Texas Tech University
Center for Pulsed Power
& Power Electronics

P3E BROCHURE

2023-2024

The Center for Pulsed Power and Power Electronics (P3E) has three primary research areas: Plasma, Pulsed Power, and Power Electronics.

Photoconductive Solid-State Switching > 50 kV.

www.p3e.ttu.edu

The Center for Pulsed Power and Power Electronics Research is committed to the values of: the highest level of research, creativity and innovation, cooperation and communication, academic and intellectual freedom, pursuit of excellence.

INTRODUCTION

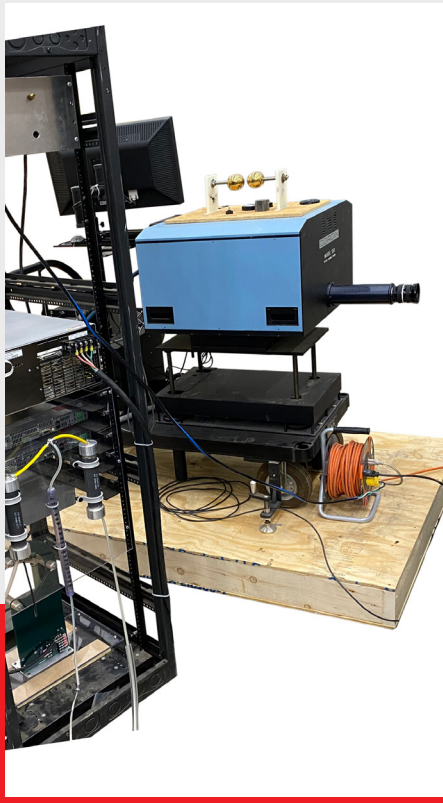
The Pulsed Power display case shows the long history of the Center for Pulsed Power and Power Electronics.

P3E Center at a Glance

The Center for Pulsed Power and Power Electronics had its beginning as a Plasma research group at Texas Tech University in 1966. Harmonic ion cyclotron resonances in small mirror machines, laser heating of magnetized plasmas, and pellet injection in hot dense plasmas were some of the early research topics. In 1977 a small Tokamak was constructed and used for various wave propagation studies in the ion cyclotron range of frequencies. In more recent years the emphasis, has been on compact pulsed power, high power microwave generation, fundamental studies of electric breakdown, wide bandgap switch development and evaluation, explosively driven pulsed power generators, ionospheric applications, and of course, power electronics.

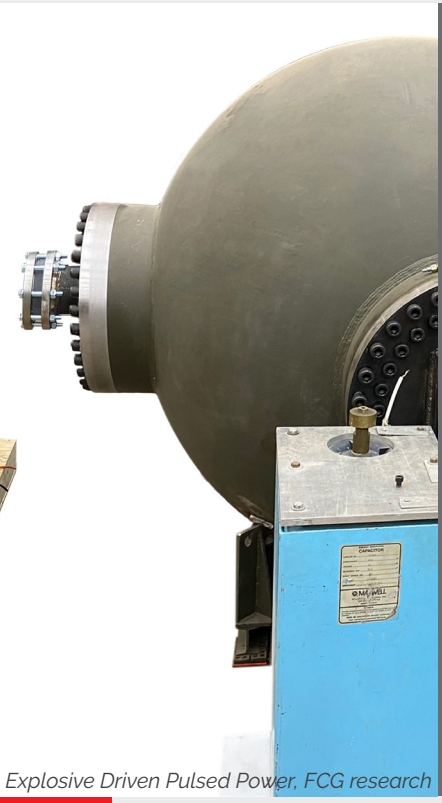
ABOUT US!

Generally, pulsed power research involves storing, shaping, transmitting, and measuring high voltage, high current pulses with the goal of delivering electrical energy to a load or applicator. The energy is transferred in short pulses of high power enabling a variety of 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 Mega-Volts and Mega-Ampere range, and time scales may be as short as the sub-nanosecond regime.



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 35,000, Texas Tech students boast of one-on-one interaction with top faculty and an environment that stresses student accomplishment above all else. We are large enough to provide the best in facilities and academics, but small enough to focus on YOU. Texas Tech University students come from every county in Texas, all 50 states and more than 90 foreign countries. A total of 150 distinct undergraduate degree programs are offered through eleven academic colleges, a graduate school, and a school of law.



Explosive Driven Pulsed Power, FCG research

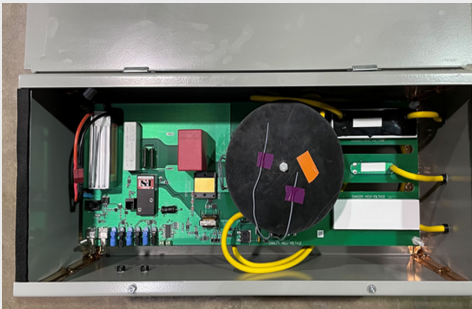
Mission Statement.

The Center for Pulsed Power and Power Electronics carries out cutting edge research and development in pulsed power and power electronics. It also provides a critically needed supply of highly trained graduates as well as advice and unique research facilities for industry and government.

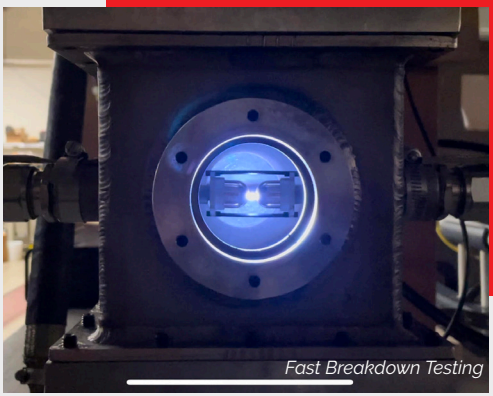
Vision Statement.

The Center will be the leading university laboratory in its field of research in the United States and internationally recognized as one of the leading research laboratories in this field in the world.

Power Electronics involves high efficiency power supply and capacitor charger designs, rotating machines, and special high average power solid state circuit designs. Applications are towards conversion and control of electric power, including renewable energy systems, energy storage, and electric vehiclesphenomena of pulsed power technology. The program has been interdisciplinary from the beginning and involves faculty members from several academic departments.



100 kV capacitor pulse charger


Fast Breakdown Testing

Research Areas

- Hard Tube High Power Microwave Sources
- Photoconductive Solid-State Switching
- Electrical Breakdown in Liquids and Solids
- Pulsed Vacuum UV Generation
- The Surface Physics of Insulators
- Explosive Driven Pulse Power
- Industrial Applications of Pulsed Power Technology
- Wide Bandgap Switch Development
- Interaction of Arcs with Electrodes and Insulators
- Solid State Power Electronics

Grant/Contract Sponsors

ONR, AFOSR, Navy, Army, CNS Pantex, LANL, LLNL, SNL, diverse companies

Laboratories and Support Facilities

The current Electrical Engineering research building, almost exclusively 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 for sensitive research and investigations involving energetic materials in the off-campus research building.

Faculty

The Plasma, Power Electronics, and Pulsed Power Group at Texas Tech consists of eight faculty members, with a wide range of expertise, with ECE, ME, and Physics background, an average of 20 graduate students, and 10 undergraduate student assistants.

J. C. Dickens (ECE)
Co-Director
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Email: james.dickens@ttu.edu

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

A. A. Neuber (ECE)
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Dielectric Surface Flashover, HV Electric Breakdown, Gaseous Electronics, High Power Microwaves, Pulsed Power Technology, Non-intrusive high speed plasma diagnostic (OSE, LIF, CARS, Raman), Microdischarges

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Power Electronics, Power Semiconductor Devices, Renewable Energy, Pulsed Power

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Pulsed Power Technology, Electric Space Propulsion, Liquid and Gas Discharge Physics, Railgun Technology, Explosive Pulsed Power, and High Power Microwave Generation

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Cyber-physical Power Systems, Monitoring and Data Fusion for Smart Grids, Power system Operations with High Penetration of Renewable Reources, Online Dynamic Security Assessment of Power Systems Using PMU Measurements

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Numerical Simulation of Gas Discharges, Boltzmann Codes, High Power Microwave Switching, Insulating Gases.

RESEARCH

Rapid Capacitor Charger, Input 208V AC 3-Phase, Out 0-50 kV up to 10kJ/sec

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 ($2,300 - $2,600 monthly salary) for graduate study is for the most part obtained from Research Assistantships and Graduate Fellowships. For all supported students, most of the university tuition and fees are provided in addition to the graduate salary. The Pulsed Power and Power Electronics Research Program at Texas Tech University has generated approximately 120 theses and dissertations over the past ten years.

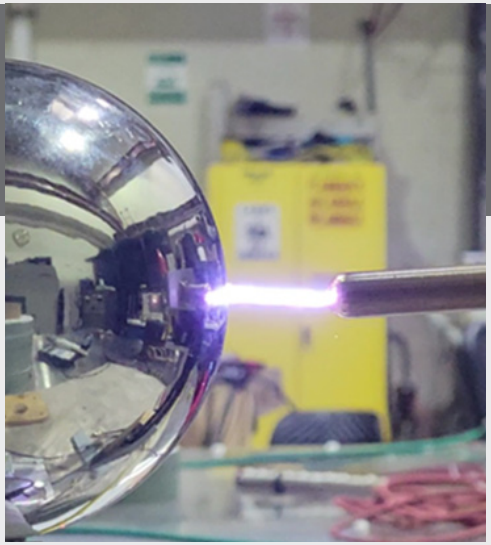
> **The Center for Pulsed Power and Power Electronics Research will: be recognized as the leading university research center in pulsed power research and one of the top 3 university research centers in power electronics, provide uniquely trained graduates in an area of national importance, provide a unique research environment in cooperation with industry and government, and provide consulting and advice to industry and governmental agencies.**

What we do?

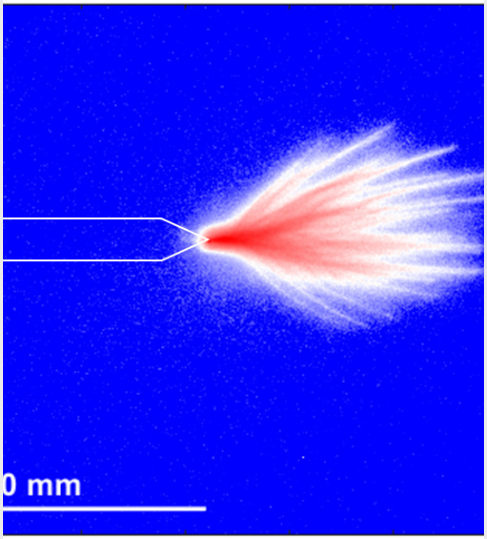
Plasma, Power Electronics, and Pulsed Power related graduate courses offered include:

- ✓ *Pulsed Power S&T*
- ✓ *Laser Spectroscopy*
- ✓ *Machine Modeling and Control*
- ✓ *Electromagnetic Field Theory*
- ✓ *Plasma Engineering*
- ✓ *Gaseous Electronics*
- ✓ *High Power Microwave Sources*
- ✓ *Power Semiconductors*
- ✓ *Power Electronics*

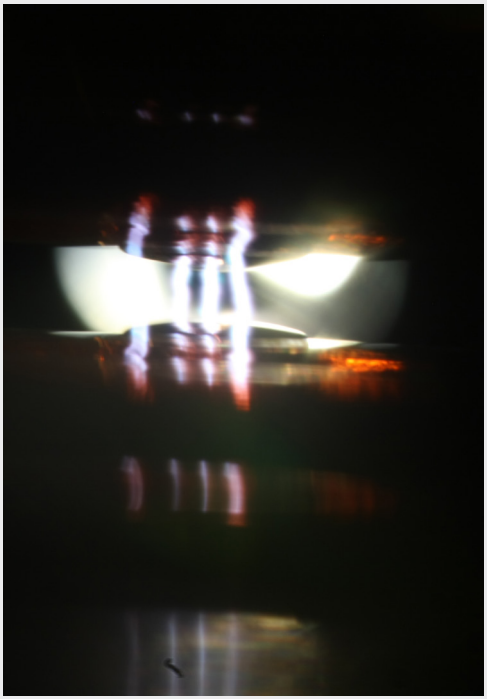
1MV coaxial feedthrough with integrated diagnostics for breakdown research next to driving Marx



Measuring Electrostatic Charge Decay in Varying Humidities



Light Emitted from Electrostatic Discharge

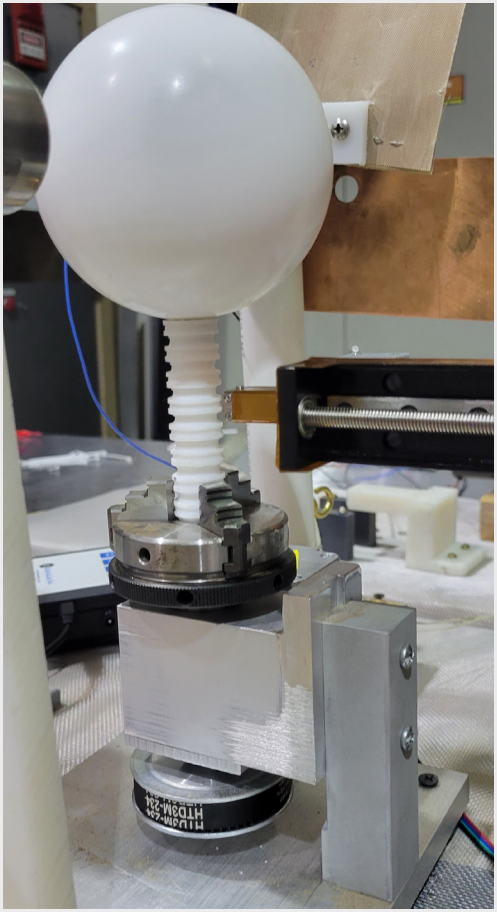


RF Breakdown using a Ring Resonator

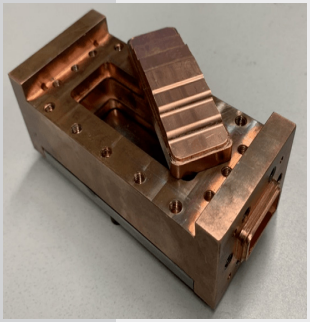
ONGOING RESEARCH OVERVIEW

P3E Students attended the IPMHVC and EIC Conference in person to present their sponsored research. A total of about 20 abstracts were submitted to the conference.

Electrostatic Surface Charge Decay of Floating Dielectrics

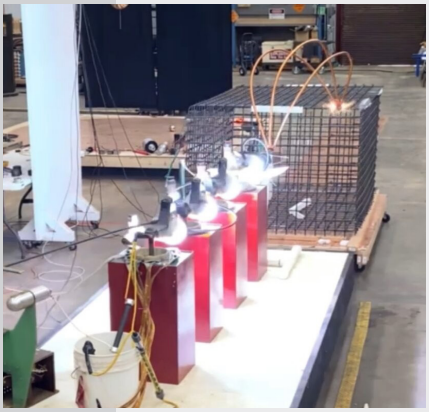


Electrostatic surface charge accumulation on dielectric materials, followed by surface charge decay, is investigated. This work focuses on charging floating dielectric surfaces to the limit of electric breakdown in atmospheric air in humid and dry conditions, succeeded by the slow charge decay on the timescale of minutes to hours. The mechanisms leading to reducing the surface charge density include surface charge cancellation from ions attracted from the surrounding gas medium as well as charge migration along the dielectric.



Probing Multipactor in X-band Waveguide Components

Multipactor is a vacuum-based resonant effect that causes detuning, heating, and ultimately component damage in microwave systems. Suppression of this effect then becomes important in high power systems such as satellite communications. To study multipactor, a plug and play setup was designed and fabricated to allow for quick testing in a waveguide-like structure. A tunable Xband magnetron, tuned to 9.4 GHz, with a typical pulse length of 2.5 μs delivers peak power output of 130 kW.

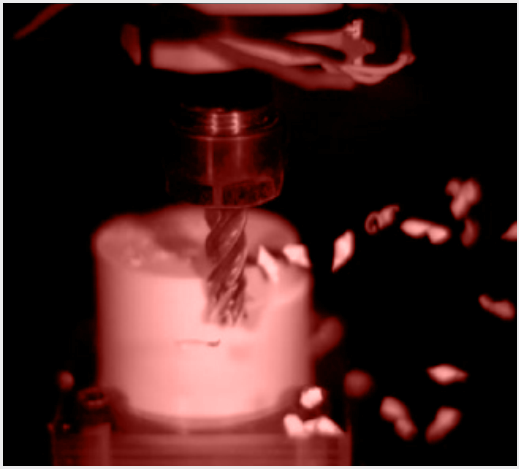


Experiments on a Scaled Rebar Structure to Quantify Lightning Strike Induced Fields on Rebar Reinforced Concrete Structures

Understanding electric and magnetic fields induced by lighting strike events is crucial to developing efficacious techniques for mitigating the negative effects of lightning strikes. However, experiments investigating the matter are sparse in literature as the prohibitive cost and complexity associated with a full-scale experiment make it impractical to perform.

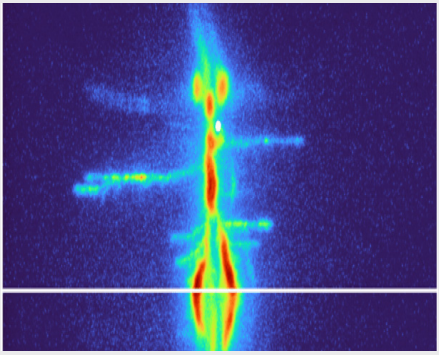
Electrical diagnostics and nanosecond imaging of vacuum surface flashover

When an insulator in vacuum between an anode and cathode becomes electrically stressed due to the application of a fast high voltage pulse on the anode, the surface of the insulator is typically the first location to breakdown. An experimental apparatus and diagnostics have been designed which localize anode-initiated vacuum surface flashover so that the relationship between voltage, current, and temporally resolved images may be derived to characterize this phenomenon.



Journal Publications

Research Excellence: Establish the Center as the leading university research laboratory in its field.



Exploring the Basic Physical Mechanisms of Cathode- and Anode-Initiated High-Voltage Surface Flashover

W. Brooks; R. Clark; J. Young; M. Hopkins; J. Dickens; J. Stephens; A. Neuber

IEEE Transactions on Plasma Science (Volume: 50, Issue: 10, October 2022)

Objective: Increase number of publications in refereed journals, conference proceedings, book chapters, patents, etc.

A Continuum Approach For Multipactor Using Vlasov-Poisson Analysis

Silvestre, L; Shaw, ZC; Sugai, T; Stephens, J; Mankowski, JJ; Dickens, J; Neuber, AA; Joshi, RP

Multipactor is studied based on the coupled Vlasov-Poisson equation set and applied to a parallel plate geometry. This approach can be considered complementary to the particle-in-cell (PIC) methods that have provided excellent insight into multipactor behavior.

Journal of Physics D: Applied Physics, Volume 55, Number 4, 2021

Assessing the Role of Photon Processes in Facilitating Radio Frequency Breakdown of Air at Atmospheric Pressure in Millimeter Gaps

Xiaoli Qiu; Benedikt Esser; Ivan Aponte; John Mankowski; James C. Dickens; Andreas A. Neuber; Ravi P. Joshi

The behavior of the breakdown electric field versus gap lengths (in the 1–5-mm range) and at different frequencies in the 1–80-MHz span, has been studied numerically at atmospheric pressure.

IEEE Transactions on Plasma Science (Volume: 50, Issue: 11, November 2022)

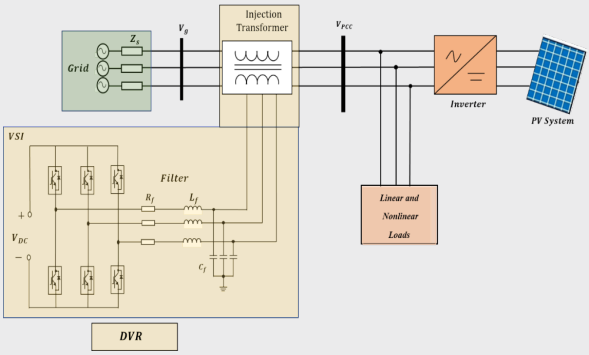
Centralized Control Topology For Pv Farms Shading Detection And Gmpp Searching Restarting Condition

C. A. Negri; S. Daneshvardehnavi; K. E. K. Schmitt; A. Esmaeel Nezhad; P. H. J. Nardelli; S. Bayne; M. G. Giesselmann

The power output of the solar panels follows a power-voltage (P-V) characteristic containing only one Global Maximum Point (GMP) in the normal conditions. However, under Partial Shading Conditions (PSC), the unbalanced irradiance in the panels creates Local Maximum Points (LMP) in the P-V curve.

IEEE Access, 10, pp.28991-29008, 2022

With the advancement of technology, electric equipment and loads have become more sensitive to problems related to power quality, such as voltage sag, swell, imbalances, and harmonics. To detect faults and to protect sensitive loads from these voltage distortions, a Dynamic Voltage Restorer (DVR) series compensator is among the best available cost-effective solutions.



Dynamic Voltage Restorer (DVR) With A Novel Robust Control Strategy

DaneshvarDehnavi, S; Negri, C; Bayne, S; Giesselmann, M

ISA Transactions Volume 121, February 2022, Pages 316-326

One of the main goals of the DVR is to achieve a control structure that is robust, stable, and can handle properly the disturbances (e.g., grid voltage issues, load current, and fluctuations at the DC link voltage) and model uncertainties (e.g., inverters and filter parameters). In this work, a novel framework control strategy based on Uncertainty and Disturbance Estimator (UDE) is proposed to improve the response of the DVR to properly compensate the load voltage under a variety of power quality issues, particularly the ones associated with the grid voltage disturbances. Additionally, the stability of the proposed control system is analyzed and validated using the Lyapunov stability theory. The advantages of the new control system are robustness, simplified design, good harmonic rejection, low tracking error, fast response, and sinusoidal reference tracking.

An Investigation Into The Surface Skidding Response Of Pbx 9501And Pbx 9502

S. A. Watkins, R. J. Lee, T. H. Austin, J. Mankowski, J. Brinkman, J. Dickens, A. A. Neuber

While polymer-bonded explosives, PBX, have reduced sensitivity to ignition from mechanical shock or heating compared to conventional explosives, the investigation of the mechanical ignition mechanisms for PBX remains vital to assessing the safety during machining and general handling.

Propellants, Explosives, Pyrotechnics, 47(7), p.e202200010, 2022

Optically Activated In-Waveguide Semiconductor Attenuators for the Controllable Isolation of Ka-Band Microwaves

A. T. Hewitt; B. Esser; R. P. Joshi; J. Mankowski; J. Dickens; A. Neuber; R. Lee; J. Stephens

Secondary electron yield (SEY) modeling of Ni(110) surface has been carried out with and without the inclusion of wavevector-dependent harmonic corrections (which alter both the inelastic mean free path and stopping power) and is compared to available experimental data.

IEEE Transactions On Microwave Theory And Techniques, Vol. 70, No. 4, April 2022

Evaluation of Explosive Emission Carbon Fiber Cathodes for High-Power Microwave Devices

Tyler Buntin; Matthew Abide; Andreas Neuber; James Dickens; Ravindra Joshi; John Mankowski

Most high-power microwave (HPM) sources, such as the magnetically insulated transmission line oscillator (MILO) being developed at Texas Tech, utilize cold cathodes that generate electrons via explosive emission.

IEEE Transactions on Plasma Science (Volume: 50, Issue: 10, October 2022)

Faculty, Staff, and Students

From Left to Right: Dr. Andreas Neuber, Dr. James Dickens, Dr. John Mankowski, Dr. Stephen Bayne, Dr. Mike Giesselmann, Dr. Miao He, Dr. Ravi Joshi, Dr. Jacob Stephens, Barbra Beller, Monika Storey, Dino Castro, Joel Perez, Lee Waldrep, Dawson Wright, Yagnya Pokhrel, Micah Lapointe, Max Flynn, Scott Watkins, Tyler Klein, Taewhan Ko, Kaylee Allen, John Agan, Cody Baker, Brandon Bywater, Zachary Cardenas, Raimi Clark, Andrew Eulenbach, Travis Wright, Tanner Hewitt, Harrison Spencer, Jacob Slattery, Jeremy Sceifford, Michael Mounho, John Mockert, Tyler Watson, Keegan Kelp, Austin Gregory, Nathan Fryar, Ben Esser, William Brooks, Luke Boswell, Luke Silvestre, Jakob Matthies, William Milestone

Laboratory lighting strike (1.4 MV Marx)

Goals, Critical Success Factors, and Objectives

Educational Activities:
Develop instructional material and offer special university courses and international short courses.

Critical Success Factors:

- *Increase the number of short courses and tutorial seminars given at national and international conference as well as at TTU.*
- *Increase the amount of lecture material and book chapters generated.*

Partnerships:
Increase cooperation with other universities, national laboratories, and industry.

Critical Success Factors:

- *Joint research programs with other universities in the U.S. and abroad.*
- *Joint research with national laboratories.*
- *Provide services and help to industrial companies.*

LET'S START
YOUR PROJECT

GET IN TOUCH

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