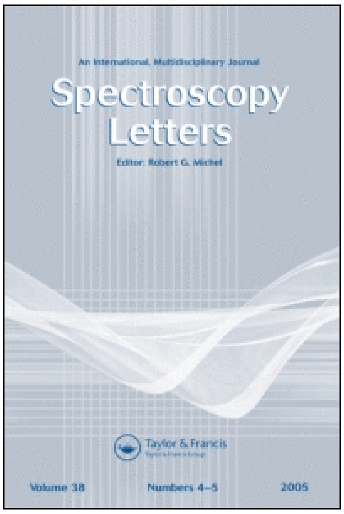

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Spectral Dependencies of the Surface Photo-Charge Effect at Conducting Surfaces

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SPECTRAL DEPENDENCIES OF THE SURFACE PHOTO-CHARGE EFFECT AT CONDUCTING SURFACES

Key Words: Surface Photo-Charge effect, Spectral Dependencies, Cu, Pb, Ag, brass, metals.

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ABSTRACT

Investigations show that the surface photo-charge effect has been observed for all solids. In this paper, experimentally obtained spectral dependencies of this effect at surfaces of several conductors (viz., Cu, Pb, Ag, brass,) are shown and discussed.

INTRODUCTION

Refs. [1-4] report the observation of the so-called surface photo-charge effect (SPCE), arising upon irradiation of samples with an electromagnetic field. The modulated light promotes the appearance of a potential difference. This effect exists in all materials investigated so far, including ceramics, ferrites, and biological objects. The frequency of the measured alternating signal is equal to the modulation frequency of the incident radiation. In the case of conducting surfaces we suppose that the surface photocharge effect arises due to the free charge carriers acquiring additional energy. If the energyy is sufficiently large, the charge carriers leave the surface, via the well-known external photoeffect. When the additional energy is smaller than the separation energy, there is no external photo-effect, rather the free charge carriers are just redistributed due to the energy absorption of the incident irradiation. If in the proximity to the irradiated body, there is another body with zero potential, a capacitive coupling between both will arise. Thus, each change in the carrier distribution in the irradiated object will lead to a change in the potential difference.

Practically, the free charge carriers are redistributed instantaneously and the surface photo-charge effect appears only when the irradiation is modulated. This is an important characteristic enabling us to check easily and quickly whether the measured signal is induced by this effect, or is due to other similar effects, such as external and internal photo-effects, thermal electricity, etc. The absence of response upon continuous irradiation is a proof to this effect, since in all other familiar cases of potential difference caused by irradiation, the signal exists also upon continuous illumination.

The aim of the present paper is to study the spectral dependencies of the surface photo-charge effect in some metals.

EXPERIMENTAL AND RESULTS

The experimental set-up is shown in Fig. 1. The monochromator (1) provides illumination with equal intensities for all the wavelengths in the spectral region of interest. The illuminated sample is placed in a metal box (3) shielding in safety from external disturbances. The output signal is taken from a wire pressed against the irradiated sample. The high-impedance amplifier (4) matches the high-output impedance of the structure [2]. For metals, where the signals are weak one needs to use a selective or phase-sensitive nanovoltmeter (5) synchronised with the chopper (2).

The structure under investigation is shown in Fig. 2. The sample (3) is fixed on a glass plate (4). There is a transparent SnO_X (5) film electrode on the opposite side of the glass plate in contact with the metal box (1) for a

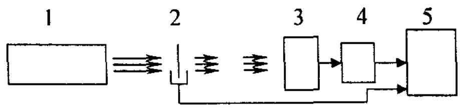

FIG. 1. Experimental set-up: 1 – monochromatic source; 2 - opticomechanical modulator; 3 - investigated structure; 4 - high-input impedance amplifier; 5 - selective or lock-in nanovoltmeter.

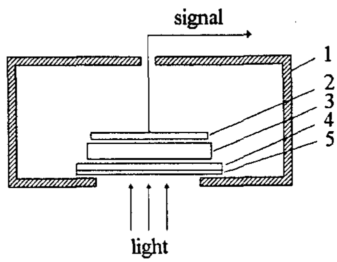

FIG. 2. Investigated structure: 1 - shielding metal box; 2 - aluminium foil; 3 - sample; 4 - glass; 5 - transparent conducting SnO_X layer.

shielding. In addition, it affects the capacitance of the structure and raises the signal amplitude. The signal is taken from the aluminium foil electrode (2) that may not be in direct contact with the sample (3) [1].

Fig. 3 shows the SPCE in the 400-1100 nm range spectral dependencies for several metals - copper, lead, gold, brass. The strong drop of the response in the begining of the curve is probably due to the disappearing of the external photo-effect. From 600 nm the signal remains approximately uniform, i.e. after the external photo-effect drops out, only the surface photo-charge effect dominates in the spectral dependence and both effects are separated. It is clear that the latter effect contributes also at wavelengths below 600 nm, but it is obscured by the much stronger external photo-effect. The observation of signals in the beginning of the infrared region is another indicator that this is not an external photo-effect.

The diameter of the illuminated area is 10 mm. For the metals under investigation, interferometric filters, rather than a monochromator (1) in Fig.

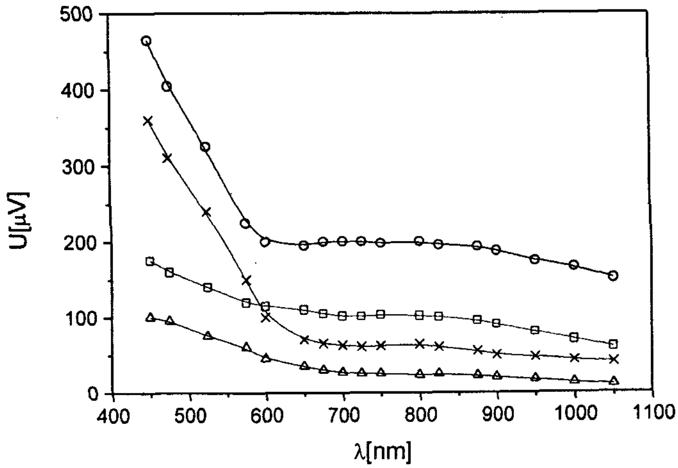

FIG. 3. Spectral dependencies of the surface photo-charge effect for copper, lead, gold and brass: Cu - O; Pb - X; Ag - ∇; brass - .

1, were used. The incident light intensity is 2 mV. The light is pulse-modulated with a frequency of 138 Hz.

In order to eliminate the influence of various impurities, two metals, i.e., copper and nickel, especially cleaned and evacuated, were investigated. The spectral response appears in both visible and infrared regions. The presence of a signal under these special conditions suggests that the signals measured are not due to uncontrolled surface contaminations in the framework of the experimental purity (pressure of 10^{-4} torr).

Ready-made photo-elements with external photo-effect were studied, using their evacuated metal cathode. For example, the spectral sensitivity of the photo-element with an antimony-cesium cathode lies in the spectral range 400-600 nm. The saturation in the voltage-current curve starts at 15 V. Fig. 4 presents the change in the surface photo-charge effect response when reverse voltage is applied, i.e., (+) to the cathode, and (-) to the anode. This is done in order to eliminate the external photo-effect. A sharp drop in the signal results from the reverse voltage, after which it remains constant and practically independent of its increase. In this experiment the light source was a He-Ne

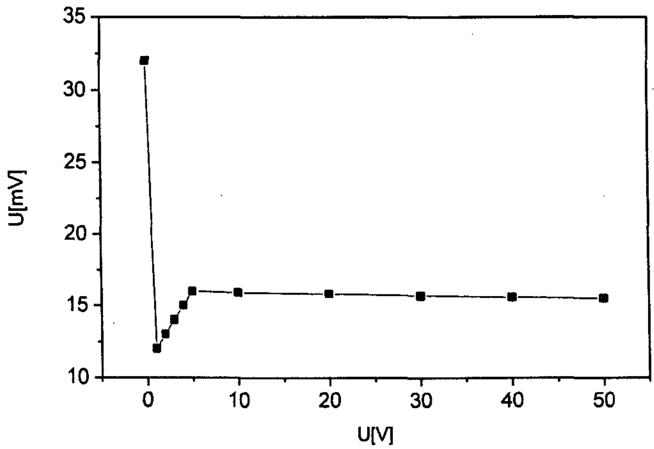

FIG. 4. Change in the signal from the surface photo-charge effect on applying reverse voltage to a photo-element with antimony-caesium cathode.

laser with a nominal wavelength of 633 nm. The light modulating frequency is 138 Hz, and the light intensity is 0.2 mW. Applied inverse voltage to the sample stops the external photo-effect, which provokes a sharp decrease of the signal in this part of the curve. The constant signal after that, which does not change on increasing the inverse voltage, originates from the surface photo-charge effect. This result conforms to our expectations, as if one rejects the presence of such an effect, it would be difficult to explain this constant signal.

The spectral dependence of the surface photo-charge effect for the photo-element in the range 450-3200 nm was also measured. The signal drops sharply from 450 to 700-800 nm and after that remains nearly constant up to 3200 nm. In other words, its behavior resembles that shown in Fig. 3.

In summary, these spectral investigations demonstrate a clear distinction between the surface photo-charge effect and the well-known external photo-effect in metals.

CONCLUSIONS

The results obtained for metals show that a well-defined distinction exists between the conventional external photo-effect and the surface photo-charge effect observed by us. This is confirmed also by other facts described in the beginning of the paper. That is why, we exclude the possibility to find an explanation of the signals observed on the basis of external photo-effect. The experiments performed for metal surfaces in vacuum reject also that surface contaminations are the reason for these signals.

REFERENCES

1. Pustovoit V., Borissov M., Ivanov O., Photon-Charge Effect on Conductors. Physics Letters, 1989; A135, 59-61.

2. Pustovoit V., Borissov M., Ivanov O., Surface Photon-Charge Effect in Conductors. Bulgarian Journal of Physics, 1990, 17, 32-40.

3. Das P., Mihailov V., Ivanov O., Gueorgiev V., Andreev S., Pustovoit V., Contactles Characterization of Semiconductor Devices Using Surface Photocharge Effect. IEEE Electron Device Letters, 1992, 13, 291-293.

4. Ivanov O., Mihailov V., Pustovoit V., Abbate A., Das P., Surface Photo-Charge Effect in Solids. Optics Communications, 1995; 113, 509-512.

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