Is an Application of a Semiconductor in its Metastable Crystal Form a Danger for the Lifetime of Possible Device?

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The idea of possible semiconductor superlattice growth and the prediction of particular physical properties of new, low-dimensional structures have been presented for the first time at the ICPS in Warsaw in 1972. Since this conference an enormous development of the non-equilibrium techniques like, e.g., the molecular beam epitaxy (MBE) serving for the growth of low-dimensional objects, is observed in the solid state physics. From one side there exists an interest in the growth and characterization of low-dimensional semiconductor in the same crystal phase, as that of its bulk equivalent. On the other side an application of MBE technique makes it possible to create thin layers of material with quite a new crystal structure, which does not exist in nature. The materials obtained in such a manner often exhibit new, required physical properties, corresponding to particular needs of given device or application. The success of non-equilibrium growth technology results from well selected crystal symmetry and lattice parameter values of the substrate. The proper choice of the substrate material due to a presence of a compressive or tensile strain introduced in the grown layer stabilize its structure. For some particular purposes like, e.g., the space applications like the space missions etc. the long lifetime of electronic elements and other devices is a crucial problem. Up to our knowledge up to now the stability of 'metastable' form of semiconductor compounds were out of the interest. We have selected this problem as a topic of our present studies.

One from the best known semiconducting compounds widely investigated in its metastable crystal structure, obtained for the first time in [1], is the MnTe in the zinc blende structure (the stable MnTe crystal phase exhibits a hexagonal structure of NiAs type). Due to its particular magnetic order of AF III type the zinc blende MnTe was intensively studied since 1989 first in the form of thin layers (see, e.g., [1-4]) and next as a constituent of superlattices and other low-dimensional quantum structures. In the present work several few μm thick MnTe layers with the zinc blende structure grown onto GaAs substrate by MBE during different periods were investigated by the SEM, AFM, XRD, and nanoindentation methods. A partial decomposition of the oldest investigated layers was demonstrated. The selected structure properties of single metastable MnTe layers were compared with those of superlattices containing this crystal phase as well as with those corresponding to the bulk MnTe crystal in its stable form.

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