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Dynamic tensor properties of silicon with deep impurity levels

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ABSTRACT

The dynamical tensoproperties of simples Si <Ni>, Si <Gd>, Si <Au> and Si <Mn> at temperatures T=293K and T=273K are investigated. The strongly increasing of dynamical tensosensitivity these specified simples at speed of change of pressure ΔP\Δt >108 Pa/s in comparison with their statistical tensosensitivities is shown.

Key words: Simple, Properties, Tensor.

INTRODUCTION

The basis of modern microelectronics is made semi-conductor material materials, and the further development of this area goes as to a direction of improvement of functional characteristics and parameters of known materials and devices, and in a direction of creation of the semi-conductor devices based on new materials and physical effects which potential possibilities yet fully are used. Researches in physics area tensoeffects in non-uniform hardly compensated semiconductor are in this respect rather perspective. Last years the compensated semiconductors, in particular, the silicon compensated by impurity with deep power levels, draws attention of the big circle of researchers. It is caused, that the compensated semiconductors are considered by that as a new material with unique physical characteristics. One of the basic characteristics of such material is its raised sensitivity to what or to external influences.

In the present's time, Creation sensitive and stable semi-conductor tenso converters, working in the conditions of the raised temperature and radiation is an actual problem. It is known that silicon with impurity of deep levels have high sensitivity to external pressure. For working out of manufacturing techniques of strain gages it is necessary to study in detail physical laws tensoeffects in semiconductors with deep levels.

DYNAMIC TENSOR PROPERTIES OF SILICON

Tensosensitivity is one of the main parameters of semiconductor tensor transformers, tensor gauges and other tensor metric devises. It is known (Abduraimov et al, 1993) that silica with mixtures of impurities has high sensitivity to external pressure. For evaluation of tensor gauge manufacture technology, it is necessary to study physical regularities of tensor effects in semi-conductors with deep levels.

And therefore, this work incorporates study of dynamic tensoproperties of samples of Si<Ni>, Si<Gd>, Si<Au> and Si<Mn> at temperatures T=293K and T=273K.

For the purpose of the study of tensoproperties highly compensated samples of Si<Ni>, Si<Gd>, Si<Au> and Si<Mn> with specific resistance of -10^5 Ohm-cm. doping of mono-crystals of Si with gold and nickel was conducted from the layer of diffusion, coated on the surface of silicon vacuum dusting on the equipment of VUP-4. Diffusion of manganese and gadolinium in silicon was done from the gas phase. Metal Au, Ni and weighed amounts of Mn, Gd of special purity 99,999% were used as diffusions.

Diffusion roasting was conducted in an electric furnace of SUOL-4M. The temperature in the furnace was determined by thermocouple of platinum-platinum rhodium. The temperature was maintained permanently with the accuracy of $\pm 3^0$C.

While considering the tensor conductivity in samples of Si<Ni> upon impulse impacts of uniform hydrostatic pressure (UHP), it was determined (Abduraimov et al, 1993) that occurrence of heat effect stimulated by the pressure and related changes in temperature result in additional changes of tensor conductivity.

Below are the results of measurements of dynamic tensor conductivity in highly compensated samples of n- and p- Si<Ni> with $\rho \sim 10^4$, 10^5 Ohm-cm and n- Si<Gd> with $\rho \sim 10^5$ Ohm-cm at impulse modes of effect of UHP in the range of $P=(0+5)\cdot 10^8$ Pa and at initial temperatures of $T_0 = 273$ K (128). All measurements were conducted by using the equipment (86).In Figure 1 shows the kinetic relationship of changes of current I = f(t) in highly compensated samples p – Si<Ni> with p ~ 10^3 Ohm-cm (curves 1 and 2) at initial temperature of T_0=293 K after the impulse of impact (Area I) and release of pressure at the velocity of (dP)/(dt)≈10^8 Pa/s, (Area II). It is seen that upon introduction of a pressure impulse P=f(t) the value of current in samples with p ~ 10^5 Ohm-cm commences to grow and upon achievement of is amplitude value by the pressure P=5 x 10^8 Pa the current reaches its maximum value I_{max} (curve 1, Area I). Further, as the time goes the currents relax exponentially to their static values I_{st}. Upon release of pressure in measurements of current, a similar picture is observed, but in this case, the currents drop to their minimum values I_{min} and further, while relaxing, regain their values to I_0. under less amplitudes of impacting pressure impulse (P=2, 5 x 10^8 Pa) changes of current I=f(t) in samples occur in less amplitudes (curve 2). For the dynamic changes of conductivity in samples Si<Ni>, Si<Gd>, Si<Au> and Si<Mn> under impulse impacts of UHP have a specific nature that differs from the those of static, and it is sensible to introduce a notion of dynamic coefficient of tensosensitivity S_D, which by taking into account the velocity of changing of pressure and temperature T can be presented as follows (Kireev, 1969):

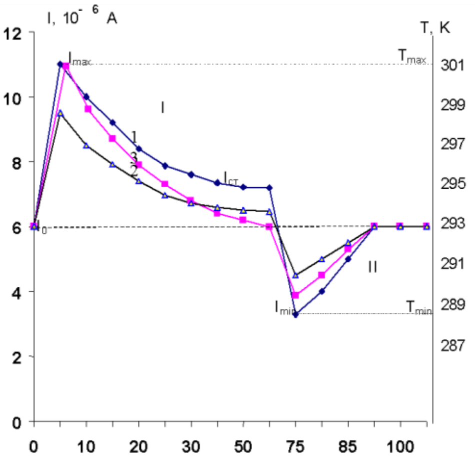


Figure1. Kinetic dependencies of current I=f(t) in highly compensated samples p-Si<Ni> at impact of impulse (I) and after release of (II) UHP at velocity of dP/dt=10^8 Pa/s under T=293 K, 1- P=5 x 10^8 pa, 2 – P=2,5 x 10^8 Pa, 3- changes of temperature at P=5 x 10^8 Pa.

$$S_D = \frac{E^Y}{P(t)} \frac{\Delta J[P,T(P)]}{J_0(T_0)} \qquad (1)$$

Where E^y is the Yung Model, P(t)–dynamic value of pressure amplitude; J[P,T(P)], J^0–dynamic and initial values of current at P≠0 and P=0 respectively; T(P) and T_0 – dynamic (at P≠0) and initial (P=0) values of temperatures respectively.

For study of the relationship of dynamic tensosensitivity and velocity of increase of pressure, we experimentally determined the coefficients of tensosensitivity at various velocities of pressure increase.

In Figure 2 shows the dependencies of coefficients of dynamic tensosensitivity S_D on changes of pressure impulse ($\Delta P/\Delta t$) at T=293 K in samples Si<Ni>, Si<Gd>, Si<Mn> with specific resistance of p ~ 10^5 Ohm-cm. Calculations of S_D was done as per formula (Abduraimov et al, 1993), by using experimentally obtained maximum values I_{max} of changes of currents I=f(t), at impulse impacts of UHP with amplitude of P=5 x 10^8 Pa at initial temperatures of working area T_0 =293 K and T_0 =273 K. The figure shows that in samples n-Si<Ni> at T_0=293 K (Figure 1, curve 2) values of S_D monotonously increase with the velocity of changes of impulses of UHP ($\Delta P/\Delta t$), but at values of velocity of ($\Delta P/\Delta t$) > 10^8 Pa/s in this dependence a plateau/region is observed, i.e., dynamic tensosensitivity already does not depend on the velocity of change of pressure impulse.

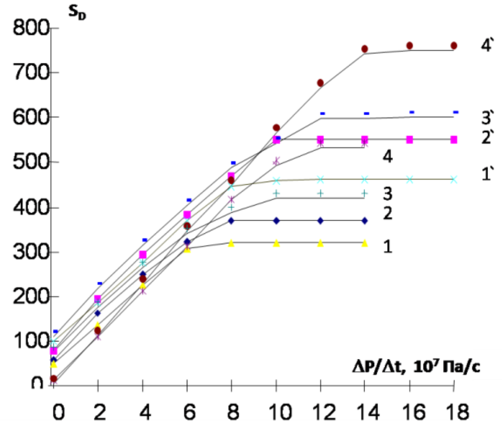


Figure2. Dependencies of coefficients of dynamic strainsensitivity S_D on velocity of pressure impulse (dP/dt) in samples of Si<Gd> (1), Si<Ni> (2), Si<Mn> (3) and Si<Au> (4) under T=293 K (1, 2, 3 4) and T=273 K (1’, 2’, 3’ and 4’).

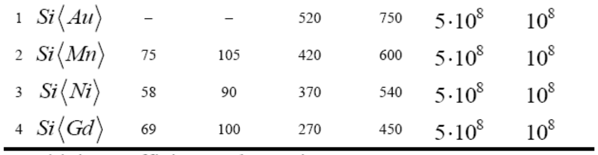
Analysis of our experimental results and comparison with existing literature data showed that the plateau observed is related with complete ionization of impurity atoms of Ni in Si. Comparisons of the value of static S_{cm} of dynamic S_D coefficients of tensosensitivity ($\Delta P/\Delta t$) >10^8 Pa/s the value of S_D becomes 5-6 times more/higher than S_{st}. similar results are also observed in samples Si<Gd>, Si<Mn> and Si<Au> (Figure 2, curves 1, 3 and 4 respectively). In this case, the area/zone of saturation of these samples corresponds to different values of ($\Delta P/\Delta t$). Table 1 contains the values of coefficient of tensosensitivity S_D for the samples under study.

We also studied the dependence $S=f(\Delta P/\Delta t)$ at $T_0=273$, curves 1', 2', 3' and 4'). It should that in this case in work areas zones with initial value of $T_0=273$ K, the areas of saturation for the dependence $S=f(\Delta P/\Delta t)$ are displaced towards the higher values of $\Delta P/\Delta t$.

Increase of values of coefficients of dynamic tenssensitivity and displacement of this plateau at drop of initial temperature T_0 of work areas zones, obviously, are related with decrease of initial concentration of charge carriers, for in this case efficiency of contribution in changes of tensor conductivity of excessive charge carriers is increased that are generated upon impulse impacts of UHP, and also as a result of the heat effect, stimulated by impulse pressure.

From the analyses conducted, we can say that physical properties of observed, relatively large values of dynamic tenssensitivity coefficient in samples of Si<Ni>, Si<Gd>, Si<Au> and Si<Mn> are obviously related with the heat effect, stimulated by impulse impact of VGD and considerable exceeds their static tenssensitivity, which is of interest from the point of view of creating sensitive gauges.

Table 1: contains the values of coefficient of tensosensitivity S_D for the samples



No.:	Simples	S_{st} (T=293K)	S_{st} (T=273K)	S_D (T=293K)	S_D (T=273K)	P (Pa)	$\Delta P/\Delta t$ (Pa/s)
1	$Si\langle Au\rangle$	–	–	520	750	$5\cdot10^8$	10^8
2	$Si\langle Mn\rangle$	75	105	420	600	$5\cdot10^8$	10^8
3	$Si\langle Ni\rangle$	58	90	370	540	$5\cdot10^8$	10^8
4	$Si\langle Gd\rangle$	69	100	270	450	$5\cdot10^8$	10^8

Where, S_{st} – tensosensitivity coefficient under static pressure;
S_p – strain sensitivity coefficient under dynamic pressure;
P – pressure values;
$\Delta P/\Delta t$ – velocity of change of pressure impulse.

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CONCLUSION

The semiconductor material is a basis of modern microelectronics, and the further development of this area goes as a direction of improvement of functional characteristics and parameters of known materials, and also creation of semiconductor devices based on new materials and physical effects. In this case investigate the tensoeffects in non-uniform strong compensated semiconductors in physics area are respect rather perspective. The compensated semiconductors, particularly, the silicon, which compensated impurity with deep energetic levels, draws attention of researchers in last years. It is caused, that the compensated semiconductors are considered by that as a new material with unique physical characteristics. One of the basic characteristics of such material is its raised sensitivity to what or to external influences. Creation of sensitive and stable semi-conductor tensorecharging, which is working in the conditions of the raised temperature and radiation, is an actual problem in present time. It is necessary to study of physical laws of tensoeffects on semiconductors with deep levels, for the impurity it is manufacturing techniques.

This solution not only describes the gravitational field around elliptical objects in shape but also it can explain the field around spherical objects too. One of the applications of this line element is planetary orbit of an object around the elliptical object. Differential equations of motion for planetary orbits in elliptical and spherical are different. For elliptical objects we found a new term as mentioned in the equation (31). The differential equation of motion of elliptical objects for ($a=0$) is same as differential equation of motion for spherical objects. Consequently, elliptical line element (16) and differential equation of motion (31) are more general and accurate than spherical form.

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