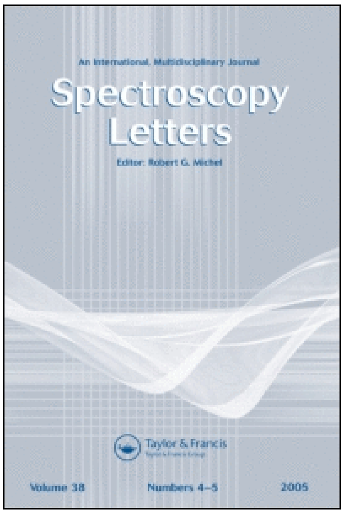

Spectroscopy Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597299

Two Interfering Effects in Optogalvanic Detector Hollow Cathode Discharge

D. Z. Zhechev[a]
[a] Institute of Solid State Physics, Sofia, Bulgaria

To cite this Article Zhechev, D. Z.(1992) 'Two Interfering Effects in Optogalvanic Detector Hollow Cathode Discharge', Spectroscopy Letters, 25: 8, 1221 — 1229
To link to this Article: DOI: 10.1080/00387019208017860
URL: http://dx.doi.org/10.1080/00387019208017860

SPECTROSCOPY LETTERS, 25(8), 1221-1229 (1992)

TWO INTERFERING EFFECTS IN OPTOGALVANIC DETECTOR HOLLOW CATHODE DISCHARGE

Key words: Optogalvanic signal, Hollow cathode discharge, Penning process, Photon-charge effect

D.Z.Zhechev

Institute of Solid State Physics,BAS, Blvd Trakia 72

1784 Sofia, Bulgaria

ABSTRACT

Two effects in optogalvanic detector - hollow cathode discharge are reported.They appear at light irradiation of the detector and interfere with its properties.First effect, connected with Penning process in Ar-Cd plasma, is used for identification of negative plasma resistance. The other effect is a light induced potential on the cathode.

INTRODUCTION

The wide use of the Hollow Cathode Discharge (HCD) as an Optogalvanic (OG) detector extends the interest to the light-HCD interaction, including some specific HCD features.The HCD advantages are more often discussed from this point of view[1].We report two interfering effects, limitting the application of HCD in OG spectroscopy - the appearence of nonoptogalvanic components at a negative plasma impedance and with HCD lamp turned off.The first type of experiments is stimulated by our previous investigations on the correlation between V-A characteristics and the behaviour of OG signal in HCD. At present, based on this correlation the inverse problem is treated, i.e. the use of the OG signal pecularity for indication of a negative plasma impedance.To clarify this problem we performed an analysis and comparison of OG signals and V-A curves of various trade mark HCD lamps.The second type of experiments is connected with the cathode potential when an irradiated lamp is turned off electrically.

EXPERIMENT

The OG response - the light induced change ΔU of the voltage dropp U is detected for certain HCD lamps (Ar/Cd /"Narva"/, Ne/Zn, Ne/Fe, Ne/FeCuMnNiCoCr/"Hilger"/), irradiated consequently by 488 nm and 514 nm spectral

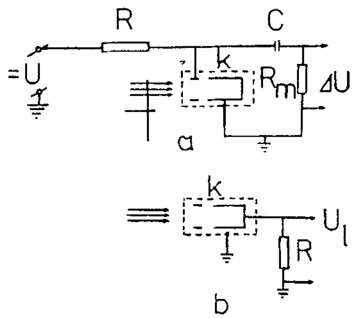

Fig.1. Experimental set-up for measuring of:
a - optogalvanic ΔU response;
b - light induced cathode potential U_l.

lines from Ar^+ laser (1 W) and 632.8 nm from He-Ne laser (20 mW). ΔU values are measured in a standart integrating OG scheme with a lock - in (Fig.1a).U- values of V-A characteristics are measured between the anode and the cathode directly at short step Δi of the discharge current i.

In the second type of experiments the spectral lines 1.06 μm(4 x10^{10} J.cm^{-2}.s^{-1}) and 532 nm (2.5 x10^{10} J.cm^{-2}.s^{-1}) from a Nd:YAG laser (pulse duration 30 x10^{-12}s) are focused on the cathode of a Ne/Cu lamp /"Narva"/. The light induced potential U_l on the cathode is detected by a scheme identical to the one used for OG measurement in the cathode circuit (Fig.1b).To eliminate the labpratory electrical background the lamps are inserted in a grownded box.

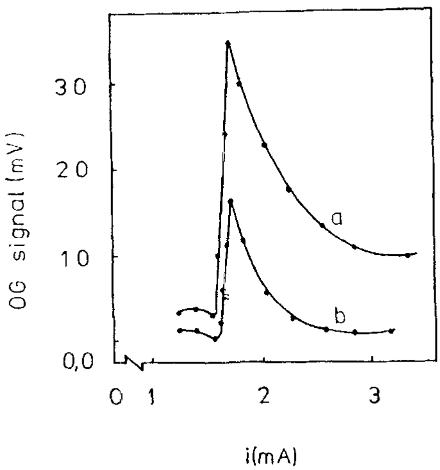

Fig.2. Galvanic response of Ar/Cd HCD lamp to ArII 514.5 nm resonant irradiation: a - laser power 1 W; b - laser power 100 mW.

RESULTS AND DISCUSSIONS

1. Among $\Delta U(i)$- curves, which are more or less monotonous, we would like to emphasize on the curve for Ar/Cd lamp, irradiated by Ar^+ laser (Fig.2).In the vicinity of the discharge current i= 1.7 mA a local peak arises.In our case it is a sign of increased plasma conductivity.The character and i- localization of the peak does not depend on the characteristics of the irradiating light flux.The extremum appears at irradiation by 632.8 nm too, although the resonant interaction is absent.This nonselectivity is the reason which rises a doubt about the OG character of the ΔU-

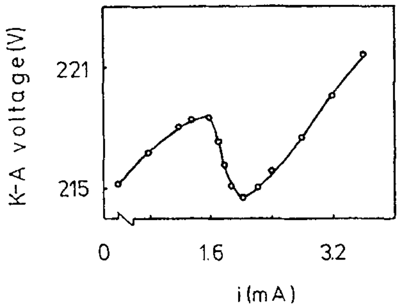

Fig.3. Local V-A characteristics of Ar/Cd HCD lamp.

extremum.Recently, we observed a response of the same type in Ne/As lamp[2].Our analysis confirmed that Penning reaction $As + Ne^m \longrightarrow As^+ + Ne + \Delta E$ (Ne^m is a metastable state of neon atom and ΔE is the defect of energy) proceeds with great probability.The correspon-ding change of AsII spectral line intensities was measured at the ΔU- peak discharge current; simultaneously, a negative plasma resistance $\frac{\partial U}{\partial i} = R < 0$ was found in the same i- region.

If both the nonselective response ΔU and $R < 0$ are interconnected then V-A characteristics of Ar - Cd plasma should contain a negative part $R < 0$ too. Indeed, V(A) - values, measured between anode and cathode, illustrate the negative plasma resistance near i =1.7 mA (Fig.3).We consider this local change of the conductivity as a consequence of Penning process between Ar-Cd species.A comparison of the Ar, Ar^+, Cd and Cd^+

energy levels shows sufficient closeness ($\Delta E = 635 cm^{-1}$) between the metastable $Ar^m(^3P^o_0)$ and $Cd^+(^3S_1)$ levels[3,4]. Then the reaction

$$Ar^m(^3P^o_0) + Cd(^1S_0) \longrightarrow Ar(^1S_0) + Cd^+(^3S_1) + \vec{e} + \Delta E(635\ cm^{-1})$$

proceeds with a great probability ($^1S_0$ is the ground state of Cd atom). Note, that in other lamps no negative resistance and ΔU- extremum are found.

The observed anomalous responses of abovementioned type including that in Ne/Cu lamp at pulse irradiation [5] are the reason to state that ΔU- extremum is formed by an integrating of plasma conductivity oscilations, arizing in $R < 0$ region. Here the light flux is only a perturbation, independent on its frequency. So the corresponding part of $\Delta U(i)$ response is not of OG type, but it is an indication of the negative plasma resistance near $i = 1.7$ mA.

2. An effect unreported, in our opinion, up to date in the OG references is observed. When the electrodes are electrically isolated (without power supply) the incident light induces a potential in the cathode. The detected signal, i.e. the appearence and development of a cathode potential $U_1(t)$ is shown in Fig.4. The signal consists of two components: a narrow part, shorter than 100 ns which is followed by a wide one

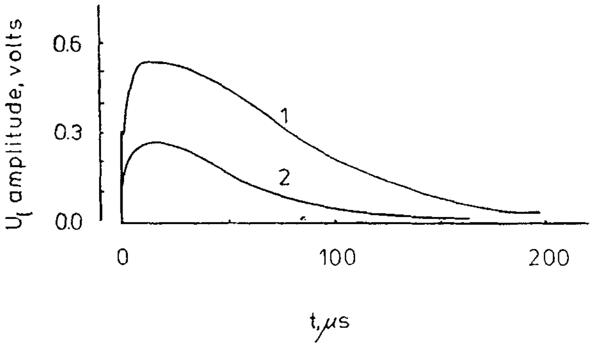

Fig.4. Light induced potential U_1 on the cathode with hollow cathode lamp turned off and laser irradiation: $\lambda_1 = 1.06\ \mu m$ (curve 1); $\lambda_2 = 532$ nm (curve 2);

of relaxation type.Fig.4 illustrates in fact the appearence of a current between the cathode and the ground.Since the filling gas neon is transparent for both irradiating frequences, the fotoeffect from the cathode Cu- surface seems to be the only probable reason for the aforementioned signal.But such a point of view contradicts the "red limit" data for cuprum[6,7]. We would like to note, that there is no oxide layer, decreasing this limit in our experiment.In fact, this effect is quite similar to the "photon-charge effect" in Ref. 8.Regretfully, that experiment proceeds in the air atmosphere and such an important factor as the surface conditions, is not discussed.In this sense our experiment (cathode surface bombarded by ions for a long time in neon) is more "pure".But the interpretation in Ref. 8 , i.e. a local light induced change of the surface potential seems to be suitable for the explanation of our results.It is more important that the light flux - cathode surface interaction forms a galvanic channel which is alternative and interfering with the OG channel.

CONCLUSION

Our investigation concerns the accuracy of the optogalvanic response.Penning process raises a specific deformation of the signal by means of the negative plasma resistance.Here we use this deformation for plasma diagnostic, i.e. identification and localization of its negative resistance.The light induced cathode potential is another interfering effect, competing the OG signal.It is not discussed in detail, but we emphasize on the necessity the optogalvanic detector to be tested accounting the additional cathode potential.

REFERENCES

1. Rao G., Govindarajan J. and Reddy M. Optogalvanic Spectroscopy of Sputtered Atoms. In: Hyperfine Interactions .Ed.Rao, J.C.Baltzer Scientific Publishing Co, Basel, 1987, 539-552

2. Zhechev D.Penning Interaction Ne-As and Optogalvanic Signal Deformation, Spectroscopy Letter 1992; 25 to be published.

3. Striganov A.P., Sventizki N.S.Tables of Spectral Lines.Atomizdat,Moskva 1966

4. Radzig A., Smirnov B.,Parameters of Atoms and Atom Ions, Energoatomizdat,Moskva 1986

5. Djulgerova R.,Zhechev D.,Jaskowska I.,Lukaszewski M. Enhancement of the Dynamic Optogalvanic Signal by a Magnetic Field.In: Europhysics Conf.Abstracts 20th EGAS, European Physical Society,Graz,1988,370-372

6. Chemistry Guide, ed.Nicolski B.,Chemistry,Moskva 1966

7. Short Guide of Phisico-Chemical Constants,eds.Matenko K., Ravdel A., Chemistry,Leningrad 1974

8. Pustovoit V.,Borisov M. and Ivanov O.Photon-Charge Effect in Conductors,Phys.Lett.A 1989;135;59-61

Date Received: 05/20/92
Date Accepted: 06/21/92