主　論　文　要　旨

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論文題名

Study on transfer matrix method applicable to arbitrary multiple-layer photodiodes and on the development and practical use of high speed receivers using it

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主論文要旨

Theoretical and experimental study on high-speed photodiodes is descried in this thesis. For high-speed performance, low capacitance and short carrier transit-time are needed. To obtain low capacitance, it is necessary to increase thickness of depletion layers; however, thicker depletion layers increase transit-time. Therefore, there is a trade-off between them. The carrier transit-time must be handled rigorously. Conventional theoretical method needs complicated boundary conditions to analyze and design high-speed photodiodes because the frequency response is given by an integral of electron and hole densities over the total depletion layer. It is not suitable practically for designing complex structure devices, thereby increasing the computation-time. In this paper, transfer matrix of each layer is introduced to calculate the frequency response. With this method, the total layer structure can be easily described without using explicit complicated boundary conditions. Moreover, this method is extended to calculate arbitrary multiple-layer photodiodes with unified equations of absorption and multiplication phenomena. The high speed photodiodes used in future networks have been investigated using this transfer matrix method.

①For 25-Gbps interconnection PIN-PDs, the layer where only fast electrons run through is introduced for achieving low capacitance. A 3-dB bandwidth of 25 GHz with 25-μm-diameter PIN-PDs is demonstrated.

②For 43-Gbps DPSK PIN-PDs, the evanescently coupled waveguide PIN-PDs is proposed to achieve high-speed, high-responsivity and high-input-power-operation. A 3-dB bandwidth of 50 GHz and responsivity of 0.9 A/W are demonstrated as a result of the optimum design.

③For 10-Gbps access-network APDs, the mesa structure APDs with p-type graded absorption layer which enables short hole transit distance are designed and fabricated. A maximum 3-dB bandwidth of 11 GHz and GB-product of 120 GHz are realized.

④For 25-Gbps APDs aiming for over 100G-Ethernet-systems, waveguide APDs with an undepleted absorption layer are designed and fabricated. 25-Gbps operation with a multiplication factor of 7 is demonstrated.