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Summary

Experiments were performed showing that the electron emission from silver irradiated by high power laser beam depends on the direction of polarization relative to the surface. The measurement was carried out under conditions where the Richardson effect was negligible. It may be concluded that the effect observed is caused by multiphoton process.

In recent years many theoretical [1] [2] [3] [4] [5] [6] investigations were performed to clarify the mechanism of electron emission caused by the absorption of high power laser beams. According to theory the free electrons are produced by multiphoton ionization in gases irradiated by high power beams. The existence of this effect was experimentally proven [7] - [1o]. The theory predicts a quite similar effect if a high power laser beam strikes the surface of a solid, however, this latter, so-called multiphoton photoeffect or field emission, according to our knowledge, has not yet been experimentally verified, since in the experiments published so far [11] [12] [13] the Richardson effect caused by classical absorption of the high power laser beam was dominant. Only one of the authors [13] mentions the possibility of the contribution of other effects.

To get experimental evidence on the effects predicted by theory, a series of experiments were started in this laboratory [14]. In the course of these experiments measurement of electron emission of metals was performed under experimental conditions with the Richardson effect kept negligibile and investigating the dependence of electron emission on the direction of polarization of the incoming light beam.

The experimental setup is shown in Fig.1. The high power light pulse is generated by a ruby laser L with a passive Q-switch. The duration of the light pulse was τ = 3o nsec. This light pulse passes through a Glan-Thompson prism /GT/ striking at angle of incidence $\theta = 87^{\circ}$ the material to be investigated. The laser beam was not focused on the target and the peak power density of the light pulse on the sample was only 0,5 MW/cm^2. As sample material silver was chosen in order to eliminate the linear photoeffect. /The work function of silver is 4,7 eV which exceeds the 1,8 eV quantum energy of single photons./ The plane of polarisation /E_0/ of the laser beam before passing through the polarizer was adjusted as shown by detail "A" in Fig. 1./ The unfocused beam reaches the target by passing through a slit which prevents the edges of the target to be illuminated. The calculated temperature rise of the target produced by the light pulse never exceeds $\Delta T = 10^{o}C$, owing to the high reflectance of silver at the angle of incidence and to the relatively small beam power density used. Therefore, the thermionic emission caused by the Richardson effect was negligibile, in comparison with the current observed /see below/.

The vacuum in the bulb containing the target was 10^{-8} torr. To collect the electrons emitted from the target by the laser pulse, a potential of U=1000 V was applied to the measuring cell. The experiment was carried out in the following way:

1./ The Glan-Thompson prism was so adjusted that the plane of polarization i.e.the plane of the electric field vector was parallel to the plane of incidence /$\phi = 0^o$/ and the signal produced by the emitted electrons was measured by oscilloscope. The value of the peak current was $J_{max}/\phi = 0^o/ = 4,5$ mA.

2./ The Glan-Thompson prism was turned by 90^o, to have the plane of polarisation perpendicular to the plane of incidence / $\phi = 90^o$/, and the measurement of the signal was repeated. In this case the peak of the signal was $J_{max} / \phi = 90^o/ = 0,25$ mA.

It was carefully verified by intensity measurements carried out with both photomultiplier and calorimeter that the intensity of the beam falling on the target was equal in both positions of the Glan-Thompson prism. It should be mentioned that in both positions the duration of the signals observed was smaller than that of the light pulse.

As it can be seen from the comparison of the values of J_{max} $(\phi = 0^o)$ and J_{max} $(\phi = 90^o)$ a strong dependence of the electron emission on the direction of polarization was observed. The peak signal current in other directions of polarization was measured too /see Fig.2./.

It can be seen from Fig.2. that the maximum of electron emission is at $\phi \approx 20^o$. This is due to that the contributions from the parallel and perpendicular components of the electric field to the emission are different. In the same figure the variations of the parallel / $E_{\parallel}$ / and perpendicular / $E_{\perp}$ / components of the electric field strength /i.e. the parallel and perpendicular components relative to the plane of incidence/ with ϕ are also shown.

It should be noted that at the pressures used during the experiments in the bulb, a monoatomic layer is still present on the sample which may have some influence on the emission process and that the shape of the signal depends slightly on polarization.

It can be seen from the results of the experiment that an electron emission was observed showing a strong dependence on the direction of polarization which may be explained by alternative or combined multiphoton photoeffect, field emission or inverse Bremsstrahlung.

Investigations on the dependence of electron yield on the material used and on the power density as well as on the role of the monoatomic layer and the difference in the electron signal shape are in progress.

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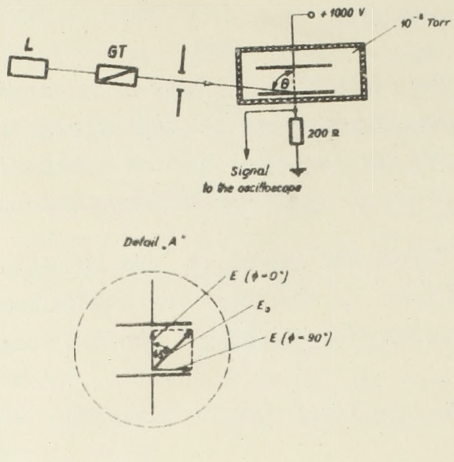

FIG.1.

Block diagramm of the experimental setup. In detail "A" notation used for direction of polarization is given.

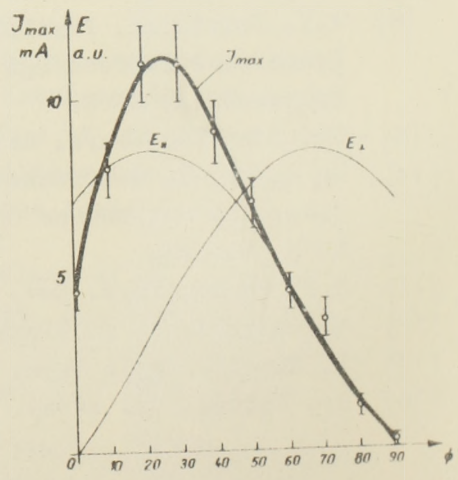

FIG.2.

The dependence of the peak electron current of the direction of polarization. In the figure the parallel and perpendicular components $E_{\parallel}$ and $E_{\perp}$ respectively are also shown.

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