Photoelectrical properties of p-CdZnTe/i-CdTe/n-CdTe diodes with PbTe nanoinclusions

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Devices based on cadmium telluride (CdTe) are widely used in renewable energy applications and medicine, due to its favorable physical and chemical properties (wide and direct band gap, high radiation resistance, low Auger recombination rate etc.) Detection range of CdTe-based detectors can be extended toward longer wavelengths by incorporation into the device structures of inclusions from a narrow-gap semiconductor, such as lead telluride (PbTe) having the energy gap of 0.31 eV at 300K. CdTe and PbTe have almost identical crystal lattice parameters, thus the lattice mismatch is only ~ 0.3%. However, CdTe and PbTe crystallize in the zinc blend and rock salt, respectively. As a result of the difference in crystal lattice structures these materials are almost immiscible. Limited miscibility allows creation of high-quality quantum size inclusions with high efficiency of electro-and photoluminescence even at room temperature [1, 2].

Here we report on optical and photoelectrical investigations of p-CdZnTe/i-CdTe/n-CdTe thin-film diodes with PbTe nanoinclutions produced inside the intrinsic CdTe absorption layer. The thin-film heterojunctions were grown by molecular beam epitaxy (MBE) on monocrystalline, semiinsulating (100) GaAs substrates from elemental sources. The n-type CdTe films were produced by iodine doping. Depending of the growth parameters either PbTe quantum dots or PbTe quantum wells were formed in the intrinsic CdTe layer. The CdZnTe layers were doped with nitrogen supplied from nitrogen-plasma source. The investigated structures exhibit a very strong photoluminescence (PL) emission in the infrared spectral range in the entire temperature range from liquid He temperatures up to room temperatures. At low temperatures strong PL signal centered at wavelength of 4.9 μm is detected. The full width at half maximum of the emission spectrum is 0.4 μm, which corresponds to 17 meV in energy terms. With the increasing temperature the emission peak narrows down to 7 meV and shifts towards higher energies reaching 3.49 μm at T=290 K. The temperature coefficient of the peak emission, 0.44 meV/K is in perfect agreement with those of the PbTe energy gap. The current-voltage characteristics of a p-CdZnTe/i-CdTe/n-CdTe diodes were measured in darkness and under infrared illumination (wide spectral range: 1- 20 μm). The dark forward-to-reverse current ratio for this diode is 10^6 at the bias of 0.8 V and the diode ideality factors is about 1.5. The leakage current of 1×10^{-10}A in reverse bias is observed. The reverse current increases under infrared illumination. Photocurrent is generated in diode due to absorption of the infrared light by PbTe quantum structures. The peak spectral response is observed at about 5.30 μm at 10 K. Reference CdTe diodes without PbTe nanoinclusions do not show any sensitivity in the mid-infrared spectral region. The investigated p-CdZnTe/i-CdTe/n-CdTe structures with PbTe nanoinclutions proved to be very promising for IR sensor applications.

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