When cleaved in the (111) plane, indium antimonide is polarized, the (111)A plane consists of indium atoms, while the (111)B plane consists of antimony atoms. The effect of the polarity on the photocurrent has been studied. The quantum yield is reported for both planes, and the energy spectrum of the Auger electrons is analyzed.

The behavior of semiconductors is governed by their surface state as well as by their bulk properties. Since the conditions for surface atoms are different from those for interior atoms, the surface naturally has properties different from the bulk properties.

In the indium antimonide single crystal, which has the zinc blende lattice, there is particular interest in the [100], [110], and [111] planes, since all surfaces with greater Miller indices can be represented as stepped structures constructed from combinations of these three basic families of planes.

The (111) plane can be treated as if it were laminated (Fig. 1); each layer consists of two closely spaced planes each consisting of only one kind of atom. In a layer, each atom of one plane is connected by three bonds with different atoms in the other plane. Only one bond remains to connect one double layer with another. Three-fourths of the total binding energy of the crystal goes into interior binding between planes in a single layer. The distance between the planes of a layer is only one-fourth the distance between neighboring layers. In each double layer, atoms of group III of the periodic table precede group V atoms in one direction and follow them in another, as has been determined by x-ray diffraction near the absorption edge [1].

There are important physical and chemical differences between the [111] and [111] crystallographic directions in the crystal; i.e., the crystal has polarity along the <111> axes. The polarity is manifested in the following phenomena: cleavage, the piezoelectric effect, the rate of anodic oxidation, the thickness of the oxide film formed during anodic or chemical oxidation, crystal growth and etching. The contact potential difference between these surfaces was determined experimentally in [2].

We denote the plane on whose surface the group III atoms are found by (III)B, and we denote the opposing plane, made up of group V atoms, by (III)A. A feature of the (111)A planes is the crystal growth and removal of material (by polishing or etching) occurs by entire layers consisting of two closely spaced atomic planes made up of A and B atoms.

Selection of Samples for Study

Semiconductor compounds of the AIII BV type are very difficult to purify. Furthermore, the electrical properties of these compounds are governed at room temperature primarily by impurities. An exception to this rule is indium antimonide. Because of the difference in the pressures of the components making up AIII BV single crystals, an excess pressure of one component must be maintained. The vapor pressure of group V elements above AIII BV compounds is higher than that of group III elements. However, it was found in a comparison of InSb with InAs and InP that the Sb vapor pressure above InSb is lower than the As vapor pressure above InAs, while the latter is lower than the vapor pressure of P above InP. We conclude that the antimonides can be obtained with a more regular structure than can the arsenides, while the latter can be obtained with a more regular structure than can the phosphrides.
RESULTS AND DISCUSSION

The emission I–V characteristics were recorded from solid photocathodes in a quasispherical analyzer [3]. The samples were cut into disks 12 mm in diameter and 1.2 mm thick and oriented on an URS-50I apparatus. The angle between the shear plane and the crystallographic plane was determined within 15'. The InSb samples had the following initial properties: \( p = 0.043 \text{ ~cm} \), \( \mu = 10^5 \text{ ~cm}^2/\text{V} \cdot \text{sec} \), and \( n = 1.4 \cdot 10^{14} \text{ ~cm}^{-3} \). The samples were ground by M10 abrasive. Mechanical treatment of a surface (cutting, grinding, or mechanical polishing) of course always damages the surface layer of a sample: there is a thin, very fragmented layer at the surface and a deeper layer which is plastically deformed. Grinding too intensely results in work hardening. The depths of the damaged layers have been measured for certain AlIBV compounds [4]; they turned out to be different on the (111)_A and (111)_B surfaces. The difference has been attributed to the distorted tetrahedral structure of the (111)_A surface. The depth of the damaged layer of InSb resulting from grinding by M10 abrasive is \( 6 \mu \) for the (111)_A surface and \( 9 \mu \) for the (111)_B surface. Etching was carried out in the following etching solution: \( \text{HNO}_3 : \text{lactic acid : HF : H}_2\text{O} (10 : 40 : 5 : 15) \). This solution makes good etching figures on the (111)_A plane (Fig. 2). The (111)_A surface differs significantly from the (111)_B surface; in certain regions of the surface, the etching figures form entire clusters. The (111)_B surface is found to be more developed than the (111)_A surface. The difference in the total quantum current yield from the (111)_A and (111)_B surfaces is governed primarily by the relative friability of the (111)_B surface.

Photoelectric absorption of the characteristic CuK\( \alpha \) radiation, having photon energies of 8.040 keV, excites the L shells of both In and Sb. The absorption of a photon by an atom in the L shell leads to the creation of a rapid photoelectron whose energy may be equal to the photon energy. The x-ray photoelectron, moving from the region in which it was created toward the photocathode surface, causes a shower of secondary electrons. Like a fast electron, it sometimes may not be observed but may instead appear purely as a secondary electron. The escape probability for a fast x-ray electron into a vacuum is \( e^{-\alpha x} \), where \( \alpha \) is the linear attenuation coefficient of the electron flux, and \( x \) is the depth at which the electron was created.

Figure 3 shows the emission I–V characteristics for retarding potentials up to only 4 kV. We showed previously [3] that the InSb photocurrents can be reliably recorded up to 6 kV. The contribution of higher-energy photoelectrons is negligible, probably because of the following. It was shown in a study of photoemission from dielectric photocathodes [5] that the secondary-electron escape zone is very effective and is comparable in depth to the escape zone of the x-ray electrons themselves, so an x-ray electron may cause