«Priority» Experiment

ADVANCED SPACE MATERIALS AND RELATED TECHNOLOGY FOR THE INFRARED AND RADIATION-RESISTANT ELECTRONICS

Rarenko I. M.

Chernovtsy State University
2 Kotsubynsky St., Chernovtsy 58032 Ukraine
tel. (380) +0372 +59 84 75, fax: (380) +0372 +55 18 09, e-mail: microel@chdu.cv.com

Tkachenko V. G., Maksimchuk I. N.

International Center for Electronic Materials Science and Applied Problems of Aerospace Technology
3 Krzhyzhanovsky St., Kyiv 03142 Ukraine
tel. (380) +44 +444 11 90, e-mail: dep59@ipms.kiev.ua

Slunko E. I.

Chernovtsy Department of the I. N. Frantsevich Institute for Materials Science Problems, NAS Ukraine
5 I. Vilde St., Chernovtsy 58032 Ukraine
tel. (380) + 0372 +52 22 71, e-mail: slunko@impspas.chernovtsy.ua

Space experiments completed in the USA and the USSR starting from 1980ies revealed the low effectiveness of space technology for the unstable CdHgTe alloys because of the gradual Hg-induced decomposition of their inhomogeneous and cored semiconductive solid solutions. Moreover, the high Hg toxicity posed a threat for the astronaut's life. Obviously, in order to avoid the relatively rapid degradation of widely used microelectronic devices in solid-state microelectronics and to increase their stability, service life and radiation resistance, these Hg-doped alloys should be replaced by ecologically clean and Hg-free materials of a new generation, including the unique set of InSb-InBi solid solutions with regulated (to 0.1 eV) width of the exclusion zone. In addition, due to the presence of intrinsic stoichiometric vacancies the advanced semiconductors of A^3B^6 group have the radiation resistance, which exceeds that of Si-materials by more than 2-3 orders of magnitude in the wavelength range of 0.3...5.0 μm without changes of electrophysical properties. For example, it will be possible to obtain radiation-stable photoreceivers with the specific detectivity $D^* = 3 \cdot 10^{13}$ cm$\cdot$Hz$^{1/2}$W^{-1} at the wavelength of 10 μm on the epitaxial layers of PbSnGeTe<In> (10 μm thickness). This detectivity exceeds by more than two orders of magnitude the value for the currently available materials.

The structural perfection of a substrate determines also the maximum density of photosensitive elements in the matrix photodetectors. The technical characteristics of crystals on the basis of new materials will enable the integral density to be increased up to 104 elements (for the element size of 35×35 μm and step of 50 μm). Reduction of element size down to 3 μm (5 μm step) will provide the integration density of 10^6. Doping with 3rd-group and rare earth metals of alloys with the same composition allows production of materials with a high resistance $\rho \geq 10^3$ Ohm$\cdot$cm at the temperature $T = 77$ K.

However, it is practically impossible to produce homogeneous and structurally perfect InBiSb solid solutions by monocrystal growing under the terrestrial gravity because of the strong gravitational liquation of Bi. First experimental evidence indicates the principal possibility to produce the high-grade Hg-free materials by space technology ensuring the structural homogeneity of solid solutions and uniformity of a distribution of Bi.

The main purpose of the proposed experiments is to grow structurally homogeneous, perfect monocrystal of composite $InSb_xBi_{1-x}$ and PbMLTe solid solutions (where M is Ge, Mn; L is In, Ga, Yb) under microgravity ensuring a stability of mass and heat flows at the solidification front. To achieve the required structural perfection of monocrystals, it is necessary to significantly reduce the instability of magneto-hydrodynamic diffusion layer at the solidification front of an ingot. This is possible under the conditions of microgravity ($g < 10^{-3}$) at the vibration amplitude $g < 10^{-4}$, i. e. under the conditions of space flight. Computer simulation will be applied for comparison of the obtained results with the gravitational experiment in the magnetic field. It will be further used for definition of the optimum technological requirements for industrial production of materials.