Topic number 8

Hydrogen low-pressure pulsed plasma: measurement of H atom decay in the post discharge

X. Yang, D. Kogut, J.M. Layet, G. Cartry

PIIM, Service 241, Aix Marseille Université, Centre de St Jérôme, 13397 Marseille Cedex 20, France

H atom decay in the post discharge of a 10 Pa hydrogen pulsed plasma is measured by two different diagnostics, namely two photon absorption laser induced fluorescence (TALIF) spectroscopy and Pulsed Induced Fluorescence (PIF) which is a simpler method based on optical emission spectroscopy. Both methods are compared and the best one is selected to obtain the atomic hydrogen surface loss coefficient from the measurements.

1. Introduction

Surface loss of atomic or radical species in low-pressure plasmas is a key parameter in modelling low pressure plasmas. It has been shown that the surface loss is strongly dependent on surface state which in turn is dependent on the ion flux to the wall [2], on the ion energy, on the surface temperature, on the species impinging the wall, etc. It is therefore almost impossible to predict theoretically surface loss coefficients. Most of plasma models use published experimental results in similar conditions or fit its value to get a good agreement with experiments. The best practice is to measure the loss coefficient *in-situ*, if possible. This is the aim of the present work. We want to measure hydrogen atom loss coefficient on surfaces using whether two photon absorption laser induced fluorescence (TALIF) spectroscopy, or Pulsed Induced Fluorescence (PIF) which is a simpler method based on optical emission spectroscopy.

2. Experimental set-up and results

2.1. Experimental set-up

A 3 turn loop antenna is installed above a quartz plate on top of a spherical vacuum chamber. Inside the chamber a quartz tube of 160 mm in diameter and 140 mm in height is limiting the plasma extension. A sample holder is placed at the bottom of the tube and holds a quartz sample (or any material under study) of 100 mm in diameter. The plasma geometry is well defined and simplifies both calculation of loss coefficient and plasma modelling. The antenna is powered by a 13.56 MHz Dressler generator through a matchbox. The plasma is operated at 10 Pa of hydrogen or deuterium gas, with injection of 1000 W of RF power. The plasma is pulsed at 1 or 10 Hz with a duty cycle of 10%. The decay of the atomic H density vs. time in the post discharge is measured whether by TALIF or PIF. For TALIF diagnostic, two photon absorption at 205 nm excites ground state hydrogen atoms to the level n = 3. Fluorescence from the level n = 3 to the level n = 2 at 656 nm is measured using a collimating lens, an interference filter and a photomultiplier. For PIF diagnostic, H atoms are re-excited in the time post discharge by a short plasma pulse (probe pulse). The Hα signal at 656 nm at the beginning of the probe pulse is assumed to be proportional to the density of the remaining atoms in the post discharge. For both diagnostics the delay between the main pulse and the laser shot or the probe pulse is varied in order to measure H atoms versus time in the post discharge. The characteristic time of atomic loss in the post discharge is correlated with the surface loss probability.

2.2. Result

Both diagnostics give different results. While H atom density at plasma centre measured by TALIF demonstrates a mono-exponential decay in post discharge, the line integrated H density obtained by PIF demonstrates a bi-exponential decay. In order to understand this difference and to select proper measurement to get the surface loss coefficient we have developed a simple 2D fluid modelling taking into account gas heating and neutral depletion effects. The model allows detailing the difference between a line integrated signal and a measurement at plasma centre. It helps understanding the influence of gas heating on the H atom density variation in post discharge and on the diagnostics.

3. References

[1] Cartry, G., L. Magne, and G. Cernogora Journal of Physics D: Applied Physics 32, n° 15 (1999): L53.

[2] C. M. Samuell and C. S. Corr 2014 Journal of Nuclear Materials 451 pp 211