The afterglow plasma of pulsed hollow cathode discharge - a high density metastable source

A Surmeian[(*)1], C Diplasu[1], A Groza[1], A.Tempez[2], P Chapon[2], M Ganciu[1]

1. National Institute for Lasers, Plasma and Radiation Physics, 077125 Bucharest- Magurele, Romania
2. Horiba Jobin Yvon, 91665 Longjumeau, France
[(*)] E-mail: surmeian@infim.ro

Abstract. The temporal distribution of the concentration of neon metastable atoms in the afterglow of a high voltage pulsed hollow cathode discharge plasma is measured by atomic absorption spectroscopy with temporal resolution using a conventional spectral source operating in pulsed mode. The obtained values for the density of Neon 2 $^3P_2$ metastable state > 10^{12} cm^{-3} will allow the use of this kind of plasma to generate metastable beams as supplementary source for ionization in GDMS systems.

The evaluation of the temporal evolution of metastable atoms density, achieved in this work, is useful in processing occuring in transient plasmas and especially in analytical investigations with systems like GDMS and DARTMS, in which the energy transfers from the metastable atoms, are central for the Penning ionization of the analyte species [1]. The specific study of Neon metastables source is required for direct analysis of gases, liquids, and solids in open air under ambient conditions, where the use of Argon in a metastable atoms source is not suited because argon metastables are rapidly quenched in the presence of water vapor by a reaction involving hemolytic cleavage of the water bond.

The temporal evolution of the concentration of neon metastable atoms in the afterglow of a high voltage pulsed discharge is achieved from the transmission profile obtained by a specific home made electronic arrangement [2] that allows the temporal synchronization of pulses from the ***spectral lamp*** with that from the hollow cathode ***pulsed discharge tube*** containing the absorbing species. The set up detects the transmitted light at various times in the temporal afterglow plasma of the high voltage discharge. The HV Pulser which supplies the ***spectral lamp*** was triggered using the signals collected by a current probe inserted in the hollow cathode ***pulsed discharge tube*** circuit and controllable delayed from the discharge tube current pulse by an Adjustable Pulse Generator. The recording data are than processed with the well known absorption spectroscopy relations [3] obtaining the neon metastable atoms concentrations at various measured times in the afterglow.

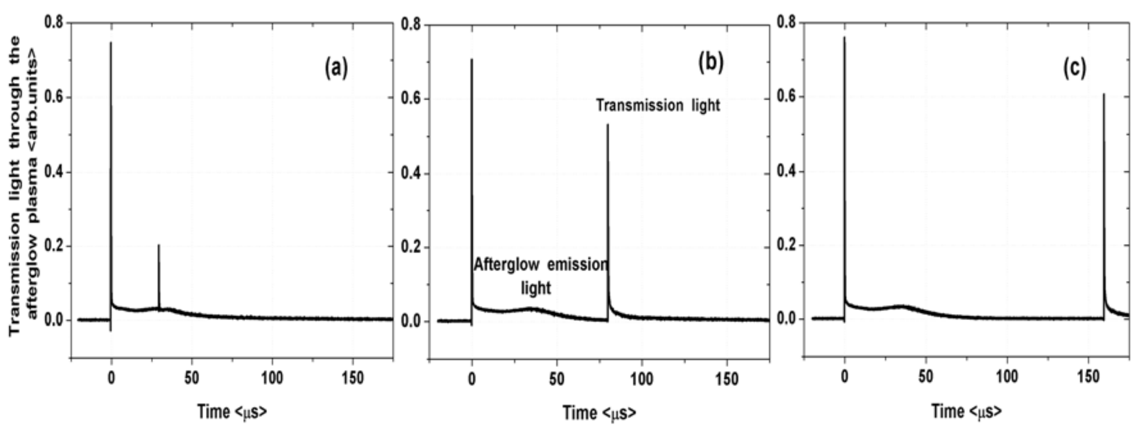

Figure 1 The temporal profile with long afterglow of the Ne 588.1 nm emission line and the transmission light of the spectral lamp syncronized with the pulsed discharge and positioned at various temporal position in the afterglow; (a) 30µs, (b) 80µs and (c) 165µs

Figure 2(a) presents the total transmission signal of the 588.1 nm Neon line, emitted by the pulsed spectral lamp after the passing through the afterglow of the hollow cathode pulsed discharge with the neon metastable atoms as absorbing species. The data were taken starting from 2 μs to 50 μs in the temporal afterglow range of the pulsed hollow cathode discharge. The Figure 2(b) shows the oscillogram recorded with long exposure time when the delay of trigger was smoothly swept over the entire period of the afterglow.

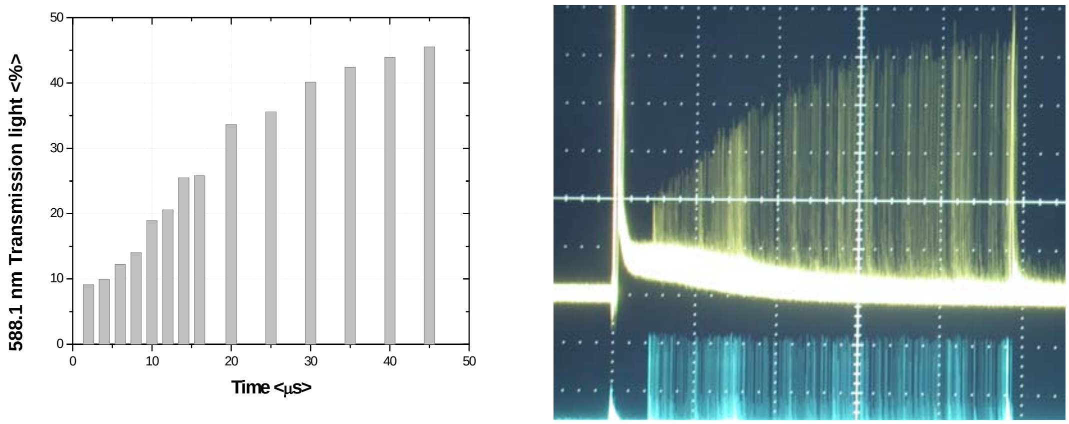

Figure 2. Temporal evolutions of the transmission signal of the 588.1 nm line of Neon; **(a)** calculated; **(b)** experimental (the trigger signal at the bottom)

The calculated concentrations of neon metastable atoms in $^3P_2$ (16.61 eV) state at various times of the afterglow plasma are plotted in Figure 3.

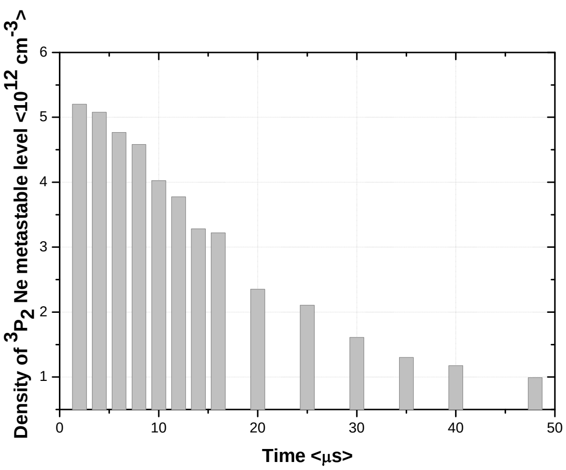

Figure 3. The temporal evolution of $^3P_2$ Neon metastable level concentration during the hollow cathode afterglow plasma according to the absorption measurements on 588.1 nm transition

The high concentration of Neon metastables during the long temporal afterglow of the hollow cathode pulsed discharge indicates the possibility of using this kind of plasma as supplementary source for the Penning ionization in GDMS systems thus increasing their detection sensitivity.

References

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