The Quest for Selectivity in Plasma Chemistry

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The goal of many non-equilibrium, low-temperature plasma systems is to selectively produce a desired chemical product, surface functionality or photon flux. This goal is accomplished by preferentially directing plasma power into a small subset of the possible excited states or dissociation channels by electron or ion collisions, or by initiating only one of the many surface reactions that might occur. In principle, this preferential power flow is accomplished by controlling the electron and ion energy distributions – $f(\varepsilon)$. Although simply stated, control of $f(\varepsilon)$ may be a necessary but not sufficient condition to achieve selectivity. It is rare that a cross section is so isolated and the $f(\varepsilon)$ so well-crafted, that plasma power can be exclusively directed into that single channel. Even if the initial reactant is preferentially generated, subsequent reactions may diffuse that selectivity. Achieving selectivity in plasma chemistry and plasma-surface interactions often requires optimizing a set of synergistic conditions in a multi-dimensional space. In spite of this more stringent requirement, there many impressive examples of selectivity in plasma chemistry, from plasma excited lasers to plasma etching. Achieving that elusive selectivity is now being challenged by environmental and biomedical applications, where the practicality or safety of the system is predicated on having highly efficient power transfer or producing highly selective reactants. In this talk, the quest for selectivity in plasma chemistry will be discussed from the system perspective – how may plasma chemical systems be designed from first principles to achieve the desired selectivity.