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EXPERIMENTAL EVIDENCE FOR AN ASYMMETRICAL DISLOCATION GLIDE IN INDIUM ANTIMONIDE

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Résumé.- Une préparation spéciale des éprouvettes d'In Sb permet de sélectionner le type (α ou β) des dislocations "60°" lors de sa déformation plastique. Les résultats expérimentaux établissent l'existence d'un comportement asymétrique du glissement correspondant aux énergies d'activation suivantes 0,6 eV pour l'orientation molle, 1,1 eV pour l'orientation dure. On considère que l'origine de l'asymétrie est une conséquence de l'ionicté du cristal.

Abstract.- It is possible to select, in a compression experiment, the flow of α or β "60°" dislocations by a special preparation of the In Sb samples. The experimental results establish a strongly asymmetrical dislocation motion for these cases, which correspond to different Peierls energies : 0.6 eV for the soft case, 1.1 eV for the hard case. This asymmetry is taken to be consequence of the crystal ionicity.

The plasticity of sphalerite structure materials exhibits a special feature, compared to covalent semiconductors in the sense that, due to noncentrosymmetry, two types of "60°" dislocations can be found /1, 2/. Because of the two kinds of terminal atomic rows, the "60°" dislocations may possess either an anionic or a cationic character, depending on sign of Burgers vector. This implies that they do not introduce the same energy levels inside the band gap. So, one could expect, independent of whether they are dissociated or not, they do not experience the same Peierls potential. Nevertheless, the usual compression experiments were, till this time, considered as unable to distinguish between these different types of glide. Consequently no attempt was made, to deduce by activation parameters measurement, the Peierls energy corresponding to these cases.

On the other hand, it has been observed that, for any kind of deformation tests on III-V compounds of high mechanical quality, the stress-strain curves exhibit a pronounced yield point. The upper yield point is, in fact, very sensitive to the surface preparation : it strongly decreases when surfaces have been mechanically ground.

This remark indicates that the observed yield point is presumably connected to the lack of mobile dislocations and induces a possible way to select the flow of the desired α or β type dislocations. In addition, this allows us to study their characteristic glide parameters.

To show this latter point, let us consider the dislocation loop represented in figure 1 which con-

sists of the more common dislocations found in this crystal structure, i.e. screw and "60°" dislocations segments.

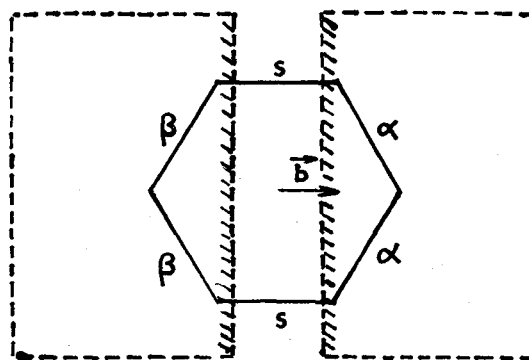


Fig. 1 : Sketch of a perfect dislocation loop, with sections of sample surfaces in dashed lines.

Owing to the symmetry, any property of both screw segments should be equivalent. This does not hold for the "60°" dislocation parts which for instance correspond to some distribution of α or β characters as shown in this figure. So by orienting the surfaces of a sample as indicated by the dashed lines in figure 1, it is possible to induce by compression, a macroplastic flow of selected α or β dislocations, provided that dislocations sources are located near the surface of right side as shown in figure 1, not in the bulk.

1. Experimental procedure.- This experimental situation has been obtained in high quality crystals of n-doped InSb ($n = 10^{14} \text{ cm}^{-3}$) containing a low density of grown in dislocations (less than 10^{+2} cm^{-2} as

* associé au C.N.R.S.

observed by X-rays transmission topography). Samples with a compression direction chosen in order to activate only one glide system were first carefully chemically polished. Then one of the two sides with the above special orientation was mechanically ground by an abrasive paper. Two series of such samples were then deformed by uniaxial compression at various temperatures.

The obtained stress-strain curves are shown in figure 2.

the evolution of apparent activation volume V^* versus applied stress, as measured at the lower yield point. Temperatures as 280°C and 300°C for the soft or hard case respectively appear to be the upper bounds of the activation range. Owing to the presence of yield points and work hardening, neither the measured values for V^* are the "true" activation volumes, nor the lower yield point is the true elastic limit needed for activation energy estimates. Further analysis /3/ shows that all

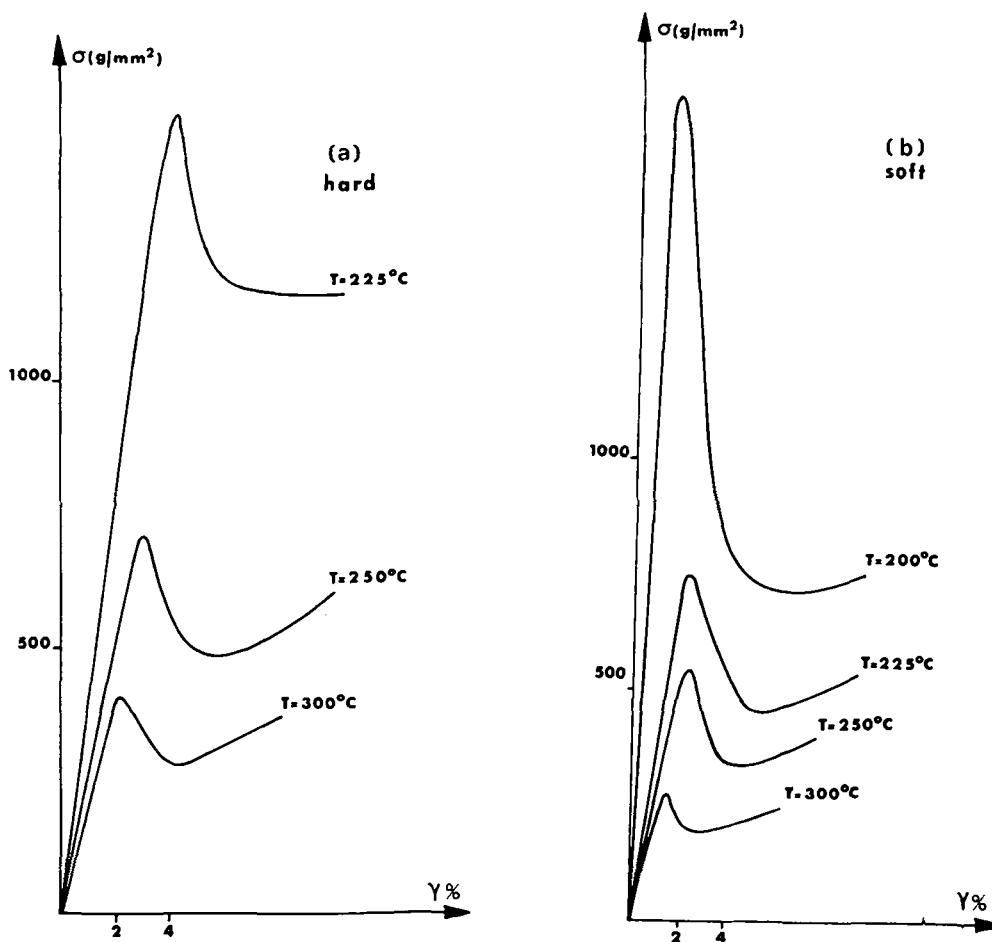


Fig. 2 : Stress-strain curves, for the hard and soft cases, at various temperatures.

Two main observations can be pointed out :

- 1) One case looks "harder" than the other, i.e. the yield point and the flow stress are systematically larger in one case than in the other. They will be called "hard" and "soft" in the following.
- 2) In both cases, the lower yield point, strongly decreases with increasing temperature. This shows that dislocation motion is thermally activated. Stress relaxation tests have been performed which confirm this thermal activation. Figure 3 shows

the activation parameters can be deduced from these measurements and yields the activation energies for the soft and hard cases.

$$(\Delta G_0 \text{ (soft)} = 0.6 \text{ eV} \quad \Delta G_0 \text{ (hard)} = 1.1 \text{ eV})$$

Therefore, the existency of an asymmetrical behaviour is clearly established which indicates that one of the "60°" dislocation type β (or α) should be less mobile than the others (either α (or β) or screw). This can be related to the following inequality

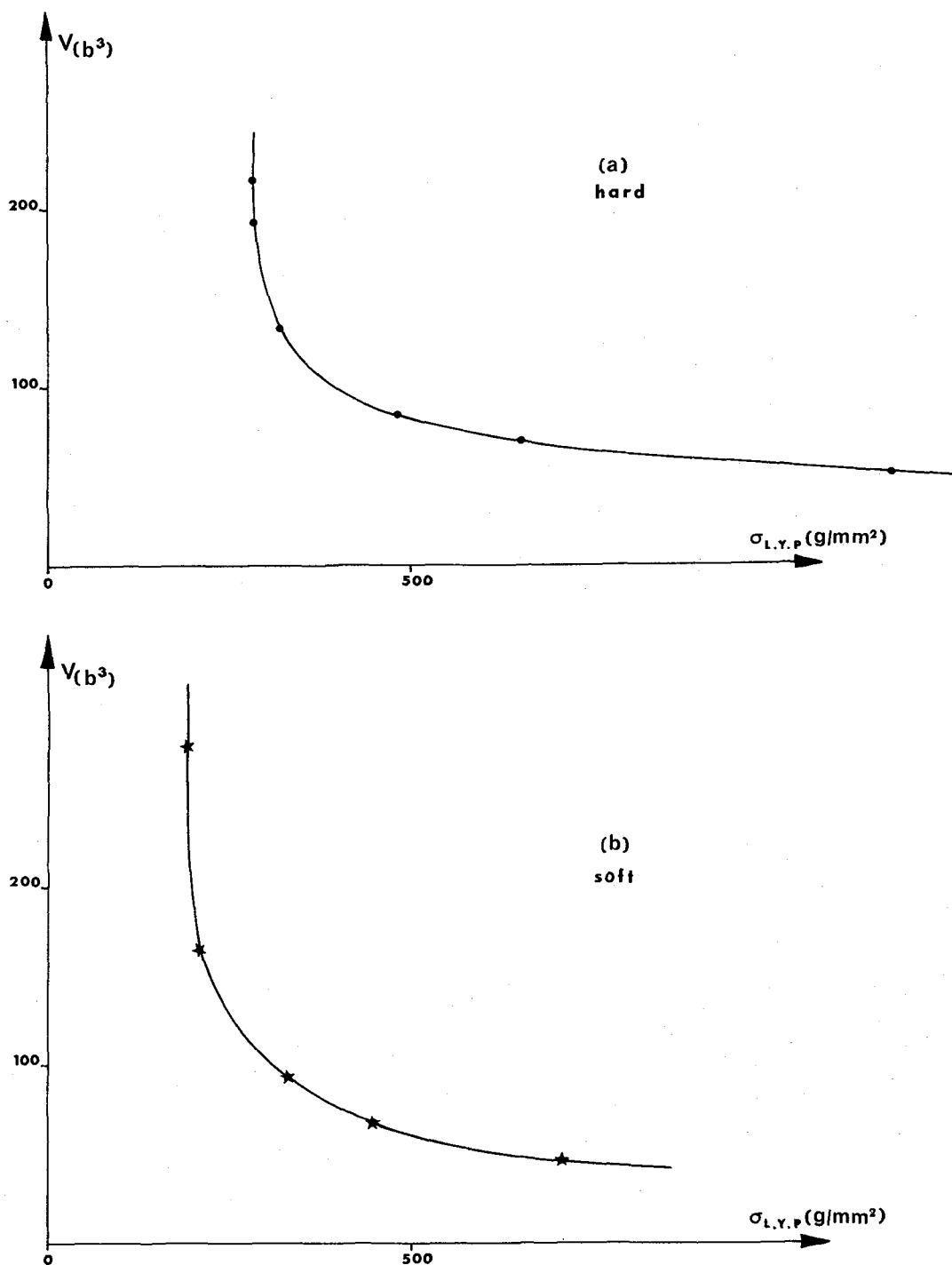


Fig. 3 : Activation volume versus lower yield strain for both soft(*) and hard (●) cases.

$$\Delta G_{\beta/or \alpha} > \left\{ \begin{array}{l} \Delta G_{\alpha/or \beta} \geq \Delta G_{screw} \end{array} \right\}$$

Note that direct measurements of dislocation velocities in n-doped InSb /4/ support a similar relation with the β -type as the slowest one $\Delta G_{\beta} > \Delta G_{\alpha} \approx \Delta G_{screw}$. From symmetry arguments, it is clear

that this inequality can only be attributed to differences in lattice friction experienced by β (or α) dislocations, i.e. to the ionicity of atoms in the dislocation cores independently on any dissociation scheme. Calculations of Peierls energies are currently in progress which support a difference in the Peierls potential similar to the ones observed when the core ionicity is changed from α to β type.

References

- /1/ Haasen, P., Acta. Metall., 5 (1957) 598.
- /2/ Venables, J.P. and Broudy, R.M., J. Appl. Phys., 29 (1958) 1 025.
- /3/ Ferre, D. and Farvacque, J.L., Phys. Status Solidi (a), 49 issue 2 (1978)
- /4/ Erofeeva, S.A. and Osipyan, Yu. A., Sov. Phys. Solid State, 15 (1973) 538; ibidem, 16 (1975) 2 076.