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Analytical characterization of the In0.53Ga0.47As n+nn+ infrared detectors

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One of the most critical parts in fiber communication system is the receiver of the optical signal. Optical receiver in a digital communication system contains the photo detectors, tranimpedance amplifier and post amplifier then followed by decision circuit. The photodetectors characterization based on electrical and optical parameters of the devices where the dimensions of the structure are comparable with the incident wavelength. On the other hand, the appropriate choice of the photodetector is related to the responsivity value which is proportional to the efficiency absorption of the photons, the excess carrier generation, the free carrier concentration of the emitter layer and the optical incident power. The photodetector performance depends on the development of the advanced devices: structures and materials. The homo junction nanostructures have been demonstrated as wavelength tunable infrared detectors in recent years. This concept was successfully tested on Si, Ge and In GaAs materials. Moreover, the In1−xGaxAs has a high intrinsic carrier concentration with a high carrier mobility and saturated velocity. This material can detect and amplify radiation of wavelength within the range from 0.1 μm to 1.8 μm which is of recent interest in fiber-optic communication systems. The random fluctuations in a detector's output limit its responsivity to a certain minimum detectable power. The power necessary to generate an output signal equal to the noise is known as the Noise Equivalent Power (NEP). The NEP is the optical power that generates sufficient photocurrent to equal the noise current. However, the current noise level, of the structures and the materials used for the detection, can determine the radiative noise arriving at the detector from the background environment. In addition, the detectivity (D_), gives a meaningful comparison between different detectors, is widely used for the infrared photodetector characterization. This contribution presents an analytical model for the calculation of the responsivity and the detectivity of the In0.53Ga0.47As n+nn+ diode by using the current spectral density (current noise) in a n+nn+ structure developed. The current noise is evaluated at room temperature and under a constant voltage applied between the diode terminals. The noise calculation considers the synchronous motion of the free carriers in each region of the structure, the so-called"returning" carriers and the plasma resonances at the n+n homojunctions. In addition, the model can calculate in a first step the responsivity of the n+nn+ structure to light by using the photocurrent evaluation. The analytical approach takes into account the responsivity evaluation in the wavelength range of the In0.53Ga0.47As absorption. Then in the second step, the detectivity is investigated at different doping concentrations and at different thickness of the emitter layer in one dimensional inhomogeneous n+nn+ structure.

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