Multijunction-type PIN photodetector with pinhole reflection for optical communication applications

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In this paper, we studied a trade-off relationship between photodetector aperture size and 3 dB bandwidth, and the improvement of the responsivity. Here, we proposed a multijunction-type photodetector with a pinhole structure and discussed its potential for a high-frequency response and high responsivity in optical communication applications. The multijunction-type PIN-PD consisted of two stacked PIN blocks based on InGaAs contact layers on a p-InP/InGaAs/n-InP layer grown on an InP substrate with 5 um pinholes. A large photodetection area with a 0.3 mm diameter was employed. A lightwave was introduced from the back side of the substrate. A 3 dB bandwidth of 0.2 GHz in a conventional single PIN-PD is consistent with the simulation result. For a proposed double-stacked PIN-PD sample with a fill factor of 50 % of the pinhole yielded a 3 dB bandwidth (0.95 GHz) four times higher than that in a single PD. The responsivity of the double-stacked PD was calculated to be as high as 0.3 A/W, because a lightwave from the surface was mainly absorbed at the first absorption layer, and more than 50 % of the reduced lightwave power was absorbed at the second absorption layer. The photocurrent was defined as the minimum photocurrent in the two PIN blocks. When comparing the double-stacked PIN-PDs with and without pinholes, a 50 % responsivity difference was observed. By tilting the incident beam angle to the PD with pinholes, we found that an approximately 2 times higher responsivity was achieved.