-implanted 5,000V 4H-SiC P+iN diode”, IEE Elect. Lett. Vol. 37(8), pp.531-533, 2001)
16. The first demonstration of SiC APD arrays in 2001 (“Design and fabrication of 4H-SiC APD linear arrays”, Proc. 2001 International Semiconductor Device Research Symposium. p 17-20; “Demonstration of 4H-SiC avalanche photodiode linear array”, Materials Science Forum, v 389-393, pt.2, 2002, p 1431-1434).
17. Conceived and developed a very small bevel angle edge termination technology in 2001 which is now widely used by many for SiC APD fabrication. (“A novel technology for the formation of a very small bevel angle for edge termination”, ICSCRM-2001, p 1305-8; And “Low-noise visible-blind UV avalanche photodiodes with edge terminated by 2° positive bevel”, Electronics Letters, v 38, n 7, Mar 28, 2002, p 335-336).
18. Patented and demonstrated a novel normally-off SiC field-gated bipolar transistor (3000V) in 2001 (“A novel, planar 3,000V normally-off Field-gated bipolar transistor in 4H-SiC”, ICSCRM-2001, Materials Science Forum, Vols. 389-393, pp.1345-1348, 2002).
19. Patented and demonstrated a novel and the first normally-off SiC vertical JFET (2,510V) in 2001 (“A novel high-voltage normally-off 4H-SiC vertical JFET”, ICSCRM-2001, Materials Science Forum, Vols. 389-393, pp.1223-1226, 2002)
20. Patented and demonstrated a novel planar, normally-off unipolar SiC junction-field-effect transistor (1,050V) in 2003 (Demonstration of first 1,050V, 21.7m-ohmcm2 normally-off 4H-SiC junction field-effect transistor with implanted vertical channel”, IEE Elect. Lett. Vol39(1), pp.151-152, 2003.
21. Invented and demonstrated a novel TI-VJFET (Trenched-and-implanted VJFET) with then record high performance characteristics (“1,710V 2.77mΩcm^2 4H-SiC trenched and implanted vertical junction field-effect transistors”, IEEE EDL Vol.24(2), pp.81-83, 2003).
22. Demonstrated a 10kV 4H-SiC Schottky barrier diode (highest voltage to date) in 2003 (“Demonstration of the first 10kV 4H-SiC Schottky barrier diode”, IEEE EDL, Vol.24(6), pp.402-404, 2003).
23. Demonstrated the first Al-free base ohmic contact high performance SiC BJT in 2003 (“High Voltage (>1 kV) and High Current Gain (32) 4H-SiC Power BJTs Using Al-Free Ohmic Contact to the Base” *IEEE Electron Device Letters*. Vol 24 n 11 pp. 695-697, 2003).
24. Demonstrated the first 10kV SiC TI-VJFET (normally-off mode) in 2003 far surpassing the prior record set by us of ~3kV normally-off VJFET (“Demonstration of first 10 kV,

130 mΩ.cm^2 SiC TI-VJFET", *Electronics Letters*, Vol: 39, Issue: 25, 11 Dec. 2003 Pp. 1860 – 1861).

25. Demonstrated the then record high power and the first all-SiC BJT based three phase power inverter in 2003 ("The First 4H-SiC BJT-based 20 kHz, 7HP PWM DC-to-AC Inverter for Induction Motor Control Applications", ICSCRM-2003, also in *Materials Science Forum*, Vol. 457-460, pp.1137-1140, 2004.)
26. Demonstrated the then world record normally-off planar SiC VJFET in 4kV-5kV range in 2003 ("4,340V, 40 mΩcm^2 Normally-Off 4H-SiC VJFET," presented at ICSCRM-2003, *Materials Science Forum*, Vol. 457-460, pp.1161-1164, 2004).
27. Demonstrated the first implantation-free and regrowth-free SiC BJT in 2004 and reported the still record-high voltage SiC BJT ("Demonstration of first 9.2 KV 4H-SiC bipolar junction transistor", *IEE Electronics Letters*, Vol. 40, No. 21, pp1381-1382, 2004).
28. Demonstrated an 11kV SiC TI-VJFET (normally-off mode) in 2004 which is still holding the record for SiC VJFETs ("Fabrication and Characterization of 11-kV Normally Off 4H-SiC Trenched-and-Implanted Vertical Junction FET," *Electron Device Letters, IEEE*, Vol: 25, Issue: 7, pp.474-476, 2004).
29. Demonstrated a record high figure-of-merit SiC VJFET (normally-off) ("3.6 mΩ cm^2, 1726 V 4H-SiC normally-off trenched-and-implanted vertical JFETs and circuit applications", "IEE Proceedings: Circuits, Devices & Systems", Vol. 151 (3) pp231-237, 2004).
30. The first demonstration of 4H-SiC MSM detector in 2003 ("Demonstration of the first 4H-SiC Metal-Semiconductor-Metal Ultraviolet Photodetector", ICSCRM-2003, Leon France, and Materials Science Forum, Vol. 457-460, pp. 1491-14946, 2004.)
31. Demonstrated the then record high figure-of-merit 4H-SiC BJT in < 2kV range in 2005 ("1677 V, 5.7 mΩ.cm^2 4H-SiC Bipolar Junction Transistors", IEEE EDL Vol.26 (3), pp.188-190, 2005).
32. Demonstrated the first SiC single photon avalanche photondetector (SPAD) in 2005 ("Demonstration of 4H-SiC UV single photon counting avalanche photodiode", IEE Electronics Lett. Vol 41(4), pp.212-214, 2005).
33. Demonstrated the first EUV SiC photodetector in 2005 ("Demonstration of 4H-SiC visible-blind EUV and UV detector with large detection area", IEE Electronics Lett. Vol. 41 (21), 2005, pp.1192-1193, 2005).
34. Demonstration of the first high voltage 4H-SiC bipolar RF power limiter in 2005 "Demonstration of High-voltage 4H-SiC Bipolar RF Power Limiter", presented at ICSCRM-2005 and published in Materials Science Forum, Vols. 527-529, pp. 1371-1374, 2006).
35. Demonstrated the record high figure-of-merit SiC BJT in 1kV-2kV range in 2005 ("1836 V, 4.7 mΩ.cm^2 high power 4H-SiC bipolar junction transistor", presented at ICSCRM-2005 and published in Materials Science Forum, Vols.527-529, pp.1417-1420, 2006).
36. Demonstrated the lowest specific on resistance for SiC BJT in <1kV range in 2006 ("4H-SiC Power Bipolar Junction Transistor with a Very Low Specific On-resistance of 2.9 mΩ.cm^2", IEEE Electron Device Letters, Vol.27, pp.368-370, May, 2006).
37. Proposed a novel lateral power SiC JFET suitable for integration and demonstrated the first SiC lateral power JFET in 2006 ("430-V 12.4-mΩ·cm^2 Normally off 4H-SiC Lateral JFET," IEEE Electron Device Letters, vol.27, pp. 834- 836, Oct. 2006).
38. Demonstrated the first SiC power IC (DARPA RIPE Final Report and "1000V 9.1mΩcm^2 normally-off 4H-SiC lateral RESURF JFET for power integrated circuit applications', IEEE EDL Vol. 28, No.5, 2007, pp. 404-407. Invited presentation in TWHM-2007, J. H. Zhao, K. Sheng, Y. Zhang, and M. Su, "Current status and

future prospects of SiC power JFETs and ICs”. Full paper appeared in IEICE Trans. Electronics. Vol. E39-C, No.7, 2008.)

39. Proposed and demonstrated the first double-base implant-free SiC BJT with 1,300V and a gain of 31 in 2006 (J. Zhang, Ph.D. thesis, Rutgers U. 2006, and “Implantation-free 4H-SiC bipolar junction transistors with double base epilayers”.
40. Developed a defect-assisted diffusion model and identified a simple and very effect experimental method based on the model to drastically increase the yield of InGaAs/InP photodetectors over 3 inch open-tube-diffused wafers. And developed a simple method in forming ohmic contacts to InGaAS/InP photodetectors with excellent quality and uniformity (“Utilizing Zn segregation at InP/InGaAs interface for as-deposited ohmic contact formation for photonic and electronic device applications”, IEE Elec. Lett. Vol.37(16), pp.1048-1049, 2001).
41. Demonstrated the first resonant cavity-enhanced GaInAsSb photodetector for 2.35um in 1996 ("Resonant cavity enhanced GaInAsSb photodetectors grown by MBE for room temperature operation at 2.35 u*m", Electronics Let*, VoL 32(24), Nov. 21, 1996, pp. 2268-69).
42. Observed for the first time the quantum confined start effect in GaInAsSb/AlGaAsSb quantum wells in 1997 ("Quantum confined Stark effect in GaInAsSb /AlGaAsSb quantum wells grown by molecular beam epitaxy", *Electronics Lett*, Vo1 33(3), 33(3), pp.248-250, 1/1997).
43. Demonstrated the first tunable resonant cavity enhanced photodetectors in GaInAsSb/AlGaAsSb (“"Tunable photodetectors based on strained compensated GainAsSb/AIGaAsSb multiple quantum wells grown by molecular beam epitaxy", *IEEE Trans. on Electron Devices*, Vol. 44, pp.2167-2173, 1997.)
44. Proposed and developed the first general planar waveguide optical filter based on signal processing approach in 1996 ("A general planar waveguide authoregressive optical fiber” *Lightwave Technol*. Vol. 14(3), 3/1996, pp.437-447) which was later included in our book titled <<*Optical Filter Design and Analysis --- A signal Processing Approach*>>. The book was listed among the Top Ten Best Seller under Corning Fiber Optics Series on Amazon.com in 2000. "A general planar waveguide authoregressive optical fiber” *Lightwave Technol*. Vol. 14(3), 3/1996, pp.437-447
45. Pioneered the MSEFET surface active defect characterization in 1990 ("Modeling the Effects of Surface states on DLTS Spectra of GaAs MESFETs", *IEEE Trans. on Electron Devices*, Vol. 37, 1990, pp. 1235-1244).
46. Developed a simple method for the determination of semiconductor trap capture cross section activation energy by DLTS in 1987. ("Determination of Carrier Capture Cross Section of Traps by DLTS of Semiconductors", *J. Appl. Phys*, Vo1.62 (7), 1987, pp. 2865-2870).
47. Introduced a correct DLTS method in determining trap concentration in thin epilayer in 1987 and at around heterointerface in 1990. ("Theoretical and Experi- mental Determination of Deep Trap Profiles in Semiconductors", *J. Appl. Phys*, Vo1.61 (3), 1987, pp. 1063-1067; And "Effects of Carrier Confinement by InGaAs/GaAs Heterointerface Barrier on Deep Trap Concentration Profiling", *IEEE Trans. on Electron Devices*, Vol. 37(10), 1990, pp. 2158-2164).