Properties of Infrared Detectors Made of $Pb_{1-x}Mn_xTe$/CdTe Multilayer Composite

S. Chusnutdinow[1,2], A. Kazakov[2], M. Szot[1,2], S. Schreyeck[3], R. Jakiela[1], K. Brunner[3] and G. Karczewski[1,3]

[1]Institute of Physics, Polish Academy of Sciences, Aleja. Lotników 32/46, PL-02-668 Warszawa, Poland
[2]International Research Center MagTop, Aleja Lotników 32/46, PL-02-668 Warszawa, Poland
[3]Physikalisches Institute, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

Infrared detectors are widely used for various purposes, such as chemical gas analysis, gas leak detection, IR imaging, remote temperature measurements, etc. In particular, there is continued interest in applications and consequently in the development of IR detectors operating at room temperature. We have shown experimentally that photoresistors made of the PbTe/CdTe multilayer composite are highly sensitive to infrared light, and their detectability at room temperatures is comparable to that of commercially available infrared detectors [1]. The high performance of PbTe/CdTe detectors is due to three factors. The first factor is a significant reduction in the concentration of free carriers in conductive PbTe layers due to their capture by broken bonds located at PbTe/CdTe interfaces. The atomic bonds at the interfaces are broken because of the different crystal structures of PbTe and CdTe, the rock salt and zinc blende, respectively. The second factor is a high mobility of carriers present in the PbTe layers. Despite the huge number of defects at the interfaces, the high mobility is preserved due to the high dielectric constant of PbTe, which effectively screens the scattering centers at the interfaces.

The main objective of the present work is to check how manganese atoms introduced into PbTe layers affect the performance of IR photoresistors made of $Pb_{1-x}Mn_xTe$/CdTe multilayer composite. It is known, that Mn effectively increases the energy gap of $Pb_{1-x}Mn_xTe$ [2], which leads to the increase of carrier effective masses and thus of the density of states. As a result, the concentration of carriers is expected to decrease with the increasing manganese content, x, which in turn should made the of $Pb_{1-x}Mn_xTe$/CdTe photoresistors more sensitive to optical excitation. Properties of $Pb_{1-x}Mn_xTe$/CdTe multilayer composite grown by molecular beam epitaxy on GaAs substrates have been studied. The study included morphological characterization by X-ray diffraction, scanning electron microscopy, secondary ion mass spectroscopy as well as transport and optical measurements. The main focus was on sensing properties of photoresistors made of $Pb_{1-x}Mn_xTe$/CdTe in the infrared spectral region. It was shown that the presence of Mn in $Pb_{1-x}Mn_xTe$ conductive layers shifts the cut-off wavelength toward blue and weakens the spectral sensitivity of the photoresistors. The first effect is due to an increase in the energy gap $Pb_{1-x}Mn_xTe$ with an increase in Mn concentration, and the second is due to a pronounced deterioration in the crystal quality of the multilayer by the presence of Mn atoms as shown by the morphological analysis.

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