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P-Type 6H-SiC Photoconductive Switches

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The thermal conductivity and electric field strengths of silicon carbide (SiC) are ten times greater than for GaAs. Therefore, SiC appears to be an ideal semiconductor material for high–temperature and high–power photoconductive switching applications. Although the optoelectronic potential of SiC has been known since 1907, electronic device grade SiC has only recently become available. As a consequence, the material parameters of 6H-SiC crystals are poorly understood, and much research is being directed towards determining these constants. One of the parameters in question is the carrier lifetime in p-type bulk 6H-SiC. In our investigation, we employed photoconductive techniques to measure both the surface and bulk carrier lifetimes. In order to separate the surface and bulk material properties, we used both lateral and vertical switches.

Measurements were made with both a nitrogen (N_2) laser and an N_2-pumped dye laser as the optical source, which permitted investigation of the switch behavior, both above and just below the 6H-SiC absorption edge. The switches were placed in a low-impedance dc circuit, which was designed for maximum sensitivity. Current-voltage (*I-V*) measurements indicate that ohmic contact to the 6H-SiC material was achieved. The optical absorption coefficient for this material was also measured.

We report the measurement of photovoltaic and photoconductive effects for both switch geometries and at several wavelengths near the 6H-SiC absorption edge. The bulk and surface carrier lifetimes in p-type 6H-SiC are also reported. Although the devices possess dark resistances on the order of $10\ \Omega$, the switching efficiency of the vertical switches approached 32 percent, while the resistance of the lateral devices could be reduced by 50 percent with 200 μJ of laser radiation at $\lambda = 337$ nm. In addition, we measured photoconductivity in the vertical switches with device static power dissipation exceeding 11 W. Although the device was glowing from the high level of dc power being dissipated, only the switch mount was damaged. 6H-SiC is indeed a high-temperature optoelectronic material.

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FAST OPENING GaAs PHOTOCONDUCTIVE SWITCH CONTROLLED PULSED POWER SYSTEM[*]

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A GaAs photoconductive opening switch controlled pulsed power system has been demonstrated which produces a 6 kV, 70 kW pulse with a risetime of less than 10 ns and power gain of 10.

The pulsed power system utilizes a novel circuit structure consisting of ten ($Z_0 = 50\ \Omega$) series current charged transmission lines (CCTL's) as an inductive energy storage element that is placed in parallel with a matched $500\ \Omega$ load. Energy is initially stored in an open ended $50\ \Omega$ transmission line which is charged to a voltage V_0. The open ended line is then discharged into the CCTL's through a GaAs photoconductive switch. When the switch opens the current which is stored in the CCTL's passes through the load resistor, producing an output voltage pulse which may be greater than the initial charging voltage, V_0. A computer model of this configuration has been developed which agrees well with the experimental data.

The GaAs photoconductive switch is the essential element in the pulsed power system. In order to achieve voltage step-up and power gain the switch must have a long on-time and fast opening time. In previous work[1] the opening time and on-time were determined by the shape of the controlling laser pulse. A specially tailored 500 ns, square laser pulse was required. However, with this circuit, the switch conductivity is sustained well after the laser pulse has ended. Furthermore, the switch opens after a time determined by the open ended charging line length with an opening time that is less than 10 ns. Hence, a commercial Q-switched Nd:YAG laser (12 ns-90 mJ) could be used without pulse shaping.

The mechanism responsible for the sustained conductivity of the switch is now being investigated. We have found that the GaAs switch exhibits a conductivity that is sustained for more than 100 ns beyond the laser pulse when switched into a high impedance ($500\ \Omega$) load. This sustained conductivity even occurs at charging voltages that are well below the critical "lock-on" voltage. We believe that the sustained conductivity and fast opening of the switch may be related to carrier injection at the switch contacts.

[1] E. E. Funk, E. A. Chauchard, M. J. Rhee, and Chi H. Lee, "80-kW Inductive pulsed power system with a photoconductive semiconductor switch," *IEEE Photonics Technology Letters*, Vol. 3, pp. 576-577, 1991.

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