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# High voltage SiC MOSFET Opportunities for Dielectric Barrier Discharge Transformerless Power Supply

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From an electrical point of view, cold plasmas are complex loads to control. For ignition, high voltages are required, and once established, the plasma can easily go into the arc regime (thermal plasma). In Dielectric Barrier Discharge (DBD) setups, at least one dielectric is placed between the two metallic electrodes that supply the gas. Current flowing through the plasma also charges these dielectrics: their voltages increase and the gas voltage also decreases. Through this limiting mechanism, the dielectric barriers limit the current and therefore prevent from going into the arc regime. This property makes the DBD particularly appealing in various applications that require plasmas with low temperatures: UV excimer lamps, thin film deposition, surface treatment, disinfection. Our developments are geared toward DBD UV lamps [1], but the approach proposed is applicable to any DBD setup (plane-plane setup for thin film deposit was also tested).

The capacitive character of the dielectrics requires supplying DBDs using an alternative source. Furthermore, to ignite the discharge at atmospheric pressure, the required voltage usually reaches several kilovolts. This high alternating voltage is traditionally obtained via amplification using a step-up transformer. Unfortunately, the parasitic capacitances of the latter (inter-turn and inter-winding) limit the power transfer: these capacitances have generally low values but often are of the same order of magnitude as those of the DBD. It is parallel to the DBD, so it diverts a significant proportion of the current transferred. This slows down the voltage rise and delays the ignition. This increases the *OFF* time, during which the excited species created by the previous discharge disappear. In some processes this can even change the behavior of the discharge. As a matter of fact, the main consequences of the parasitic capacitance of the transformer concern the functioning of the discharge and not the energetic efficiency of the system.

These reasons incited us to investigate power supplies for DBD without transformer. To our knowledge, only theoretical developments have been proposed to date [2], high-voltage switches being available only for a few years. Our solution is to directly connect a high-voltage current-pulsed [3] quasi-resonant inverter to the DBD, as presented on Figure 1. It involves using high-voltage switches: the required characteristics are thyristor-like behavior (closing switches with spontaneous turn-off at null current), but actual thyristors have frequency limitations which make them incompatible for DBD applications. Several solutions for such synthesized devices are evaluated, tested experimentally, and compared, including

10kV-10A SiC power DMOSFETs designed by CREE (single switch and series connection).

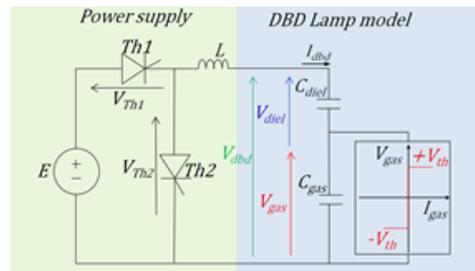


Figure 1: Power supply and DBD electrical model

The design and implementation of a converter's prototype are presented and tested with a DBD UV lamp [1]; we especially detail the implementation of high voltage MOSFETs, and the control board designed in order to sustain the high voltage insulation.

Experiments highlight the topology's performances and the effects of the 10kV SiC switch characteristics on the discharge and on the efficiency: the main advantage of the converter is its transformerless operation, with a reduced number of switches. We demonstrate the feasibility of using 10kV SiC MOSFETs in transformerless supply for DBD. For our knowledge, it is the first time that these switches are used in a pulsed current converter for DBD. However using 10kV SiC MOSFET presents a serious drawback in this topology: the *OFF* state MOSFETs voltage reach up several kV ( $E$ ); when turn *ON* takes place, the parasitic capacitance is shorted and its stored energy ( $C_{oss} \cdot E^2 / 2$ ) dissipated. These losses are inherent to our application and depend on the  $E$  operating voltage but not on the power transferred to the DBD. For increased efficiency of the converter, these 10kV SiC MOSFET should be preferently selected for high power DBDs.

## References

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