ARPA-E PROJECT SELECTIONS –
STRATEGIES FOR WIDE-BANDGAP, INEXPENSIVE TRANSISTORS FOR CONTROLLING HIGH EFFICIENCY SYSTEMS (SWITCHES) (SBIR/STTR)

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These projects have been selected for negotiation of awards; final award amounts may vary.

SBIR & STTR

Lead Research Organization	Amount	Lead Organization Location (City, State)	Project Title Project Description
Avogy, Inc.	$1,725,000	San Jose, CA	**Vertical GaN Transistors on Bulk GaN Substrates** Avogy will develop a vertical gallium nitride (GaN) transistor that can conduct significantly more electricity and is 30 times smaller than a conventional silicon transistor. With such a small device, Avogy could achieve functional cost parity with current technologies within three years while offering significant performance improvements. If successful, Avogy's transistors will enable smaller, more reliable, energy-efficient, and cost-effective high-power converters, electrical motor drives, and photovoltaic and wind inverters.
Fairfield Crystal Technology	$1,425,000	New Milford, CT	**High Quality, Low-Cost GaN Single Crystal Substrates for High Power Devices** Fairfield Crystal Technology will develop a new technique to speed up the growth of gallium nitride (GaN) single-crystal boules. A boule is a large crystal cut into wafers and polished to provide a surface, or substrate, suitable for semiconductor device manufacturing. Fairfield Crystal Technology's unique technology can grow superior quality GaN crystal boules rapidly, overcoming multiple barriers associated with conventional technologies, including the current state-of-the-art hydride vapor phase epitaxy (HVPE) technique. If successful, Fairfield Crystal Technology would yield large, low-cost GaN substrates to build semiconductor devices suitable for energy-efficient electrical power converters.
iBeam Materials, Inc.	$793,477	Santa Fe, NM	**Epitaxial GaN on Flexible Metal Tapes for Low-Cost Transistor Devices** iBeam Materials will develop a new way to manufacture low-cost gallium nitride (GaN) devices for use in large-scale power electronics. iBeam Materials will use crystal-aligned coatings on large-area, flexible, metal foils for deposition of epitaxial GaN films. This low-cost coating technology was recently developed to manufacture high-quality, low-cost

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			superconductor wire. If successful, iBeam Materials will adapt the coating technology for use in high-performance GaN electronic devices, significantly reducing manufacturing costs.
Kyma Technologies, Inc.	$3,224,993	Raleigh, NC	**High Quality, Low Cost GaN Substrate Technology** Kyma Technologies will develop a cost-effective technique to grow high-quality gallium nitride (GaN) by developing a high growth rate process for creating crystalline GaN boules, which are used as a starting material for semiconductor device manufacturing. Currently, growing boules from GaN seeds is slow, expensive, and inconsistent, which negatively affects manufacturing yield and electronic device performance. Kyma will select the highest quality GaN seeds and use their proprietary hydride vapor phase epitaxy (HVPE) growth process to rapidly grow the seeds into boules while maintaining high crystal structural quality and purity. If successful, Kyma will produce low-cost, high-performing boules needed for power semiconductor manufacturing.
MicroLink Devices	$1,725,000	Niles, IL	**Vertical-Junction Field-Effect Transistors Fabricated on Low-Dislocation-Density GaN by Epitaxial Lift-Off** MicroLink Devices will engineer affordable, high-performance transistors needed for power conversion. Currently, high-performance power transistors are prohibitively expensive because they are grown on expensive gallium nitride (GaN) semiconductor wafers. In conventional manufacturing processes, this expensive wafer is permanently attached to the transistor, so the wafer can only be used once. MicroLink Devices will develop an innovative method to remove the transistor structure from the wafer without damaging any components, enabling wafer reuse while significantly reducing costs.
Monolith Semiconductor, Inc.	$3,224,845	Ithaca, NY	**Advanced Manufacturing and Performance Enhancements for Reduced Cost Silicon Carbide MOSFETs** Monolith Semiconductor will utilize advanced device designs and existing low-cost, high-volume manufacturing processes to create high-performance silicon carbide (SiC) devices for power conversion. SiC devices provide much better performance and efficiency than current silicon devices, however they currently cost significantly more. Monolith will develop a high-volume SiC production process that utilizes existing silicon manufacturing facilities to keep capital costs down.

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SixPoint Materials, Inc.	$1,725,000	Buellton, CA	**GaN Homoepitaxial Wafers by Vapor Phase Epitaxy on Low-Cost, High-Quality Ammonothermal GaN Substrates** SixPoint Materials will create low-cost, high-quality vertical gallium nitride (GaN) substrates using a multi-phase production approach that employs both hydride vapor phase epitaxy (HVPE) technology and ammonothermal growth techniques to lower costs and maintain crystal quality. Substrates are thin wafers of semiconducting material needed for power devices. In its two-phase project, SixPoint Materials will first focus on developing a high-quality GaN substrate and then on expanding the substrate's size. If successful, SixPoint Materials will enable high-power GaN circuits that can convert power for electric motors and electric vehicles with half the energy loss compared to today's GaN devices.
Soraa, Inc.	$225,000	Fremont, CA	**Large Area, Low-Cost Bulk GaN Substrates for Power Electronics** Soraa will develop a cost-effective technique to manufacture high-quality, high-performance gallium nitride (GaN) crystal substrates that are better than today's GaN crystal substrates, which are expensive and prone to defects. Soraa will also develop pathways to large-area GaN substrates that can handle power switch applications. Substrates are thin wafers of semiconducting material needed for power devices like transistors and integrated circuits. If successful, Soraa will produce GaN crystal substrates that have 100 times fewer defects than conventional GaN substrates, cost eight times less, and are three to four times larger in diameter.

Non-SBIR

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Arizona State University	$420,434	Tempe, AZ	**Diamond Power Transistors Enabled by Phosphorus Doped Diamond** Arizona State University (ASU) will develop a method to produce low-cost, vertical diamond semiconductor devices for use in high-power electronics. Diamond is an excellent conductor of electricity when boron or phosphorus are added, or doped, into its crystal structures. In fact, diamond can withstand much higher temperatures with higher performance levels than silicon, which is widely used in today's semiconductors. However, growing uniformly doped diamond

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			crystals is expensive, and it is difficult to grow them in multiple layers while maintaining the structure necessary for semiconductor devices. ASU's innovative diamond-growing process could create greater doping uniformity, enable improved electrical contacts, and help lower the cost of diamond semiconductors.
Columbia University	$3,000,000	New York, NY	**Vertical GaN Power Transistors Using Controlled Spalling for Substrate Heterogeneity** Columbia University will create vertical gallium nitride (GaN) devices using a technique called spalling, a method to transfer entire GaN devices to alternate substrates or bases. Columbia will spall entire fabricated transistors from GaN wafers to lower-cost silicon substrates. Columbia will also interconnect the supporting silicon substrates, enabling small-scale integration of its GaN devices. If successful, Columbia University's GaN transfer method will enable the use of low-cost, high-power transistors for industrial motors and other automotive applications.
HRL Laboratories, LLC	$2,900,000	Malibu, CA	**Low-Cost Gallium Nitride Vertical Transistor** HRL Laboratories will develop a new, high-performance gallium nitride (GaN) vertical transistor that will displace inefficient silicon transistor technologies used in high-power switching applications like electric motor drives. HRL will improve device fabrication and circuit design to enable high-power operation of GaN. This new GaN vertical transistor could have 10 times lower power loss at the same cost as today's widely used silicon transistors.
Michigan State University	$558,914	East Lansing, MI	**Diamond Diode and Transistor Devices** Michigan State University (MSU) will build high-voltage diamond semiconductor devices for use in high-power electronics. Diamond is an excellent conductor of electricity when boron or phosphorus are added, or doped, into its crystal structures. Diamond can withstand much higher temperatures with higher performance levels than silicon, which is widely used in today's semiconductors. Current techniques for growing layers of doped diamond are too expensive, however, to create semiconductors that are capable of handling enough electricity to power advanced electronics. If successful, MSU's innovative technique to grow diamond layers with different doping levels and elements will facilitate devices capable of conducting enough electricity for high-power electronics.

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University of California, Santa Barbara	$3,172,205	Santa Barbara, CA	**Current Aperture Vertical Electron Transistor Device Architectures for Efficient Power Switching** The University of California, Santa Barbara (UCSB) will develop several new vertical gallium nitride (GaN) semiconductor technologies that will enhance the performance and reduce the cost of high-power electronics. The team's current aperture vertical electron transistor devices could reduce power losses and reach beyond the performance of lateral GaN devices when switching and converting power. If successful, UCSB's devices will enable high-power conversion at low cost in motor drives, electric vehicles, and power grid applications.
University of Notre Dame	$2,496,428	St. Joseph, IN	**PolarJFET Novel Vertical GaN Power Transistor** The University of Notre Dame will develop an innovative high-efficiency gallium nitride (GaN) power switch. Notre Dame's design is significantly smaller and operates at much higher performance levels than conventional power switches, making it ideal for use in a variety of power electronics applications. Notre Dame will also reuse expensive GaN materials and utilize conventional low-cost production methods to keep costs down. If successful, Notre Dame's miniature, high-performance, low-cost GaN power transistors could make silicon switches obsolete.