Modelling of plasma-chemical propellant interaction in electrodeless helicon plasma thruster

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The aim of the HPH.com (Helicon Plasma Hydrazine COmbined Micro) research program has been to design, optimize and develop a space plasma-thruster in the range of power lower than 50 W, based on helicon-radio-frequency technology; moreover a detailed feasibility study has been also conducted to evaluate whether it is possible to use the plasma thruster to heat and decompose a chemical monopropellant, and building up a combined-two-mode-thruster able to operate in the low-thrust high efficiency plasma-mode and high-thrust low-efficiency chemical mode. The monopropellants considered were N2H4 and N2O, in a frame of green propellants performance evaluation.

This paper describes the numerical model comprising a plasma global model and a chemical thermal decomposition model, which have been realized and tailored for the two monopropellants. The above models, and relevant results, have been used to investigate about the feasibility of the high-thrust low-efficiency chemical mode.

The plasma model includes formulation of bulk-plasma and surface-plasma processes; heating of the gas resulting by electron-collisions energy transfer is also evaluated. The chemical model simulates the thermal decomposition of the considered monopropellant.
The final model is able to follow the evolution in time of the densities of the chemical species, identifying the main kinetic mechanisms depending on initial and boundary conditions. The chamber pressure and temperature during both plasma ignition and subsequent self-sustained decomposition can be evaluated providing indications about thruster performances.

The output of the work shows the possibility to ignite and sustain a thermal decomposition of N2H4 with a low RF power input level, while major difficulties are required for the ignition of N2O.