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DESIGN OF PHOTOELECTRIC CONVERTORS ON THE BASIS OF SI-GE SOLID SOLUTIONS

Keywords: whisker, photo-e.m.f., resistivity, dimensional effect

Electric and photoelectric properties of $Si_{1-x}Ge_x$<Hf> (x=0.1) whiskers were investigated. The whiskers were grown by method of chemical transport reactions in closed Si-Ge-Au-Hf-Br system. Concentration of Hf in whiskers is $1{,}6\cdot10^{-2}$ mg/cm^3, concentration of Au is 10^{-3} mg/cm^3. The samples have n-type conductivity; their resistivity ρ changes from 0.5 to 12 Ω·cm depending on the whisker diameter. The whisker diameters change from 10 to 80 μm, the whisker length is equal to 0,5÷5 mm.

The whiskers were shown to be photosensitive both in photovoltaic and in photoresistive regimes. Photo-e.m.f. value is about 100 mV in the whisker with small diameter (d=20 μm) and it decreases at a rise of the whisker diameters from 20 to 80 μm. Appearance of photo-e.m.f. is caused by existance of Shotki barrier in SiGe-Pt contact to the whiskers. Dimensional effect of the whisker photo-e.m.f. is explained by the dimensional dependence of the whisker resistivity.

High values of photo-e.m.f. for Si-Ge <Hf> whiskers allow their using for photoconvertor design.

1. INTRODUCTION

Si-Ge solid solutions are prospective materials of semiconductor electronics (on their base photodetectors, thermogenerators, etc were designed) [1]. Electric properties of crystals are substantially defined by their doping. Their photoelectric properties to large extent are determined by presence of rare-earth elements. So, Hf impurity is interesting in silicon like crystals, in particular in Si it is known to influence on life time of carriers [2]. A behaviour of Hf impurity in Si-Ge whiskers was investigated in [3], but it has been studied as yet unsufficiantly.

In the present work electric and photoelectric properties of $Si_{1-x}Ge_x$<Hf> (x=0.1) whiskers were investigated. It was found dimensional effects of photo-e.m.f. and resistivity of the whiskers, which allows their using for photoconvertor design.

2. EXPERIMENTAL RESULTS AND DISSCUSION

The whiskers were grown by method of chemical transport reactions in closed Si-Ge-Au-Hf-Br system [4]. Concentration of Hf in whiskers is $1{,}6\cdot10^{-2}$ mg/cm^{-3}, concentration of Au is 10^{-3} mg/cm^3. The samples have n- type conductivity; their resistivity ρ changes from 0.5 to 12 Ω·cm depending on the whisker diameter. The whisker diameters change from 10 to 80 μm, the whisker length is equal to 0,5÷5 mm.

Voltage-current characteristics of the whiskers was found to be unlinear in temperature range 77-300K, and unlinearity rises at reduction of the whisker temperature (Fig. 1).

The whiskers were shown to be photosensitive both in photovoltaic and in photoresistive regimes. The whiskers were illuminated by daylight lamp with brightness of 100 lm. Photo-e.m.f. value is about 100 mV in the whisker with small diameter (d=20 μm) and it decreases at a rise of the whisker diameters from 20 to 80 μm.

Dimensional dependence of the whisker photo-e.m.f is impossible to explain by quantum dimensional effects due to large whisker diameters. Therefore it is necessary to find other reasons of this effect.

Specific dependence of resistivity upon diameter is found for Si-Ge<Hf> whiskers. Whisker resistivity increases at reduction of crystal diameter. Results of investigations are presented in Fig. 3.

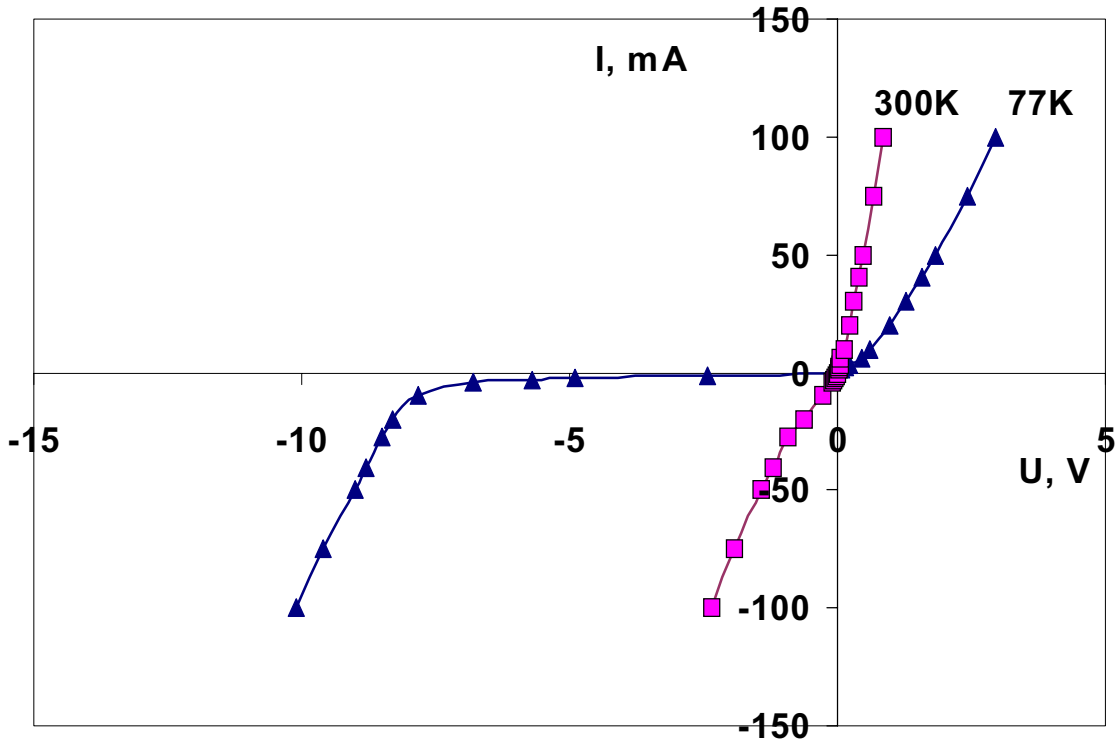

Fig. 1. Voltage-current characteristics of $Si_{1-x}Ge_x$ whiskers (x=0.1) grown in the system Si-Ge-Au-Hf-Br

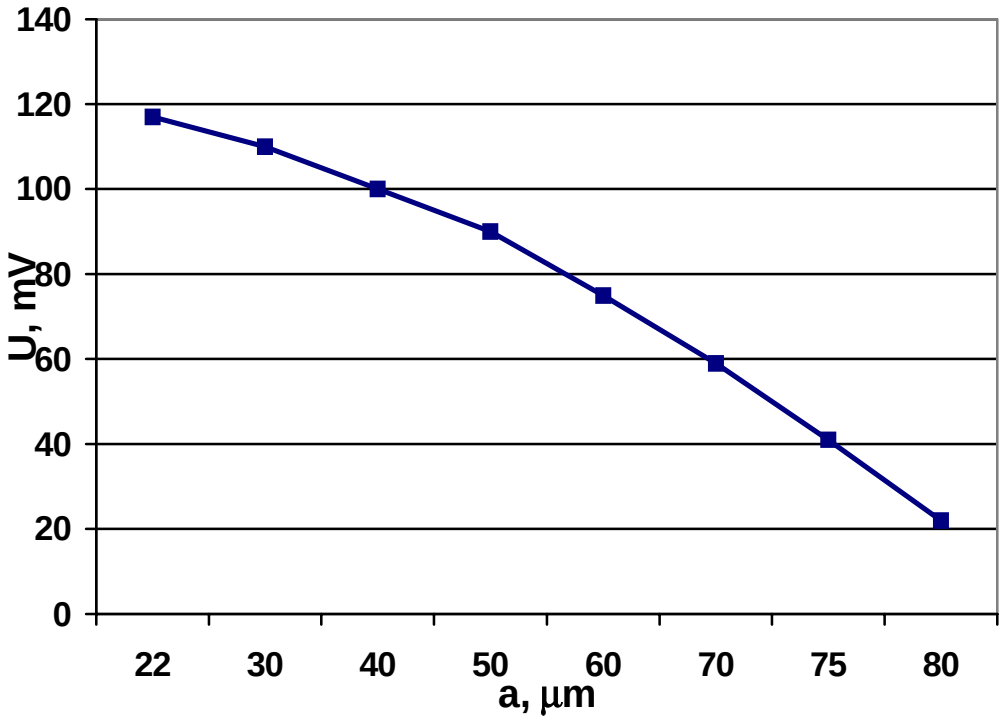

Fig. 2. Photo-e.m.f. versus face width dependence for Si-Ge<Hf> whiskers

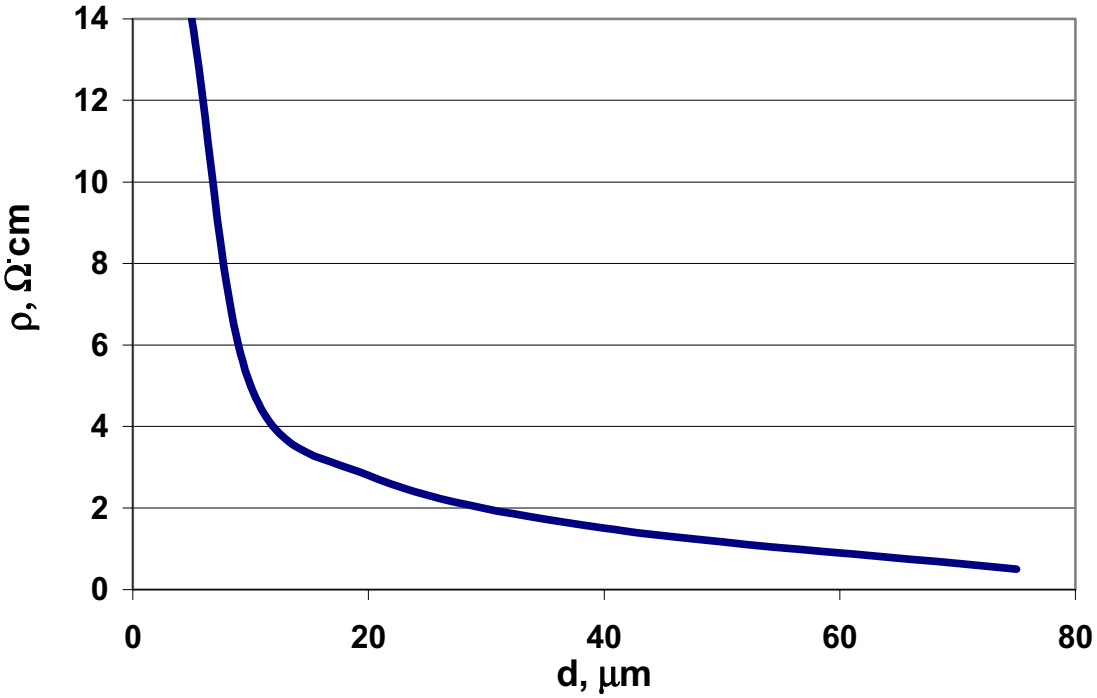

Fig. 3. Resestivity versus diameter dependence for Si-Ge<Hf> whiskers

Besides these results we can also observe dependence of photo-e.m.f upon whisker resistivity (Fig. 4). Photo-e.m.f increases from 30 to 115 mv at a rise of whisker resistivity.

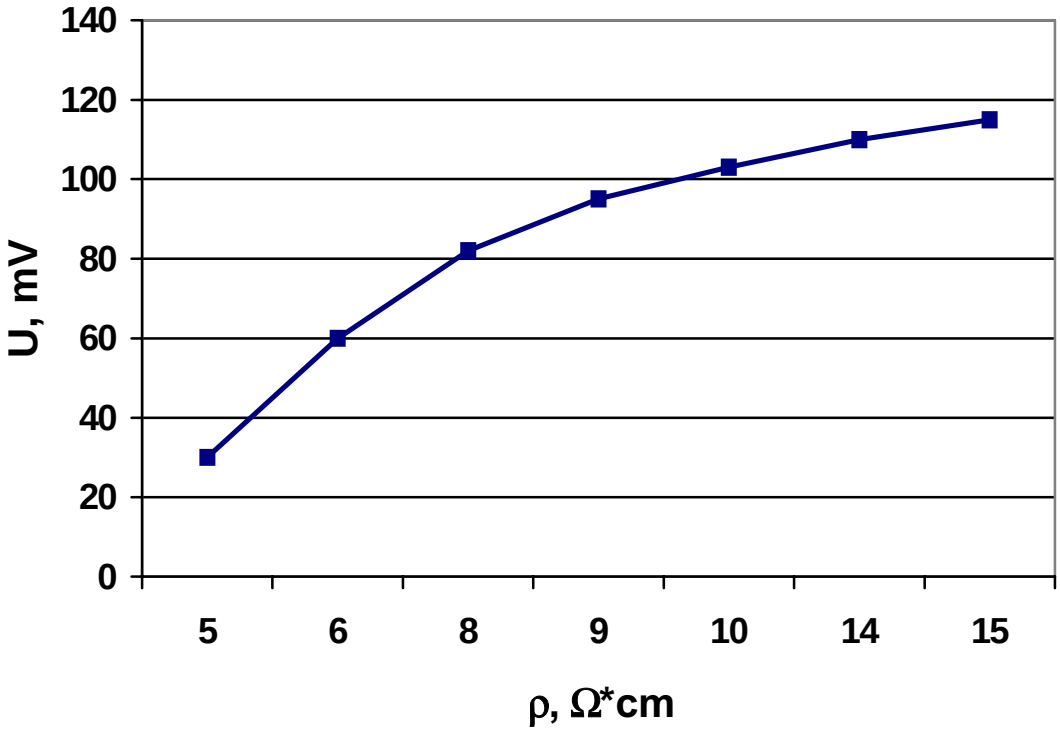

Fig. 4. Photo-e.m.f. versus resestivity dependence for Si-Ge<Hf> whiskers

Comparison of given results allows to explain the dependence of photo-e.m.f. upon whisker diameter (Fig. 2) in the following way. Whisker resistivity increases at reduction of crystal diameter (Fig. 3) that leads to increase of their photo - e.m.f. (Fig. 4).

Photo-e.m.f is known to appear in structures with p-n junction or Shottki barrier. We were not make p-n junction in the whiskers. Therefore, we supposed that appearance of photo-e.m.f. is caused by existance of Shottki barrier in SiGe<Hf>-Pt contact to the whisker. Hf impurity is known to be shallow donors in Si-based materials. As follows from our results Hf creates n-type conduction of the whiskers. We have measured temperature dependence of conductance, which allows calculate activation energy of Hf impurity in the whiskers. It is equal to 4 meV.

Shottki barrier is known to exist in n-type semiconductor – metal contact when photoelectric work function of metal is larger than that of semiconductor. Let us compare photoelectric work functions of n-Si-Ge and Pt. They are equal to 4,1-5,2 eV (depending on crystallographic orientation and composition of whiskers) and 5,32 eV correspondingly. These data show that Shottki barrier can be created in the whisker contact. Voltage-current characteristics of the whiskers were investigated to control of this barrier existance (Fig.1).The behaviour of voltage-current characteristics is typical for structure with Shottki barrier. Therefore, in n-SiGe whisker - Pt microwire barrier appears, which leads to existance of photo-e.m.f. Barrier height depends on the whisker resistivity. Our results shown that the whiskers with small diameter have great values of resistivity, which leads to increase of barrier height and photo-e.m.f. values (Fig. 4).

High values of photo-e.m.f. for Si-Ge <Hf> whiskers allow designing on their basis photoelectric convertors.

3. CONCLUSIONS

Photoelectric properties of Si-Ge <Hf> whiskers were studied at 300 K. Value of photo-e.m.f. rises at the diameter decrease reaching to 100 mV in the whiskers with 20 μm in diameter. Photo-e.m.f. is connected with the value of the whisker resistivity: it rises at increase of the whisker resistivity. As shown from Fig.3 the whisker resistivity essentially rises at decrease of the face width for whiskers with diameters less than 10 μm. Therefore, it should be expected substantial rise of photo-e.m.f. in the whiskers with small diameters. These whiskers are prospective material for sensitive elements of photoconvertors.

4. REFERENCE

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