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Fast High-Current Semiconductor Switches for Pulsed Power Applications

Abstract:

The discovery of subnanosecond switching of the high-voltage silicon structures due to the initiation of the impact-ionization wave significantly improved the switching characteristics of the semiconductor devices. Later, the study of the functioning of the low-frequency commercial thyristor triggered in impact-ionization wave mode has shown encouraging results on 56 mm wafer diameter thyristors: blocking voltage of 5 kV, switching current of more than 200 kA, rate of current rise more than 50 kA/µs and pulse duration of 25 µs. Moreover, the thyristor active area depends on a dV/dt of the triggering pulse. It means that the higher current switching parameters are possible with a larger thyristor and more powerful triggering generator.

This project will continue research on high-current thyristor switches triggered in the impact-ionization wave mode. The main goal is to prove experimentally the possibility of switching fast sub-mega-ampere currents by the semiconductor devices. Switching characteristics as a function of the triggering pulse parameters will be investigated for thyristors with a wafer diameter of up to 100 mm.

Results and Discussion:

The figure on the right presents a voltage across a 5.2 kV thyristor with a 100 mm diameter wafer. A Marx generator is used as a trigger to deliver the voltage pulse with a dV/dt faster than 1 kV/ns. In these conditions, the thyristor switches in impact-ionization wave mode when the voltage across its main electrodes reaches the double static breakdown value. The closing occurs in a few hundred picoseconds and demonstrates good reproducibility. The ongoing research is devoted to the limit of switching at high currents and high energies.