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**2D fluid simulations of discharges at atmospheric pressure in reactive gas mixtures**[1]

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Since a few years, low-temperature atmospheric pressure discharges have received a considerable interest as they efficiently produce many reactive chemical species at a low energy cost. This potential is of great interest for a wide range of applications as plasma assisted combustion or biomedical applications. Then, in current simulations of atmospheric pressure discharges, there is the need to take into account detailed kinetic schemes. It is interesting to note that in some conditions, the kinetics of the discharge may play a role on the discharge dynamics itself. To illustrate this, we consider the case of the propagation of He-$N_2$ discharges in long capillary tubes, studied for the development of medical devices for endoscopic applications. Simulation results put forward that the discharge dynamics and structure depend on the amount of $N_2$ in the He-$N_2$ mixture. In particular, as the amount of $N_2$ admixture increases, the discharge propagation velocity in the tube increases, reaches a maximum for about 0.1% of $N_2$ and then decreases, in agreement with experiments. For applications as plasma assisted combustion with nanosecond repetitively pulsed discharges, there is the need to handle the very different timescales of the nanosecond discharge with the much longer (micro to millisecond) timescales of combustion processes. This is challenging from a computational point of view. It is also important to better understand the coupling of the plasma induced chemistry and the gas heating. To illustrate this, we present the simulation of the flame ignition in lean mixtures by a nanosecond pulsed discharge between two point electrodes. In particular, among the different discharge regimes of nanosecond repetitively pulsed discharges, a "spark" regime has been put forward in the experiments, with an ultra-fast local heating of the gas. For other discharge regimes, the gas heating is much weaker. We have simulated the nanosecond spark regime and have observed shock waves generated by the discharge, in agreement with experiments. Then, we have studied the production of active species for the different regimes of nanosecond repetitively pulsed discharges. We present the relative importance of gas heating and the production of active species for the ignition of lean $H_2$-air and $CH_4$-air mixtures.

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