Picosecond Laser Filament-Guided Electrical Discharges in Air at 1 kHz Repetition Rate

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Laser induced filaments have been shown to reduce the voltage necessary to initiate electric discharges in atmospheric air and guide their propagation over long distances. Here we demonstrate the stable generation of laser filament-guided electric discharge columns in air at up to 1 kHz repetition rate, and report on the physics of discharges initiated by 1030 nm wavelength laser pulses of 7 ps duration with up to 250 mJ energy. A current proportional to the laser pulse energy is observed to arise as soon as the laser pulse arrives, initiating a high impedance phase of the discharge. Full breakdown characterized by impedance collapse occurs 100 ns to a few μs later. A record 4.2 X reduction in breakdown voltage for dc-biased discharges is observed to result predominantly from the large (>75%) density depression caused by a single laser pulse, and to be practically independent of the repetition rate up to 1 kHz. The radial gaps between the filamentary plasma channel and the electrodes are shown to play a role in the breakdown dynamics. The increased understanding of kHz repetition rate filament- guided discharges can aid their use in applications.

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