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ANALYSIS OF LOW ENERGY ION SCATTERING SPECTROSCOPY OF InGaP(001) SURFACE

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INTRODUCTION

Surfaces play an important role in a large number of industrial applications such as micro-electronics and chemistry. Due to the miniaturization of electronic devices, the surface-bulk ratio of these devices is increasing. Therefore, their properties are more and more determined by the surface. Nowadays, integrated circuits are often grown by depositing material on a semiconductor surface. Studying such a surface is more complicated than studying the bulk, both theoretically and experimentally. Theoretically, because the translational symmetry that simplifies the treatments of bulk properties, is not present perpendicular to the surface. Experimentally, because ultra-high vacuum conditions are needed in order to keep a freshly created or cleaned sample surface sufficiently long in its original state, since at ambient pressure a mono-layer may absorb in only 10^{-9} s. There are many analytical techniques available in surface science to obtain information about a sample surface. Each of these has its advantages and drawbacks, and provides only a specific kind of information. Therefore, in general a combination of different analysis techniques is used to characterize a surface . Most surface analysis techniques use the interaction of a beam of particles with the sample surface to obtain the information. These particles can be either ions, electrons or photons. An important aspect of a surface analysis technique is the information depth, i.e. the depth in the sample from which the information is obtained. The information depth depends on the mean free path of the particles, and thus determines the surface sensitivity of an analysis technique. Because most of the surface effects take place in the outermost atomic layers, the information depth should preferably be limited to only a few atomic layers. Low-energy ion scattering (LEIS) is such a technique. In LEIS a primary beam of ions with an energy typically between 0.1 and 10 keV, is directed at a sample surface . The ions interact with the atoms in the surface and due to this interaction they lose a certain amount of energy.

In this paper we presents investigation of InGaP(001) surface structure by the method of LEIS. At the calculations as a bombardment ion was used Ar ions.

Computational method

When an ion penetrates a solid, the ion will interact with the atoms in the solid. This interaction is a many particle problem and requires, at first instance, a quantum mechanical description. Since the quantum-mechanical model is too complicated to be of any practical use for computer simulation, a number of approximations is made in order to obtain a much simpler model: the binary-collision approximation (BCA) model. This model forms the basis of most computer codes for ion-scattering simulation. An important issue in ion-scattering simulation is the choice of the interaction potential, since it describes all quantum-mechanical details of the interaction between an ion and an atom. Within a solid, an ion interacts not only with the atomic nuclei but also with the electrons. This interaction causes two types of electronic processes to occur: inelastic energy loss and charge exchange. In our calculation, we used the potential of Biersack-Ziegler-Littmark (BZL). The inelastic energy losses were regarded as local depending on the impact parameter and included into the scattering kinematics. These losses have been calculated on the basis of Firsov model modified by Kishinevsky. The angle of incidence of primary ions ψ and the polar escape angle δ of scattered atoms were counted from a target surface and the azimuthal escape angle φ - from the incidence plane of the ions. In the Fig.1 presents scheme of surface semichannel.

The incident ions were followed throughout their slowing-down process until their energy falls below a predetermined energy: 25 eV was used for the incident ions. The angle of incidence of the ion beam relative to the surface was changed in the range ψ =3 and 7^0, polar and azimuth scattering angles have been marked in δ and φ, respectively (Fig.1). The aiming points filled a rectangle whose sides were divided into 1000 and 1000 segments in the beam incidence plane (I coordinate) and in the perpendicular direction (J coordinate), respectively (Fig.1).

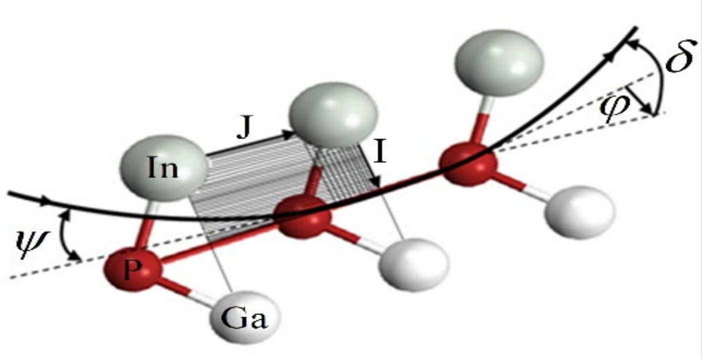


Fig.1. The scheme of ion scattering by the surface semichannel.

RESULTS

Using this methodology was simulated the scattering of 1 keV Ar$^+$ ions from InGaP(001)<110> and <ī10> surfaces at the grazing incidence. On the <110> direction formed surface semichannel, which consist In and Ga atoms on the surface layer and P atom on the second layer. And on the <ī10> direction formed surface semichannel by the atoms In which located surface layer, atoms Ga which located on second layer and atoms P which located on the third layer. In Fig.2. was shown δ (I) dependence at the angle of incidences ψ=30 and 70 with initial energy 1 keV Ar+ ions bombarding of InGaP(001)<110>(a) and <ī10> surfaces. It can be seen that the scattered ions from the semichannel wall at small angle of incidence ($\psi=3^0$) have only positive values (mirror scattering), and with an increase in the angle of incidence ($\psi=7^0$) of the ions have both positive and negative values. Also, note that the geometric parameters of the semichannel also affect the dependence δ (I). Figure 2b shows that the dependence differs from the case <110>. Because in the case of <ī10>, the width and depth of the semichannel is greater than <110>.

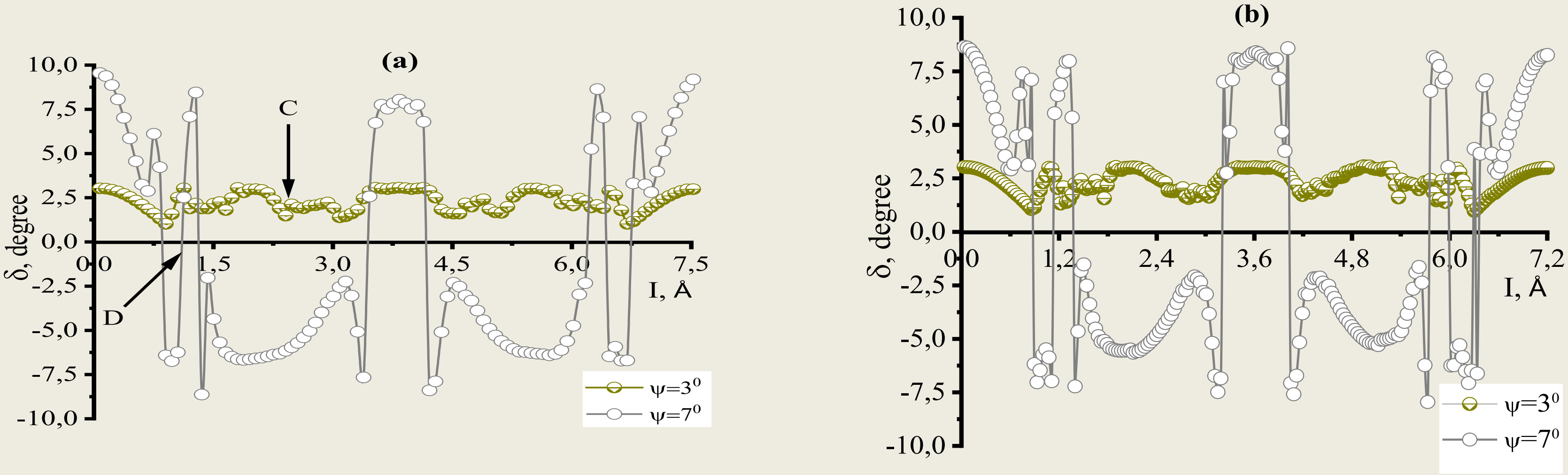
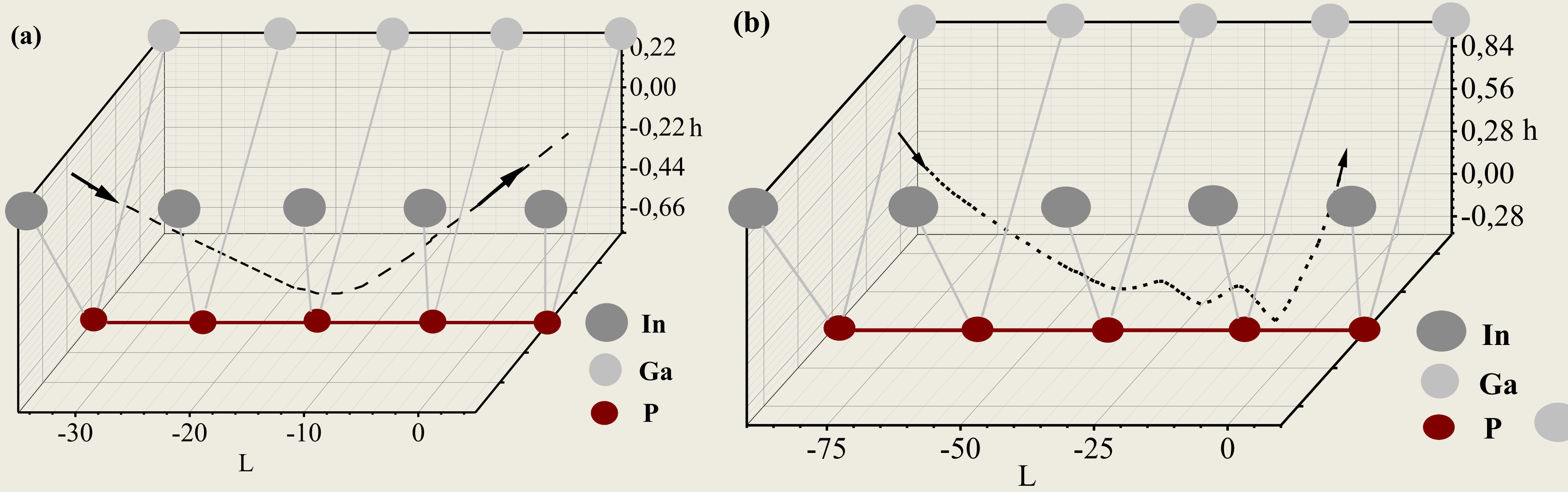
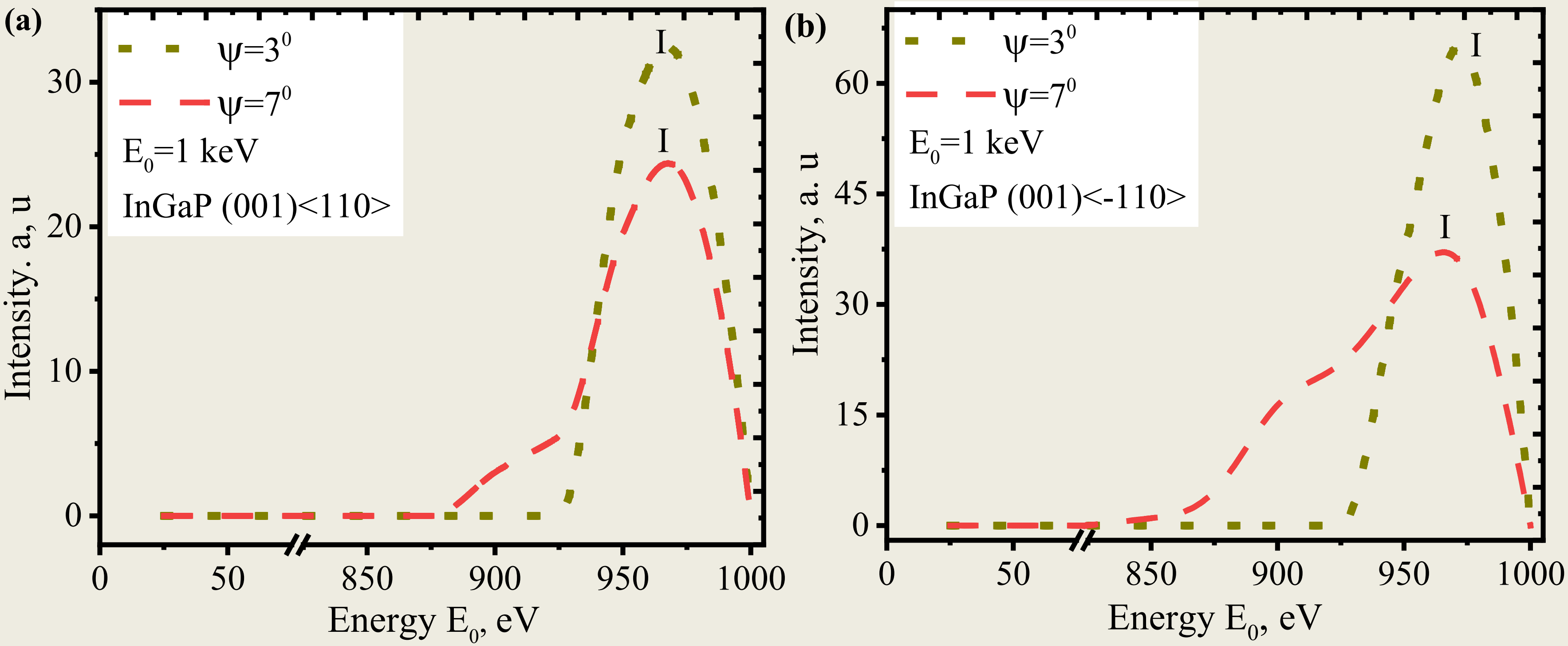


Fig.2. The δ (I) dependence at the angle of incidences $\psi=3^0$ and 7^0 with initial energy 1 keV Ar$^+$ ions bombarding of InGaP(001)<110>(a) and <ī10>(b) surfaces.

Trajectory scattered ions at the angle of incidence $\psi=3^0$ and 7^0 on the points C(a) and D(b).



Energy distribution of scattered Ar^+ ions at the angle of incidences $\psi=3^0$ (dark yellow) and 7^0 (red color) with the initial energy 1 keV bombarding of InGaP(001)<110>(a) and <ī10> surfaces.



At the angle of incidence $\psi=3^0$ on the both directions are observed only one peak (I) on the energy distribution. It means that the bomdarded ions can't penetrate to the semichannal and all incidence ions scattered from surface atomic chans. In the case <ī10> are observed intensive peak at large values of the energy of the scattered ions (I). This peak formed by ions scattered from the surface atomic chain. It should be noted, that the intensity of this peak increases with an increase in the angle of incidence of the ions. The second peak (II), which formed near the peak of the atomic chains, refers to the ions scattered from the semichannel. It can be seen that in the case of <ī10>, this peak has a large energy range and intensity than <110> case. This large energy range explained by a large geometric parameter of the semichannel.

CONCLUSION

LEIS simulations are performed for InGaP(001)<110>(a) and <ī10> surfaces. Calculated polar angle of scattering shows that we can separate group ions scattered from surface atomic chains and semichannel. And in all values of impact point we can plot trajectories of scattered ions. With the help of such simulations, the trajectories responsible for the features are much better understood. This includes common double peaks as well as a novel trajectory that involves interaction of the projectile with surface semichannels.

Our LEIS results have shown that the LEIS technique is quite suitable for surface investigations and diagnostic of many component materials.

THANKS FOR YOU ATTENTION