Partner Brief

Developing Capacitors for Pulsed-Power Fusion Energy Systems

PEAK NANO X E&P TECHNOLOGIES

As fusion energy moves towards commercialization, one of the clearest bottlenecks is the capacitor. Next-generation pulsed-power drivers demand capacitors that store more energy, run hotter, last longer, and cycle faster than anything available today. Peak Nano and E&P Technologies are partnering to solve that bottleneck.

The Partnership

E&P Technologies is a U.S.-based engineering and manufacturing firm specializing in pulsed power systems, high-reliability capacitors, and advanced power electronics for defense, aerospace, and fusion. With direct program experience from Xcimer Energy and Blue Origin, E&P combines capacitor design, automated manufacturing, and rigorous qualification in a single integrated workflow. Peak Nano NanoPlex™ HDC dielectric film was selected by E&P technologies as the foundation for a new class of high-energy, high-reliability capacitors designed for Impedance-Matched Marx Generators (IMGs), targeting demanding fusion and aerospace environments. Development samples will be available as the program advances.

THE CAPACITOR SUPPLY-CHAIN CHALLENGE

IMG fusion systems rely on thousands of capacitors to operate above 100 kV at high-cycle rates to power the fusion process. IMG Fusion platforms face three supply chain challenges. First, traditional BOPP (Biaxially Oriented Polypropylene) capacitors are not optimal for the required temperature and duty cycles. Second, over 70% of conventional capacitors and capacitor film is sourced from China, leaving fusion developers exposed to geopolitical risk, long lead times, and limited quality oversight. Third, this is driving the development of new policies for allied-nation supply chains. The partnership between Peak and E&P Technologies will address all three of these challenges with a fully U.S.-engineered, allied-nation supply chain.

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ADVANCED DIELECTRIC FILMS + PRECISION CAPACITOR MANUFACTURING

NanoPlex HDC Film

Precisely engineered nanoscale polymer configurations unlock electrical, thermal, and mechanical properties unachievable with conventional single-polymer dielectrics – delivering 2x higher dielectric constant and up to 4x greater energy density in the same volume. Performance is fully maintained at extreme temperatures with no derating, critical for repetitive-pulse applications where self-heating accumulates between shots.

From Film to Fusion Power

E&P translates NanoPlex HDC into application-specific capacitors by optimizing electrode geometry, winding, and packaging, then validating performance under real operating conditions. For IMG-based fusion systems, every capacitor is designed to exact voltage, rise time, thermal, and cycle life requirements – reducing bank footprint, enabling IoT-based real-time health monitoring, and extending service intervals to lower maintenance frequency and cost.

INTEGRATED DEVELOPMENT PATHWAY

Stage	Description
Collaborative Design	Joint development between Peak Nano and E&P to define film architecture, capacitor geometry, and packaging requirements matched to the target application and operating environment.
Rapid Prototyping	First-article capacitor builds with accelerated test cycles, enabling fast iteration between film properties, capacitor design, and real-world performance data.
Precision Manufacturing	Automated, U.S.-based engineering with consistent quality controls, full traceability, and the ability to scale output as the program advances.
Support	Lifecycle qualification testing, post-deployment technical assistance, and real-time IoT-enabled health monitoring to track capacitor performance across systems.

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PEAK NANO AND E&P TECHNOLOGIES CAPABILITIES

PEAK NANOPLEX™ HDC

Nanolayered Dielectric Film for High-Energy Capacitors

NanoPlex HDC is a nanolayered metamaterial film engineered to achieve dielectric, thermal, and mechanical properties that conventional single-polymer films cannot reach. Its architecture enables higher energy density and thermal stability in capacitor applications where BOPP has hit performance limits.

HDC Performance vs. BOPP:

- » **Dielectric constant 3.7 to 4.8** (ASTM D150) vs. ~2.2 for BOPP, enabling up to 4x higher energy density per unit volume
- » **Operates up to 125 C** without derating, compared to BOPP derating above 85 C
- » **Up to 5x longer shot life** under repetitive discharge, reducing replacement frequency
- » **Breakdown strength up to 840 kV/mm** (ASTM D149), supporting higher voltage operation per IMG brick
- » **Up to 60% lower BOM** through fewer components and longer service intervals

Connect with HDC Experts: peaknano.com

E&P TECHNOLOGIES

U.S.-Manufactured High-Voltage Capacitors

E&P Technologies designs and manufactures high-voltage capacitors for fusion, defense, and pulsed power systems. Their engineering team brings direct experience from fusion research, aerospace, and energy industries.

Core Capabilities:

- » System-level capacitor design from specification through integration
- » Rapid prototyping with validation against application-specific duty profiles
- » Advanced process automation for consistent quality at production scale
- » Full lifecycle qualification, testing, and post-deployment support

Serving:

- » Fusion energy developers
- » Defense and aerospace contractors
- » National laboratories
- » Pulsed power system OEMs

Connect with Capacitor Experts: eptech.us

Long-Term Platform for Next-Gen Capacitor Infrastructure

Peak Nano and E&P Technologies are establishing a long-term platform for co-developing future capacitor architectures aligned with evolving customer requirements and next-generation manufacturing automation strategies. This foundation will support a pipeline of high-performance products for fusion energy, aerospace, aviation, defense, grid infrastructure, and other demanding applications—delivering compact, reliable energy storage systems manufactured entirely in the United States.

LET'S BUILD WHAT'S NEXT.

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NanoPlex™ metamaterials for peak performance

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