JOURNAL OF NANO- AND ELECTRONIC PHYSICS
Vol. **5** No 4, 04029(3pp) (2013)

ЖУРНАЛ НАНО- ТА ЕЛЕКТРОННОЇ ФІЗИКИ
Том **5** № 4, 04029(3cc) (2013)

Short Communication

Diode Based on Amorphous SiC

V.S. Zakhvalinskii, L.V. Borisenko, A.J. Aleynikov, E.A. Piljuk, I. Goncharov, S.V. Taran

Belgorod National Research University, 85, Pobedy Str., 308015 Belgorod, Russia

(Received 11 October 2013; revised manuscript received 05 November 2013; published online 10 December 2013)

Diode structure on the basis of amorphous silicon carbide and p-type polycrystalline silicon (Eurosolar) were obtained with magnetron RF-nonreactive sputtering method from solid-phase target in argon atmosphere.

Keywords: Atomic force microscopy, Transmission electron microscope, Silicon carbide, Thin films.

PACS numbers: 73.20, 73.40.Eq

1. INTRODUCTION

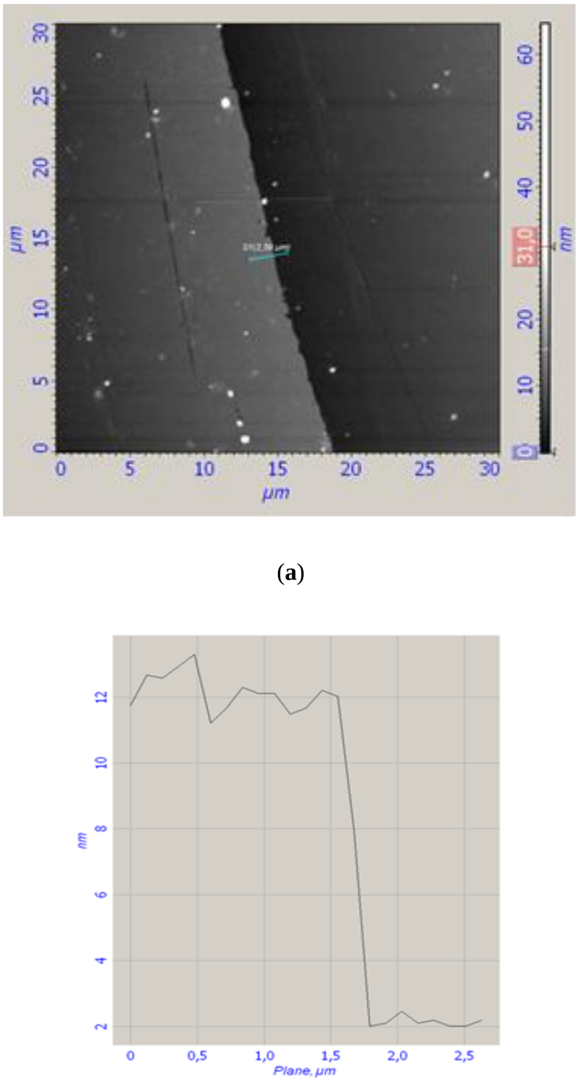
Silicon carbide is widely used in different technical fields due to its unique mechanical, chemical and electrical properties. Most of known types of electronic semiconductor units are implemented on its basis. Electroluminescence devices, visible, nuclear and ultraviolet radiation detectors, are been made on the basis of silicon carbide. Silicon carbide possess high critical breakdown field intensity, that is over $2 \cdot 10^6$ V/cm, Debye temperature ~ 1200 K, high mechanical resistance and good film adherence to lots of industry base plate, thermal stability, nuclear radiation and chemical tolerance. Application of SiC allows to improve lots of characteristics of elementary components of electronics: operation speed, ultimate commutation current and voltage, static and dynamic losses. Devices made on the basis of silicon carbide designed for high level of nuclear radiation and high temperature. Availability of properties considerably exceeding properties of analogs based on conventional matters provide a basis of expanding manufacturing of devices made from silicon carbide [1].

Greatly success of this development of elementary components of electronics trend is determinated by solving the problem of SiC base plate and quite a wide specter of requirements, but still the main of them is the price. The price of SiC base plate, that satisfy the requirements of electronics manufacturing industry is on average 100 dollars USA for 1 sq. inch [2].

The reason of such a high price of silicon-carbide electronics is SiC polymorphism. Polymorphism of SiC is defined by a big amount of similar crystal structure, called polytypes. The amount of silicon-carbide crystal structures reaches 250. In fact SiC has laminate super lattice structure, based on elemental layers of three kinds. Typical period of sequence of these elemental layers can differ from dozens of angstroms to dozens of nanometers, that can provide formation of layered superlattice.

Macroscopic properties of material, such as energy-gap width, charge carrier mobility, optical absorption coefficient, refraction index and chemical properties (oxydation rate, impurities diffusion rate) depends on relative position of layers.

Macroscopic properties of material, such as energy-gap width, charge carrier mobility, optical absorption coefficient, refraction index and chemical properties (oxydation rate, impurities diffusion rate) depends on relative position of layers.



(a)

(b)

Fig. 1 – Step on the edge of SiC film (a), height of the step on the edge of film (b)

The article was reported at the International Scientific-Practical Conference «Physics and Technology of Nanomaterials and Structures»

Silicon carbide is a semiconductor, its polarity of conductivity is strongly affected from impurities. SiC with n-type polarity of conductivity is usually determinated by nitrogen or phosphorus doping, when p-type is aluminum, boron, gallium and beryllium doping. Temperature dependence of electrical conduction demonstrated metal motion when heavily doped with aluminum, boron or nitrogen [3].

Silicon carbide is a semiconductor, its polarity of conductivity is strongly affected from impurities. SiC with n-type polarity of conductivity is usually determinated by nitrogen or phosphorus doping, when p-type is aluminum, boron, gallium and beryllium doping. Temperature dependence of electrical conduction demonstrated metal motion when heavily doped with aluminum, boron or nitrogen [3].

The problem of decreasing the price of electrical devices based on SiC could be solved by using amorphous and nanocrystalline silicon carbide. Recently there are more and more published works about investigation of properties of such materials and structures that are based on them [4].

Present article is dedicated to production of diode heterostructure based on thin film of amorphous SiC and investigation of its properties.

2. EXPERIMENT

Films of amorphous SiC were obtained by nonreactive rf-magnetron sputtering, using silicon-carbide target on plant BH-2000. As a substrate was used polycrystalline silicon Eurosolar (*p*-type). Before layering the layer of pure oxide SiO_2 was extracted from the base plate by etching in HF. Thickness of the film was controlled by methods of atomic-force microscopy (AFM) and compounded 8-9 nm (Fig. 1). On the film of amorphous SiC using magnetron sputtering method was applied Ni contact. Ag contact on the underside of base plate of polycrystalline Si was acquired with the same magnetron sputtering method. Diode structure SiC/p-Si is presented on Figure 2.

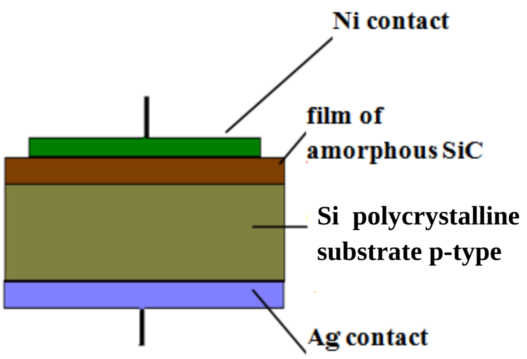


Fig. 2 – Diode structure amorphous SiC/Si polycrystalline

Amorphous nature of SiC film is affirmed by analysis results on the transmission electron microscope. Diffraction fringes on the Fig. 3(a) indicate absence of predominant orientation in amorphous film of SiC grown on the base plate of Si. As we can see, amorphous film SiC has granular structure.

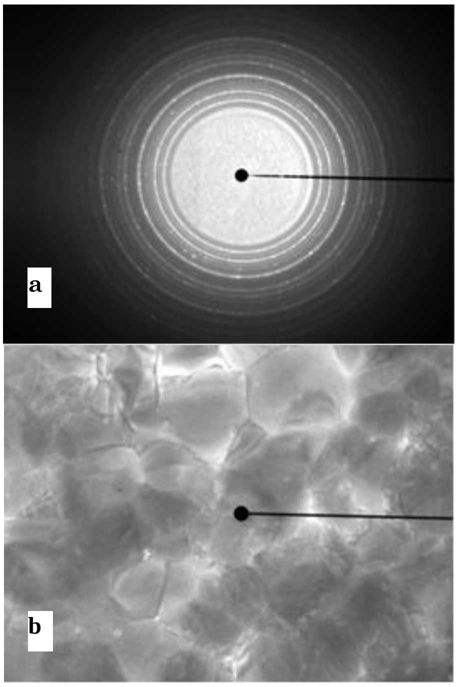


Fig. 3 – Difraction fringes indicate absence of predominant orientation in amorphous film of SiC grown on the base plate of Si (a), on the figure (b) we can see island structure of amorphous SiC film

Current-voltage characteristic was investigated a-SiC/*p*-Si on (Fig. 4) temperature 300 K. From the given above results we can see that on the strict branch of current-voltage diagram there are two parcels of dependence of current from voltage. At voltage of U_{dir} = 3 V the current was I_{dir} = 1000 μA. Enhancement of diode inverse currenttransforms into reversible breakdown of structure U_{rev} = 10 V.

3. DISCUSSION AND CONCLUSION.

Diode structure on the basis of amorphous silicon carbide and *p*-type polycrystalline silicon (Eurosolar) were obtained with magnetron RF-nonreactive sputtering method from solid-phase target in argon atmosphere. Surface morphology and thickness of the film were

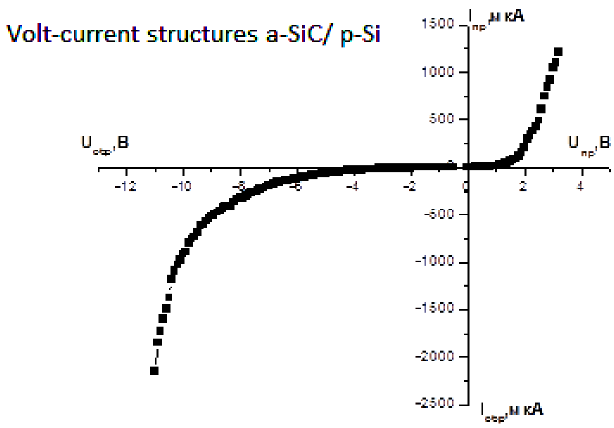


Fig. 4 – Voltage-current diagram of diode structure a-SiC / *p*-Si

investigated on the atomic-force microscope. Electron diffraction on the transmission electron microscope approved amorphous nature of SiC film. Received voltage-current diagram has features of diode structure.

ACKNOWLEDGMENT

Research was accomplished with the support of Ministry of Education and Science of the Russian Federation, within State assignment of Minobrnauki Rossii to jurisdictional institutes of higher education to research realization: reference number 2.3309.2011.

REFERENCES

1. Polishhuk, *Poluprovodnikovye pribory na osnove karbida kremnija – nastojashhee i budushhee silovoj jelektroniki, Komponenty i tehnologii*, **8**, 40 (2004).
2. V. Luchinin, J. Tairov, *Sovremennaja Elektronika* **7**, 12 (2009).
3. H. Morkoç, S. Strite, G.B. Gao, M.E. Lin, B. Sverdlov, M. Burns, *J. Appl. Phys.* **76**, 1364 (1994).
4. R.A. Andrievskij, *Uspehi Khimii* **79**, 889 (2009).