Production of molecule on a pyrex surface under plasma exposure: example of NO

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Extensive experimental and theoretical study of NO_x production in low pressure N2/O2 containing plasmas in continuous [1,2,3] and pulsed mode [4], as well as computational fluid dynamics simulation of space vehicles re-entry reveal an important role of O and N atom surface-catalyzed recombination into NO molecule. However, in all above cases analysis of the relative yield of this reaction is not straightforward and it requires sophisticated numerical modeling. We propose to study NO production on the surface pretreated in different low pressure plasmas. In ref [5], Authors claim, that O and N atoms are chemically adsorbed on the glass surface with bonding energy of about 5 eV. It allows us to expect, that atoms remain sticked on the discharge tube wall for a long time after plasma exposure.

Experimental procedure consists of several steps – pretreatment with N2, O2, Air and Ar plasmas, pumping and cooling of the tube and then O2 (or N2) plasma in which we detect NO production. The discharge tube is 2 cm inner diameter and 50 cm long, and the gas pressure is around 1 Torr. In order to eliminate plasma contamination by metallic electrodes inside the reactor, we use CCP discharge symmetrically driven by 13.56 MHz pulsed power supply, the coupling electrodes being located outside the plasma tube. During the plasma phase, the monitoring of the formation/loss of NO is made by in situ time resolved TDLAS. Depending upon the experimental condition, a time resolution as high as 5 ms may be achieved. Experiments may be carried out with a closed reactor (no gas flow) or under flowing conditions.

In N2 plasma with small admixture of NO, NO molecules are efficiently destroyed in collisions with N-atoms [6], what makes it difficult to detect nitric oxide produced on the surface. On the contrary, after a nitrogen pre-treatment of the pyrex surface, and under O2 plasma, NO production is evidenced. Figure 1 shows such an example.

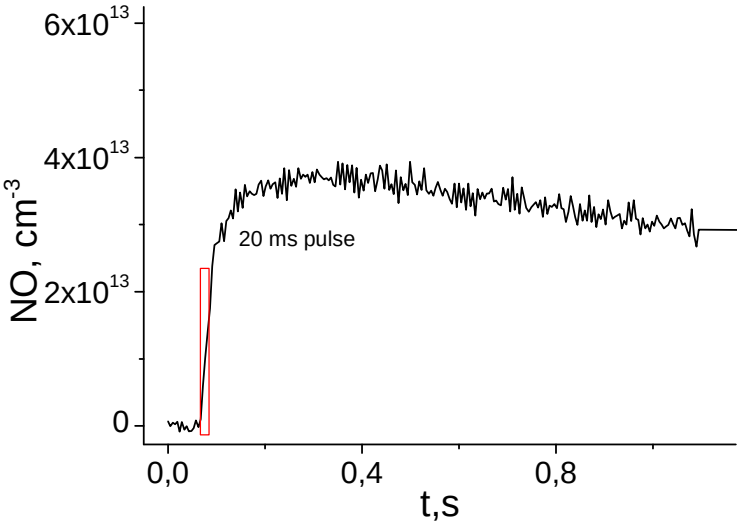

Figure 1. Production of NO molecules in a pure O2 plasma, after the pyrex surface of the reactor has been treated by 30 mn pure N2 plasma. The O2 plasma pulse is 20 ms (single shot), in a closed reactor. The monitoring of NO is made by in situ TDLAS with a time resolution of 5 ms.

It is shown that under O2 plasma pulses after N2 plasma pretreatment NO concentration reaches 1-10 10^{13} cm^{-3} depending upon the plasma pulse duration. Such a surface production corresponds to about 5-50 10^{12} cm^{-2} N atoms grafted on the pyrex surface during the N2 pretreatment. No NO formation is detected after an argon or oxygen plasma pre-treatment or a neutral nitrogen gas glow. By varying the length of N2 plasma column, proportionality between pretreated surface and amount of NO produced was verified.

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