Vacuum ultraviolet emission during onset of atmospheric breakdown

Streamer imaging of pulsed atmospheric discharges
The Center for Pulsed Power and Power Electronics started as a Plasma research group at Texas Tech University in 1966. The initial work was concerned with harmonic ion cyclotron resonances in small mirror machines, laser heating of magnetized plasmas, and pellet injection in hot dense plasmas. In 1977 a small Tokamak was constructed and used for various wave propagation studies in the ion cyclotron range of frequencies. In the last few years the emphasis has been on power electronics, applications of plasma technology to pulsed power devices, high power microwave generation, explosive generators, and electric space propulsion engines.

Pulsed Power research at Texas Tech University began in the early 70's with studies in high beta, controlled thermonuclear fusion. These initial investigations at Texas Tech, along with other developments in the field, established the need for a better understanding of the physical phenomena of pulsed power technology. The program is heavily interdisciplinary and presently involves faculty members from several academic departments.

Explosive pulsed power research at TTU was started in 1998. It emphasizes Magnetic Flux Compression Generators and techniques for matching their outputs to various loads. Other explosive generators, such as ferroelectric and ferromagnetic generators have also been investigated.

The area of pulsed power research involves storing, shaping, transmitting, and measuring high voltage, high current pulses of electrical energy. This is of importance to many application areas, such as laser drivers, high power microwave generators, particle accelerators, nuclear fusion, nuclear weapons effects and lightning simulations, industrial manufacturing technology, and electromagnetic mass drivers. The voltages and currents involved may be in the MV and MA range and time scales may be as short as the sub-nanosecond regime. This calls for extremely difficult and challenging materials, shielding, and measuring techniques. High power (> 100 MW) microwave source development is an important area for military applications. Power Electronics involves high efficiency power supply designs, rotating machines, and special, high power solid state circuit designs.

The Plasma, Power Electronics, and Pulsed Power Group at Texas Tech consists of eight faculty members, with a wide range of expertise, from the departments of ECE, ME, and Physics, an average of 28 graduate students, and 15 undergraduate student assistants.

The clerical and technical-support staff comprise seven research engineer, two machinist, four technicians, one accountant, one network administrator, and one administrative Business Assistant.

For further information about the plasma, power electronics, and pulsed power program at Texas Tech, contact any of the following faculty members. (Investigator and Research Area listed).

### Faculty

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Power Electronics, aerospace electronics, electric space propulsion and pulsed power technology, high efficiency power processing, high power solid state lasers and power electronics, explosive pulsed power and microwave communication systems.

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Surface Physics, Atomic Physics, Electrical Space Propulsion, Dielectrics, High Voltage Insulators, High Power Microwaves.

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J. J. Mankowski (ECE)
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HPM sources, Pulse Forming Networks, Liquid Breakdown, Electric Space Propulsion, Pulsed Power Technology.

A. A. Neuber (ECE)
(806) 742-1250
E-mail: Andreas.Neuber@ttu.edu
Dielectric breakdown of gases, liquids, and surfaces in vacuum and at elevated pressure (cryogenic to room temperature) under pulsed DC or HPM field, Explosive Driven Pulsed Power, High Power Microwaves, High Voltage Insulation, Pulse Generators

Visiting & Adjunct Faculty/Researchers

C.H. Watson-Munro, Univ. of Sydney 1971.


Alan Watson, University of Windsor, Canada, 1979, 1985, and 1986

Boy Blackwell, Univ. of Sydney 1980.

John Fletcher, School of Physical Sciences, The Flinders University of South Australia, 1982.


Frank Rose, (Adjunct Professor), Naval Surface Weapons Center, Dahlgren, Virginia, 1984 and 1986.

H. Akiyama, Kumamoto University, Kumamoto, Japan, 1984 and 1986.


Shinsuke Watanabe, Yokohama National University, Yokohama, Japan, 1992.

Toru Iwao, Tokyo University, Tokyo, Japan, 2000.

Research Projects


Kevin Woolverton, Intel, 2000


Euan Choi, Kwangwoon University, Seoul, South Korea, 2004

Han-Yong Ryu, Agency for Defense Development, South Korea, 2005

Klaus Frank, Erlangen University, Erlangen – Germany, 2007/2009

Recent Research Projects

The following list represents some present and recent supported research programs.

- Advanced Railgun Development (Air Force Office of Scientific Research/DoD MURI)
- Power Electronics (LTV & Northrop Grumman)
- Counter HPM (Counter High Power Microwav eConsortium, Air Force Office of Scientific Research)
- High Power Microwave Breakdown of Dielectric Interfaces (Air Force Office of Scientific Research/DoD MURI)
- Expendable Pulsed Power and High Power Microwave Devices (Air Force Office of Scientific Research)
- Cylindrically Symmetric Vircators (Air Force Office of Scientific Research/DoD MURI and FMV, Sweden)
- VUV Radiation and Breakdown Air Force Office of Scientific Research
- Switching for Explosive Driven Pulsed Power Air Force Office of Scientific Research
- Compact, Repetitive Marx System (FMV, Sweden)
- Physics of Surface Flashover at Atmospheric Pressures (Sandia National Laboratories)
- Power System Control (Northrop-Grumman)
- Compact Explosive Generator System (US Army MSDC)
- IED Mitigation (US Army)
The University

Texas Tech University, founded in 1923, is a state-supported, coeducational institution and one of the principal institutions of higher learning in the Southwest. Texas Tech University prides itself on being a major comprehensive research university that retains the sense of a smaller liberal arts institution. Although enrollment is over 28,000, Texas Tech students boast of one-on-one interaction with top faculty and an environment that stresses student accomplishment above all else. We’re large enough to provide the best in facilities and academics, but small enough to focus on YOU. Texas Tech students come from every county in Texas, all 50 states and more than 90 foreign countries. Tech offers 150 undergraduate degree programs through 11 academic colleges, a graduate school and a school of law. We offer more than 100 master’s degree programs and over 50 doctoral degree programs.

The Texas Tech University Health Sciences Center includes a School of Medicine with its Graduate School of Biomedical Sciences, a School of Nursing, and a School of Allied Health.

The Department of Electrical and Computer Engineering (ECE) has rapidly expanded and developed its graduate programs over the past decade and currently has 26 faculty members, approximately 400 undergraduates, and 130 graduate students. Thirty years ago, the annual research funding was $46,000 and has increased to an average of about $9,000,000.

The Department of Physics offers M.S. and Ph.D. degrees in Applied Physics in addition to the traditional degrees. Applied Physics majors can do research in Pulsed Power and take courses in Electrical Engineering. The major professor can be from Physics or ECE.

Research Areas

- Electrical space propulsion devices
- Breakdown in liquids and solids
- Industrial applications of pulsed power technology
- Various novel switch concepts
- The interaction of arc channels with electrodes and insulators
- High power microwave studies
- The surface physics of insulators
- Solid state power electronics
- Erosion resistant materials for space propulsion
- Sub-nanosecond pulse gas breakdown
- Magnetic flux compression generators
- Explosive ferromagnetic and piezoelectric generators
- Corona formation and mitigation
- Circuit and rotating machine modeling
- Electromagnetic Launchers

Presently, the Plasma, Power Electronics, and Pulsed Power Research Program is funded at around $4M per year.

Graduate Studies

Numerous grants and contracts support a variety of research that provides opportunities for graduate students to interact with prominent researchers in industry and at national laboratories. These associations are valuable to the research in progress and the long-term benefits are inestimable. Financial support ($2,400-$2,800 per month) for graduate study is for the most part obtained from Research Assistantships and Graduate Fellowships. All supported students pay in-state tuition and part of the tuition and fees are paid.

The Pulsed Power and Power Electronics Research Program at Texas Tech has generated approximately 75 theses and dissertations over the past ten years. Plasma, Power Electronics, and Pulsed Power related graduate courses offered in the EE Department include:

- Electromagnetic Field Theory
- Pulsed Power Technology
- Gas Breakdown Phenomena
- Gaseous Electronics
- Pulsed Power Diagnostics
- Electrical Space Propulsion
- High Power Microwave Sources
- Power Electronics
- Machine Modeling and Control

Laboratories and Support Facilities

A new EE research building, largely devoted to pulsed power related research was completed in 1980. Today, after the addition of a high bay laboratory space in 1999, the P3E Center occupies a total floor area of over 15,000 square feet. Additional space of 12,000 square feet is used in the off-campus research building.
Computers Processing Capabilities

The computer resources available in the Pulsed Power Laboratory include several state-of-the-art MPS workstations, high-end 3-D graphics co-processors and high-speed network connections. Also available in the lab are various workstation class PCs, color and black & white laser printers, scanners, image converter cameras, mega pixel digital cameras and MS Windows domain servers with redundant hard drives and domain backup servers.

Like the hardware, an impressive list of software is available in the Center. This software includes professional versions of Orcad PSpice and Semplore (both high-end circuit solvers), Maxwell 3-D (electro and magneto static/eddy current field solver), Ansoft HFSS (3-D electro-magnetic field solver), Matlab (technical programming language), Autodyn 3-D (interactive non-linear dynamic and hydro-dynamic analysis software), CTH 3D hydrodynamic code and FEMLAB (Finite element method for solving systems of partial differential equations).

In addition to its own computing facilities the Pulsed Power Laboratory has access to the university’s High Performance Computing Center (HPCC) which houses several hundred Intel compute nodes on several cluster and grid servers with data stored on large Lustre file systems.

Equipment and Facilities

A representative sample of the equipment and facilities available for research includes:

- Pulsed high voltage, high current diagnostic equipment, including conventional probes and optical detectors of electric fields
- Fast oscilloscopes
- Numerous spark gaps, rail gaps, ignitrons, thyatrons, and solid state switches
- Numerous high voltage, d.c. power supplies
- Various advanced field plotting and circuit analysis codes
- Marx generators (up to 2 MV)
- Line pulsers and PFN’s
- Laboratory power capability: 500 kVA single outlet; 1 MVA total
- Scanning electron and optical microscopes
- Screen rooms and high bay areas for high voltage work
- Pulsed and CW lasers with a wide range of wavelengths and power outputs
- Optical equipment, detectors, spectrometers
- Image converter streak and framing cameras with picosecond or nanosecond temporal resolution
- High voltage, high power loads
- Residual gas analyzers
- Spectroradiometer
- Microwave equipment
- Rotating prism and mirror framing cameras
- Numerous vacuum stations
- Microwave interferometers
- Magnetic coil systems and associated power supplies
- Various large vacuum tanks
- FT IR-spectrometer
- Closed cycle refrigeration system
- Fluorescence detection system for CW and transient measurements
- Programmable piezocantimeter and voltage sources
- High pot testers
- Febetron flash X-ray, 300 keV
- High power microwave equipment
- OMA Systems for VUV-UV-VIS-NIR spectroscopy
- Explosives chamber
- Space simulation chamber
- Dimension SST 1200es 3D Printer
- Class 100,000 (ISO8) Clean Room
- Haas TL-1 Toolroom Lathe
- Haas TM-1 Toolroom Mill
- Haas GR-510 Gantry Router
- Haas VF3-SS Vertical Machining Center w/4th Axis
Journal Publications (2008/09)

♦ "Variation of the statistical and formative time lags of high power microwave surface flashover utilizing a superimposed DC electric field," J. Appl. Phys. 106, pp. 063310-063310-4 (2009)

Conference Papers/Presentations (2009)


"Initial Results of Time-Resolved VUV Spectroscopy of Pulsed Dielectric Surface Flashover In Atmosphere" 51st Annual Meeting of the APS Division of Plasma Physics, November 2nd - 6th, Atlanta, GA, (2009)


EXPLOSIVE DRIVEN RF DEMONSTRATION AT REDSTONE ARSENAL

RAPID CAPACITOR CHARGER
WITH CURRENT MODE CONTROL

HIGH POWER MICROWAVE SURFACE FLASHOVER
IN LOW PRESSURE ARGON
HIGH VOLTAGE SILICON CARBIDE SOLID STATE PHOTO CONDUCTIVE SWITCH

LARGE HIGH-BAY LABORATORY
**Research Projects**

**Stand-alone Compact Explosive Pulsed Power System**

**Virtual Cathode Oscillator Driven by a Marx Bank**

**Off-Campus Lab for Advanced Explosives Studies and Security Sensitive Work**