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High-Gain Persistent Nonlinear Conductivity In High-Voltage Gallium Nitride Photoconductive Switches

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Wide-bandgap GaN optically-controlled switches have the potential for driving down the cost and size, and improving the efficiency and capabilities of high voltage pulsed-power applications. The key scientific challenge will be measuring the high-field photo-conductive (PC) properties of these materials to determine if they will operate in a high-gain and/or sub-bandgap triggering mode, like what has been observed in GaAs.

600 μm gap devices from GaN wafers from Kyma and Ammono were fabricated for laser testing. The laser used was a Nd:YAG Q-switched system doubled to produce emission at 532nm to 12mJ energy. With relatively low voltages applied the switch, linear photoconductive currents were measured through the pulse in response to exposure to the laser pulses. As increasing voltage is applied to the PCSS, above a threshold persistent conductivity is measured that lasts well beyond the duration of the laser pulse and discharges the charging transmission line in the system. This occurs at threshold fields of 10-15 kV/cm.

This persistent photoconductivity is a distinguishing characteristic of what is known as "lock-on"effect in photoconductive switches, most notably known in GaAs-based devices. Once lock-on is initiated from laser generated electron-hole pairs, as long as sufficient field remains applied to the switch, avalanche carrier generation is sustained to maintain conduction even after the laser illumination is removed. This effect is the basis for highly-efficient photoconductive switching requiring relatively little laser energy. In other experiments with the GaN devices, high-gain switching has been initiated with as little 35μJ laser energy thus far.

Another distinguishing characteristic of lock-on switching effect known from characterization in GaAs is the formation of filamentary current channels. These filaments can be imaged due to the emission of recombination radiation from electrons and holes in the plasma within the filaments, and have been recorded in the GaN switches.

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Authors: Dr MAR, Alan (Sandia National Laboratories); Mrs HIRSCH, Emily (Sandia National Laboratories); Dr KIZILYALLI, Isik (Advanced Research Projects Agency - Energy); Dr ZUTAVERN, Fred (Sandia National Laboratories); Dr PICKRELL, Gregory (Sandia National Laboratories); Dr DELHOTAL, Jarod (Sandia National Laboratories); Mr GALLEGOS, Richard (Sandia National Laboratories); Mr BIGMAN, Verle (Sandia National Laboratories); Mr TEAGUE, Dana (Sandia National Laboratories / University of New Mexico)

Presenter: Dr MAR, Alan (Sandia National Laboratories)

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