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Power for the Warfighter

One of mankind's greatest tools is the ability to generate electricity. To flip a switch and have light, power your tools, turn on your computer, get money at the ATM, or pump gas at the gas station. Has the electricity ever gone out while you were at work? What did you do? Went to get a cup of coffee while it was still hot?

Imagine yourself on an aircraft carrier during a high sortie rate operations. The ship is running at over 30 knots and the flight deck is full of personnel refueling aircraft, loading weapons, preparing aircraft for take-off, and retrieving incoming aircraft. The radar picks up an incoming missile closing fast. The power goes out.

Believe it or not, some of today's warships use 1960s technology to manage power, and Sailors must manually flip circuit breakers to redistribute the power loads. Picture the telephone switchboard operators of the 1930s, in a row, furiously trying to connect all the incoming calls during a period of high telephone use. Today's telephone operator doesn't handle the menial task of manually connecting the lines; the system is automated through electronic circuits.

We need our electrical systems to react at electrical speeds, not mechanical speeds, to avoid catastrophic failures. Solid-state switching enables new architectures with the ability to prevent catastrophic failures, to add intelligent power electronics with the ability to sense and adapt according to changes in the power network as a total system. To reconfigure as needed, redistributing loads automatically. To reroute intelligently when a failure occurs, the same way

the internet reroutes information when a node is down.

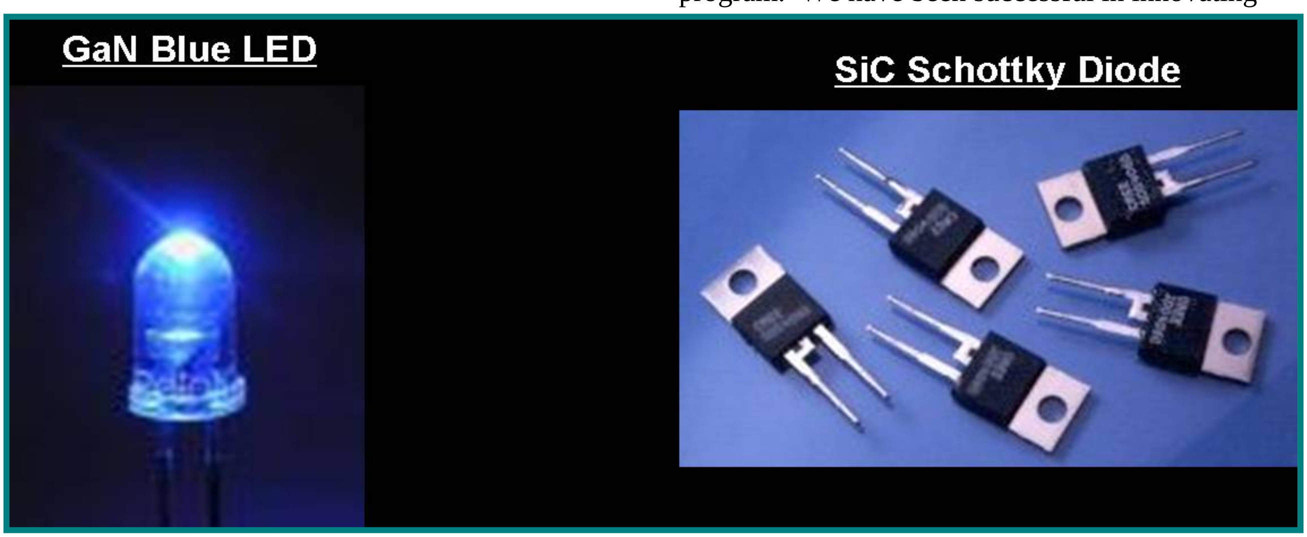
We have to bring our high power electrical systems into the 21st century.

Imagine yourself in an urban combat environment. You have localized the enemy and need to call in backup, but your radio isn't working and you realize your battery is dead. We need to provide reliable, continuous power to the dismounted Soldier so he can focus on warfighting, not worry if there will be enough power to accomplish his mission. We need to find new ways of tapping into the environment, exploiting the properties of nanomaterials, devising alternative technologies and designs to increase the capabilities of our portable electrical systems.

The demand for high quality electrical power for military platforms and for dismounted Soldiers and autonomous systems is constantly increasing. This can be seen in an annual 2 percent increase in the commercial market demand and the military's drive to have more electric platforms: the all-electric ship, more-electric aircraft, and all-electric combat vehicle. The increase in electrical power demands cannot be met using today's logistical strategies. The land warrior needs powerful sensors, better communication equipment, and innovative systems that require more power. We must increase the energy density of our systems while increasing power quality, thus enhancing efficiencies. We must provide intelligent power management with enhanced efficiencies to alleviate the cooling requirements of our more energy-dense systems. We must find power management techniques and decrease the weight and size of batteries to allow warfighters to carry more weight in ammunition. The life of the power supply dictates the length of missions and the ability to use highly specialized systems. The ability to send an unmanned aerial vehicle over the next hill and communicate with it is dictated by the ability of its power supply.

We need the ability to capture and store excess power, whether it is for a high-power platform carrying 5,500 Sailors or an individual land warrior. We need to sense the health of the system and dynamically reconfigure or allow the Soldier to recharge. To have an intelligent network with a knowledge of surroundings, to change to desired power ratings on-the-fly as a network changes or power demand increases. To allow power regeneration through bi-directional energy flow. To integrate fast solid-state digital switches with high-power quality and the ability to handle power surges. To avoid catastrophic failure through autonomous rerouting. To ensure the power system does not fail when needed. That is the vision.

Solving these problems begins with the materials and extends to integrated microsystems, developed by engineers of the nanoworld. DARPA has taken a leading role in this effort in the Wide Band Gap program. We have been successful in innovating



material processes and developing the ability to manufacture galium nitride and silicon carbide for use in integrated circuits. We have blue LEDs and SiC Schottky diodes used for their unique qualities and energy efficiencies. For high-power electrical systems, replacing silicon with silicon carbide enables less complex system architectures as we design our circuits. The SiC high-voltage levels enable us to choose the switches that give the best performance with the least number of devices. The high-voltage levels provide us with the ability to provide AC switching in a system when it is better suited than DC switches. Reducing complexity through new electrical system architectures enabled through SiC microelectronic devices. Using these new architectures to our advantage for better power quality, higher efficiencies, higher operating temperatures, and faster switching capabilities. These attributes lead to less heat dissipation, less cooling requirements, lower weights and volumes, and the ability to stop catastrophic failure of a system.

For battery-powered sources, we again begin at the materials level. How do we exploit the attributes of nanomaterials? We begin by taking advantage of their one-dimensional ionic transfer, high surface area, and high strength. Can we bring the anode and cathode closer than the 20 microns typical in batteries today to increase our energy density? Will carbon nano tubes play a role in the future? Their attributes include high strength, high thermal resistance, and ballistic electrical properties. In addition, shrinking the size of the system inherently brings in better efficiencies. I am interested in driving forward the technologies that will have a revolutionary effect on electrical power systems for the US military. If you have great ideas, I want to hear them. I look forward to working with you.