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Simulations of Streamer-Spark-Arc Discharges for Flow and Ignition Control

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Streamer, spark and arc are three typical stages of plasma discharges in moderated and elevated pressures. A streamer initiates from the tip of the pin electrode and propagates along the electric field line, once the it penetrates the gap between electrodes, a spark will be generated with significant chemistry and thermal effects. If the discharge continues, the plasma column will suffer an non-to-equilibrium transition into an arc. If the arc is coupled with the gas flow, a so-called gliding arc appears and as the gliding arc is stretched, an equilibrium-to-non equilibrium occurs.

The hydrodynamics, chemical and thermal effects in the streamer-spark-arc discharges enable the possibility in active flow, combustion control and energy conversion industries[1,2,3]. Flexible control of air flow and fuel ignition at high altitude and high speed flight vehicles is one of the pioneering field in aerospace researches, plasma actuators and igniters in various configurations were fabricated and studied by research groups around the world in the past tens of years. Figure 1 briefly summarized the applications of spark-arc discharges in the field of high speed flow control and ignition.

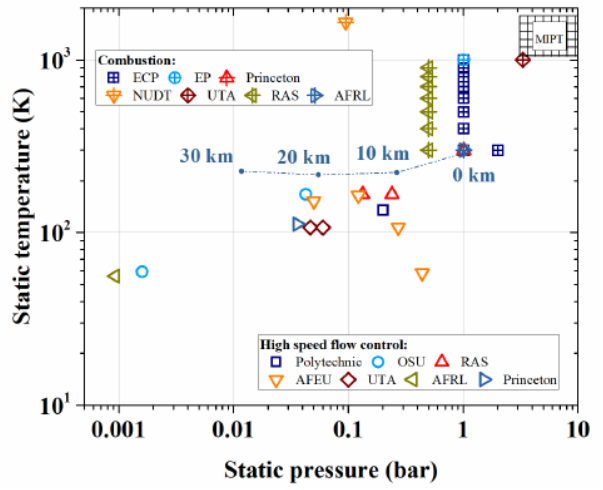
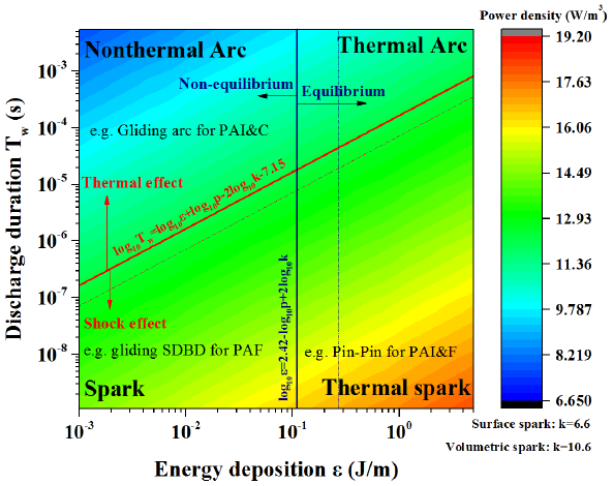


Figure 1 A review of the plasma assisted high speed flow and ignition control

Deep insights into the physics and intelligent control strategy of the aforementioned three stages are required. We present here a set of global and two dimensional simulation tools[4] for studying forward and backward transition of streamer-spark-arc in the supersonic plasma flow control and gliding arc assisted ignition applications. The performance of plasma actuators and igniters with regard to operation altitudes, discharge durations and energy depositions are calculated and concluded as a characteristics map. Figure 2 is an example of the characteristics map for atmospheric pressure air.



A physics corrected machine learning method is proposed[5] and validated for the design of the discharge waveforms. By artificially set the time evolution of Oxygen atoms, we are manage to design the electric field/ voltage waveforms with the help of machine learning technique.

References

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