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PhD Thesis Abstract

In situ resource utilization on Mars using non-equilibrium plasmas

Human colonisation on Mars is one of the hottest topics nowadays and is in the focus of such agencies as NASA, ESA and SpaceX. In-Situ Resource Utilization can provide materials for life support and propellants, thereby reducing the mass and cost of space exploration missions. Since the main component of the Martian atmosphere is carbon dioxide (almost 96%) it was proposed to dissociate it into oxygen, which can serve as fuel and breathable gas. Non-equilibrium plasmas are considered to be the most efficient medium to produce oxygen from carbon dioxide and could be applied locally on Mars, where the atmospheric pressure and temperatures are auspicious for CO_2 reforming. To do so, one specific vibrational mode of the CO_2 molecule should be pumped, with subsequent climbing into the higher vibrational levels during the relaxation process, in a process that favours dissociation. Changing the gas temperature, plasma density and other parameters of the discharge will allow to control the electron energy and the vibrational distribution functions and, therefore, the oxygen yield. The objectives of this work are to create and validate a self-consistent model of CO_2 discharges, including possible reactions with products of decomposition, e.g. CO, O_2 and O; to optimise the input data in order to minimise disagreement with experiments; to define conditions that may lead to the creation of a prototype for implementation of CO_2 reforming in Mars atmospheric conditions. The proposed thesis covers a theoretical, experimental and numerical investigation of carbon dioxide plasma decomposition including electron and vibrational kinetics, chemistry of the discharge, influence of the gas temperature, experimental validation and definition of a “reaction mechanism."