Underwater electrical breakdown: from discharge visualization to modelization

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Résumé

In the past decades, plasmas in (and in contact with) liquids have been widely studied for the breakdown of dielectric liquids, waste water treatment or plasma medicine. Pulsed discharges in liquid raise phenomena of great complexity, involving electronic processes in dense media through injection and heating of electrons and the subsequent ionization of atoms and molecules, as well as hydrodynamic and thermodynamic processes such as phase change, bubble formation and shock wave emission.
Underwater electrical breakdown is usually splitted in 3 time-based stages (pre-breakdown, breakdown and post-breakdown) and exhibit strong polarity effects (cathode versus anode regime). In this work are presented two models which intend to improve the understanding of the involved phenomena. The first one is a 0D thermochemical global model which allows us to simulate the chemistry during breakdown and post-breakdown. The chemical model of the gas phase includes 31 species involved in 628 reactions. The time evolution of the density is determined for each species, as well as electron and gas temperatures. The second model is dedicated to the post-breakdown and has been developed to reproduce the evolution of the dynamical bubble radius through the Rayleigh-Plesset and the Gilmore equation. Finally, based on discharge energy considerations, an energy balance is presented for the cathode regime of the discharge.

Mots-Clés: Plasma, liquid, cold atmospheric pressure plasma, electrical breakdown, discharge modelization, bubble dynamic

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