TOWARDS HIGH-POWER PULSED ELECTRON-BEAM-SUSTAINED PLASMAS: A DEVELOPMENT PLATFORM FOR INNOVATIVE HIGH-VOLTAGE AND PULSED-POWER ELECTRONICS

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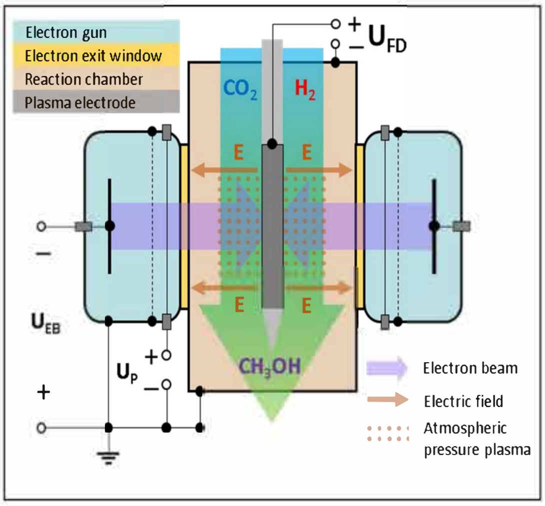
ABSTRACT

For the purposes of climate protection and resilience, Germany is undertaking the transformation of its energy system to solely regenerative sources. Efficient energy storage technologies, to equalize the daily and seasonal variation of the renewable electricity supply, are critical for the success of this “Energiewende”. In that context, Fraunhofer FEP has set itself the goal to evaluate the conversion of carbon dioxide, e.g., with (future green) hydrogen, in electron beam-sustained, ambient-pressure plasmas and to proof the advantageous energy efficiency and conversion degree of this novel, industrially scalable Power-to-X process for the production of chemical energy storage materials and “green” platform chemicals. The conceptual approach relies on the fact that overcoming the energy barrier or the kinetic inhibition of chemical reactions is not only possible thermally, but in plasmas also by directly influencing the binding states of molecules. The key to superior energy efficiency is that the plasma species and degrees of freedom are thermodynamically in non-equilibrium, which allows the gas temperature to be kept low whereas the chemically active molecular vibrations are highly excited. Electron beam-sustained plasmas are also characterized by their uniform energy density and volume filling, which simultaneously promises high degrees of conversion.



However, exploiting these rewarding features in practice poses demanding challenges for the energy injection into the electron source and the plasma, which exceed the capabilities of current solid-state switching technologies: electrical pulses with some ns rise times and a few µs duration, kA currents at kV voltages, hundreds of kW/cm³ peak power densities, some J/cm³ deposited energy per pulse, and repetition rates in the kHz range. This poster introduces a pulsed-power development platform for evaluating advanced switches, current-regulation concepts, and pulse-forming architectures involving vacuum-electronic devices.

As one representative application, a SiC-JFET current-limiter stack shall be qualified to stabilize the wire-anode discharge of an SEE cold cathode EB gun, to prevent arcing, and to enable higher power-density operation.