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DYNAMIC OPTOGALVANIC SIGNALS BEHAVIOUR IN Ne/Zn HOLLOW CATHODE DISCHARGE

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The optogalvanic effect represents plasma conductivity change as a result of resonant light absorption. It is described for the first time in [1] but the development of the tunable lasers further stimulates its wide investigation and various applications [2]. The population of the levels belonging to the illuminated optical transition is changed by the resonant quanta absorption. This disturbs the delicate equilibrium between the elementary processes in the plasma and as a result the ionization rate changes, which causes variations in the discharge tube impedance. In this way, being directly operated by electrical signals rather than the optical ones, the optogalvanic spectroscopy turns out to be simpler in comparison with several other spectroscopic techniques.

The dynamic optogalvanic signal (DOGS) represents plasma reaction after a short (ns) laser pulse absorption. It is significantly more informative than the stationary signal because the former is characterized not only by its amplitude and sign but also by its time dependency shape and peculiarities. For this reason the DOGSs can serve as explicit markers for plasma diagnostics.

The present work gives the change in dynamic optogalvanic signal shape due to Penning effect along with a correlation of the tube V-I characteristics. The response of the hollow cathode plasma to the resonant laser light absorbed by Ne I 436.35nm and Ne I 434.60nm optical transitions as function of discharge current in Ne/Zn and Ne/Fe hollow cathode lamps is shown in Figs. 1 and 2, respectively. The first component of the signals is understood as impedance decrease in the discharge due to the increased population of the upper levels, which can be easier ionized by low energy electrons than the origin levels. The next part of the DOGS reveals the relaxation behavior of the disturbed plasma. It depends not only on the characteristics of the two levels coupled in the transition, but also on discharge conditions, tube design and parameters of the electrical circuit. It is seen in Figs. 1 and 2 that the DOGS amplitudes exhibit increasing trends at growing values of current i, but their widths decrease. Peculiarities in these uniform dependencies of signal width are noticed at i=3.2 mA for Ne/Zn hollow cathode lamp. Careful look at the V/A characteristics of Ne/Zn hollow cathode lamp shows a peculiarity corresponding to the negative impedance dU/di<0 just at i=3.2 mA (Fig. 3), where the DOGS width manifests diversions from the uniform dependencies. No peculiarities are found in the DOGSs amplitude and width for Ne/Fe hollow cathode lamp and in its V/A characteristics. The negative impedance could be raised by various causes but in our case we consider it is due to the fast change in the ionization effectiveness just at the mentioned discharge current. The electron impact ionization and the Penning ionization are the main ionization processes in the hollow cathode plasma for all i- values.

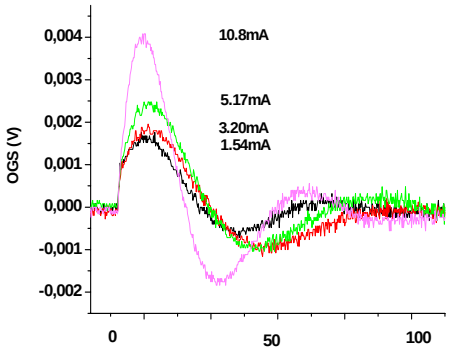

Fig.1 DOGS corresponding to Ne I 434.60nm optical transition (*3p-10d*) as a function of *i* for Ne/Fe hollow cathode lamp

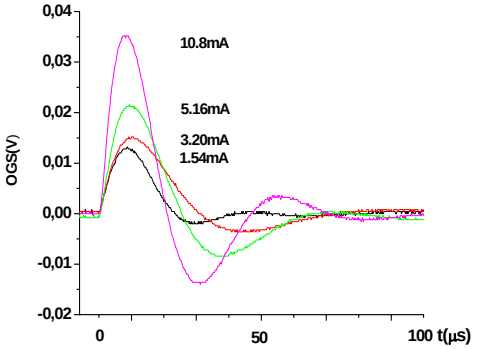

Fig.2 Dynamic optogalvanic signals corresponding to Ne I 436.35nm optical transition (*3p-9d*) as a function of *i* for Ne/Zn hollow cathode lamp

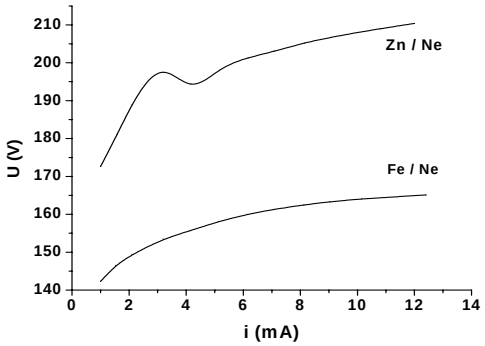

Fig.3. V/A characteristics of the Zn/Ne and Fe/Ne hollow cathode lamps

The metal atoms, having low ionization potential, could cause effective ion production through Penning ionization process especially at lower discharge current values. We attribute these peculiarities in both V/A characteristics and width dependences of the DOGS to the increased role of Penning ionization since the transferred energy of Ne metastable atoms is in close resonance with several excited Zn ion states (Zn+):

$$Ne^{m}\,(3P_2) + Zn\,(1S_0) \rightarrow Ne\,(1S_0) + Zn^{+}(2P_{1/2;\,3/2}) + e^{-} + \Delta E,$$

where ΔE is the energy mismatch taken from the colliding particles.

Conclusion

The DOGS in Ne/Zn hollow cathode lamp exhibits extra features which appear at longer times following the signal obtained in Ne/Fe lamp. Features of the DOGS shape could be also displayed as peculiarities in V/A characteristics of the discharge. These results could be used to extract and estimate the Penning rate constant by hollow cathode plasma modeling.

Reference

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