

SURFACE CONDUCTIVITY OF GaAs

ヒ化ガリウムの表面伝導変化

by HONDA, Kenichi and SHIMODA, Haruhisa

本 多 健 一*・下 田 陽 久*

Recently, it becomes clear that the unstable factors of semiconductor electronic elements mostly depend on their surface phenomena. From the study of the surface of germanium and silicon, the nature of the semiconductor surfaces can be characterized by the surface potential and surface states,¹⁾²⁾ but the details of the surface states are not clear. Furthermore, for the compound semiconductors such as gallium arsenide which will be dealt with in this report, most of the aspects of the nature of the surface are not yet clarified.

The aims of this study are to measure the changes of the surface conductivity and the surface recombination velocity of the gallium arsenide single crystals as function of the electrode potential and the pH of the electrolytic solutions, the vertical electric field and the ambient gas phases. It is also intended to compare the measured surface conductivity and the surface recombination velocity with the values calculated theoretically.

Methods

The outline of the experimental apparatus is shown in Fig. 1. The electrode potential is given

by a potentiostat with a saturated calomel electrode as reference electrode. A constant current was applied to the sample through the both ends, and the conductivity was obtained by measuring the potential between the two inner probes. The four probes for conductivity measurements were made to have ohmic contacts and the potential was measured by a high input impedance (≈ 2 Mohm) electronic potentiometer. At the measurement, a blank potential which was attributed to the influence of the contact potential was subtracted from the measured value.

The sample was a undoped single crystal gallium arsenide, and its resistivity was 2.6×10^{-2} ohm-cm, its mobility was $4700 \text{ cm}^2 \cdot \text{volt}^{-1} \cdot \text{sec}^{-1}$, and its majority carrier concentration was $5.2 \times 10^{16} \text{ cm}^{-3}$. It was cut as $0.5 \times 16 \times 5 \text{ mm}$ wafer and its surface was chemically etched after mechanical polishing.

The electric contacts were made by evaporating gold on the sample, reduced in H_2/N_2 mixture at 300°C for 30 minutes and by using indium solder. For the purpose of eliminating the influence from the other side of the surface, the sample was coated by resin except one side of the surface to be measured.

Results and Discussion

Because of the presence of a potential barrier, the conductivity of the surface layer of a semiconductor (the space charge region) is different from that of a parallel layer of comparable thickness in the underlying bulk. Thus a given semiconductor filaments consists in effect of two conductors in parallel, one associated with the definite bulk carrier densities and the other with the barrier-dependent surface densities.

If it is assumed that the carrier mobilities in the space charge layer are the same as those in the bulk, the following equation will evidently be given,

$$ds = q(m_n dN + m_p dP)$$

where, ds is the surface conductivity, q is the electronic charge of an electron, m_n and m_p are electron and hole mobility respectively and dN and dP are electron and hole excess carrier densities respectively.

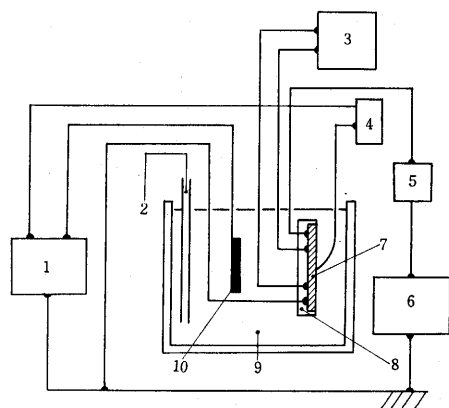


Fig. 1 Apparatus

- | | |
|--------------------------|-----------------|
| 1 Potentiostat | 6 Galvanostat |
| 2 N_2 gas inlet | 7 Sample |
| 3 Voltmeter | 8 Resin |
| 4 S. C. E. | 9 Electrolyte |
| 5 Ammeter | 10 Pt Electrode |

* 東京大学生産技術研究所 第4部

With this equation, the behaviour of the surface conductivity concerned with the surface potential can be treated qualitatively. In the accumulation layer, since the surface electron concentration becomes larger than that in the bulk, $\Delta\sigma$ has the plus sign. In the strong inversion layer, the concentration of holes becomes very large, so $\Delta\sigma$ is plus, too. On the contrary, in the depletion layer, since the carrier densities become small than those in the bulk, $\Delta\sigma$ becomes to have the minus sign. Therefore, if $\Delta\sigma$ is plotted against the surface

potential, the whole aspects of the figure will show a bell-shaped curve³⁾.

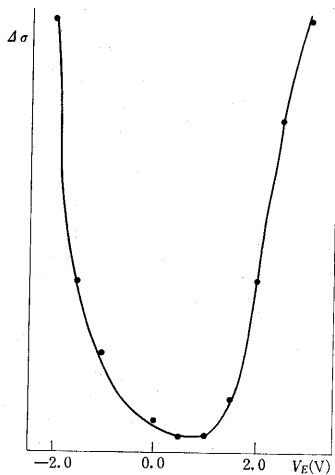
The results of the experiment are shown in Fig. 2. Here, the abscissa is the electrode potential and the ordinate is the surface conductivity.

From the studies of germanium and silicon, it is known that the electrode potential is almost consumed in the space-charge layer⁴⁾⁵⁾⁶⁾. That is to say, the electrode potential may be equivalent to the surface potential by the displacement parallel to the abscissa. However, to verify this argument and to find the relations between the electrode potential and the surface potential, we must deal this problem in a more quantitative way. In order to do this, it will be enough to calculate the surface carrier densities from the Poisson's equation and to exchange the value of the carrier mobilities in the bulk with those in the space charge layer. The results of this calculation will be presented in near future.

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References

- 1) J. Bardeen, Phys. Rev., **71**, 727 (1947).
- 2) W. Shockley and G.L. Pearson, Phys. Rev., **74**, 232 (1948).
- 3) A. Many et al., "Semiconductor Surfaces", North Holland Pub. Co., Amsterdam, (1965) p. 212.
- 4) J. Bardeen, et al., Phys. Rev., **104**, 47 (1956).
- 5) H.U. Harten, Philips Res. Rep., **14**, 346 (1959).
- 6) H.U. Harten, Z. Naturforsch., **16a**, 459 (1961).



V_E : electrode potential versus S.C.E.
 $\Delta\sigma$: surface conductivity; scale is chosen on the arbitrary unit

Fig. 2 Change of the surface conductivity

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