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Modeling of AlInAsSb waveguide avalanche photodiodes for MWIR applications

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Mid-wave infrared (MWIR) photodetectors are obtaining increased market demand in various application fields such as sensing, spectroscopy, medical diagnostics, and communication systems. The application scope is also being expanded due to the integration ability for these devices into the silicon platforms. Although the MWIR avalanche photodiodes (APDs) have been developed and reported by several laboratories, challenges are still remained on reducing the signal-to-noise ratio, enhancing the quantum efficiency and improving bandwidths etc. These goal-oriented tasks are very challenging especially due to the internal impact ionization mechanism, the structure and material complexity, and the routine design trade-off issues among all the device performances. Therefore, modeling of such MWIR APDs as well as the relevant software package are highly requested to save the development time and cost. In this work, two-dimensional modeling of MWIR AlInAsSb waveguide APDs operating at 2 micrometer is presented. The edge-butt waveguide coupling is investigated based on the beam propagation method. The APD impact ionization and photon-electronic behavior are further simulated based on a drift-diffusion theory. The frequency response and bandwidth are also evaluated. Modeling results of I-V curves, multiplication gain, breakdown voltage, excess noise factor, -3dB bandwidth and gain-bandwidth product are presented with some comparable to the experimental report from other researchers. The bandwidth results are analysed and discussed with clues for further improvement.

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