Some aspects of reactive thermochemically non-equilibrium plasmas

G. Tetard, G. Lombardi, F. Mohasseb, A. Michau, S. Prasanna, X. Duten, F. Benedic, K. Hassouni, M. Redolfi, J. Mougenot, A. Allouch, K. Ouaras, C. Arnas*, C. Rond, S. Longo**

Université Sorbonne Paris Nord, Laboratoire des Sciences des Procédés et des Matériaux, LSPM, CNRS, UPR 3407, F-93430, Villetaneuse, France
***** *LPIIM, Aix-Marseille université, CNRS, Campus Saint Jérôme, 13397 Marseille, France*
*** Department of Chemistry, University of Bari, via E. Orabona 4, 70126 Bari, Italy*

In this presentation we discuss some of the peculiarities of thermo-chemically non-equilibrium effects characterizing reactive electrical discharges and plasma flows. Although, the presentation will mainly use illustrative examples from numerical modeling studies, a brief discussion related to the different measurements that are needed to support model developments, validate modeling results and gain insight in the chemical physics of reactive plasmas will be hopefully also carried out at the end of the presentation.

We start by discussing electron kinetics in non-equilibrium plasmas and analyzing the different assumptions made and model used to determine the electron energy distribution functions in different non equilibrium situations. We will also discuss the impact of these assumptions on the description of energy dissipation and chemical kinetics. We will first discuss some collisional radiative models that are specific to plasmas generated in 'simple' molecular gases such as hydrogen or nitrogen. We will especially shows how the vibrational kinetics can play a role in the production of N-atom in nitrogen plasmas on one hand, and how the electronically excited states kinetics can contribute to the ionization kinetics in hydrogen plasmas on the other hand. Then we will consider hydrocarbon containing plasmas that show a much more complex and stiff chemistry and emphasize the non-equilibrium transport-chemistry effects induced by the electron component in these plasmas. We will also show how the chemistry may affect the discharge dynamics and the electromagnetic power deposition in RF and microwave discharges. We further discuss some examples of molecular growth and dust particle nucleation in carbon containing discharges. We will mainly focus on analyzing the interplay between discharge dynamics and chemistry and on identifying the key precursor species and governing process for particle nucleation in electrical discharges. We end up by showing some examples where reactive plasmas may transitions to dusty plasmas and discussing the coupling between discharge dynamics, aerosol dynamics and plasma chemistry.