Impurity photoplastic effect (PPE) in ZnS:Al single crystals

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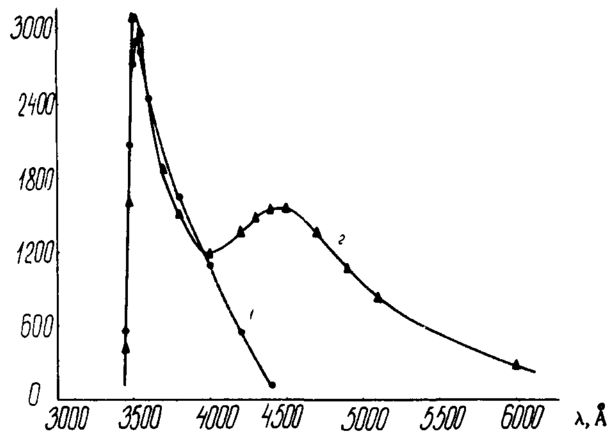
Investigations of the spectral dependence of the positive and negative photoplastic effect in CdS single crystals[1-3] have shown that the maximum value of the effect occurs in practice at the intrinsic-absorption edge and coincides with the photoconductivity maximum. In our present study of the spectral characteristic of the PPE in ZnS : Al single crystals we observed, in addition to the principal maximum connected with the interband excitation of electron-hole pairs, also a supplementary peak of the effect in excitation from a local level in the forbidden band.

The investigations were carried out on *n*-type ZnS : Al single crystals with spalerite structure, containing hexagonal layers on the order of 10–15% with resistivity 10^8–10^9 Ω-cm. The experimental conditions were similar to those described in[3]. The light source was a Cu8-200Y tungsten incandescent lamp, the light from which passed through an SPM-2 monochromator and a system of lenses and was focused on the sample.

The figure shows the spectral dependence of the PPE for undoped ZnS crystals and for ZnS : Al single crystals. Observations of the impurity peak of the PPE at λ = 4500 Å may be due to a redistribution of the charge state of the local center in the forbidden band. Such a redistribution of the charge in plastic deformation in polar crystals, in which the dislocations themselves can be charged,[4] leads probably to an enhancement of the interaction between the dislocations and the point center.[5] Moorehead and Title,[6] in an investigation of the photoconductivity spectrum and of the luminescence-excitation spectrum in ZnS : Al powders, also observed in addition to the principal maximum at



$\lambda \sim 3500$ Å an impurity peak at $\lambda = 4200$ Å ($T = 300$°K). With changing Al concentration, the position of the maximum shifts somewhat. On the basis of the data on the photoconductivity, luminescence, and EPR, they propose that the impurity maximum is due to excitation of an electron into the conduction band from the doubly-ionized Al^{2+} center.

No singularities in the PPE spectrum were noted in ZnS single crystals not subjected to special activation, and the spectral region in which the maximum of the effect is observed lies near $\lambda \sim 3500$ Å. In crystals activated with Cu, an appreciable broadening of the PPE towards the long-wave region is observed, and the value of the effect remains appreciable even at $\lambda > 8000$ Å.

It is seen from the foregoing data that special doping of crystals by various types of impurities leads to changes in the spectral characteristics of the PPE. These changes may be connected with direct ionization of the impurity centers in the forbidden band. The most significant for the determination of the actual mechanism of the impurity PPE will probably be microscopic data on the interaction of individual dislocations with local centers.

[1]Yu. A. Osip'yan and I. B. Savchenko, ZhETF Pis. Red. **7**, 130 (1968) [JETP Lett. **7**, 100 (1968)].

[2]Yu. A. Osip'yan and V. F. Petrenko, Zh. Eksp. Teor. Fiz. **63**, 1735 (1972) [Sov. Phys. JETP **36**, 916 (1973)].

[3]Yu. A. Osip'yan and M. Sh. Shikhsaidov, Fiz. Tverd. Tela **15**, 3711 (1973) [Sov. Phys.-Solid State **15**, 2475 (1974)].

[4]Yu. A. Osip'yan and I. S. Smirnova, Phys. stat. sol. **30**, 19 (1968).

[5]Yu. A. Osip'yan, Vestnik Akad. Nauk SSSR **4**, 32 (1972).

[6]F. F. Morehead and R. S. Title, J. Phys. Chem. Solids **24**, No. 6, 719 (1963).