Excitation of an anomalously high voltage in CdTe films by monatomic hydrogen

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When CdTe films obtained by oblique sputtering in vacuum and subjected to an anomalously high voltage during illumination were placed in a volume containing atomic hydrogen, the presence of a voltage amounting to several dozen volts was observed on the films. The largest observed voltage was 20–30 V. The kinetic regularities of the short-circuit current following excitation by atomic hydrogen are qualitatively the same as following excitation with light. It is concluded that nonequilibrium carriers are generated in the film when hydrogen atoms recombine on their surface.

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We produced on polished pyroceram substrate, by oblique sputtering in vacuum, polycrystalline CdTe films, in which illumination with a 100-W incandescent lamp having a color temperature ~ 2800 K generated the well known[1] anomalous photovoltage. Under illumination of about 10^3 lux, the photovoltage was 20–30 V. The films had aluminum electrodes separated by a distance 10 mm. Owing to the oblique sputtering, the films in the direction from one electrode to another had a variable thickness, but the thickness gradient was insignificant, since the distance to the evaporator in the course of sputtering was 12 cm. The average film thickness was in the interval 0.2–0.4 μm. The film resistance was approximately 10^{12} Ω. The voltage generated in the film was measured either with an electrostatic voltmeter or with a VK2-16 electrometric millivoltmeter. Since the measurement of the voltage was a rather prolonged process, owing to the appreciable time constant RC, measurements were made of the short-circuit current (SCC). To this end, the films were connected in series with a standard resistor of 10^{10} Ω, and the voltage drop across this resistor was measured. The SCC was approximately 10^{-10} A.

The CdTe films obtained in this manner, having a photovoltage of several dozen volts, were then placed in a reaction vessel, where they were subjected to the action of monatomic hydrogen. The pressure in the reaction vessel was maintained at 13 Pa, and the concentration of the hydrogen atoms was 10^{14} cm^{-3}. It turned out that the interaction of the films with the monatomic hydrogen, just as photoexcitation, generates a voltage that results in an SCC of 10^{-10}–10^{-11} A, and, in addition, the conductivity of the film increased reversibly by approximately 50% under the influence of the hydrogen atoms.

Figure 1 shows plots of the rise and fall of the SCC following excitation with light and with hydrogen atoms, while Fig. 2 shows the variation of the film conductivity under the influence of the light and of the hydrogen atoms. The rise and fall time of

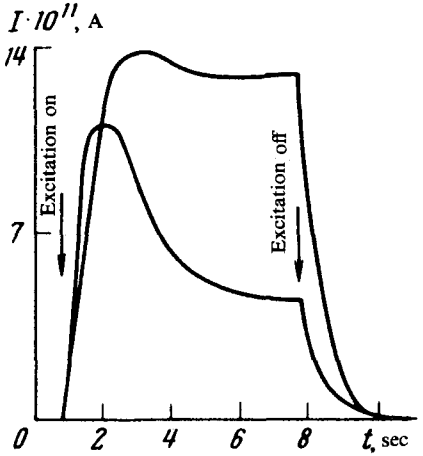

FIG. 1. a) Excitation with light; b) excitation with hydrogen atoms.

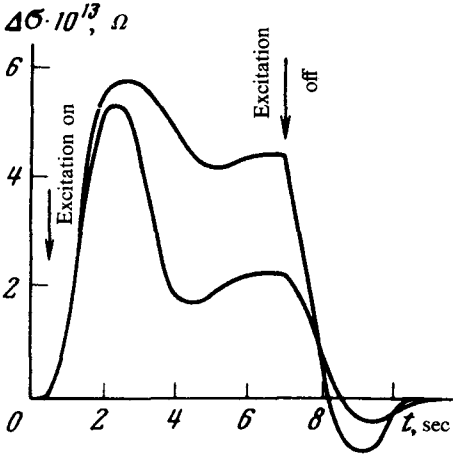

FIG. 2. a) Excitation with light; b) excitation with hydrogen atoms.

both the SCC and of the conductivity is, in both types of excitation, several seconds, thus indicating that the electronic processes are identical in both types of excitation.

The results give ground for assuming that if an anomalous photovoltage is observed in a semiconductor film, an analogous voltage can be excited in it by interaction of the film surface with monatomic hydrogen. The excitation of so high a voltage by hydrogen atoms is an obvious indication that in this case, just as under photoexcitation, nonequilibrium carriers are generated.

The generation of nonequilibrium carriers by interaction of atomic hydrogen with the surface of certain semiconductors was proposed even earlier in connection with studies of such phenomena as radical-recombination luminescence,[2] of the change of conductivity under the influence of hydrogen atoms,[3,4] or of the chemomagnetic effect,[5] but because of concomitant doubts were frequently expressed concerning this effect.

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