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Waveguide Integrated Avalanche Photodiodes for InP PICs for Data-Center Applications

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A high-speed avalanche photodiode (APD) with a gain-bandwidth-product up to 250 GHz is presented. By using a p-doped hybrid absorber in a SACM structure evanescently coupled to a waveguide bandwidths above 20 GHz and a multiplied responsivity (MR)-bandwidth product of 135 A/W*GHz are achieved.

The increasing amount of data transfer and progressing development of of fibre-optic communication raises the demand for receivers which show high sensitivity as well as high bandwidth and low power consumption especially for datacentre applications. APDs based on the concept of separated regions for absorption and multiplication by impact ionization (SACM) can fulfil these requirements even for 100-Gb/s ethernet applications [1]. The concept of waveguide integrated APDs also offers the potential for 40Gb/s optical receivers [2] and allows the monolithic integration of demultiplexers on chip like arrayed waveguide gratings.

To achieve high performance APDs it is essential to consider the physical effects for the trade-off between the bandwidth, gain and responsivity. The bandwidth is limited by the RC time constant, the avalanche build-up time inside the multiplication layer and the transit-time of slow holes inside the absorber. A p-doped hybrid absorber can still stretch the trade-off between sensitivity and bandwidth of the photodiodes by reducing the transit time of generated holes [3].

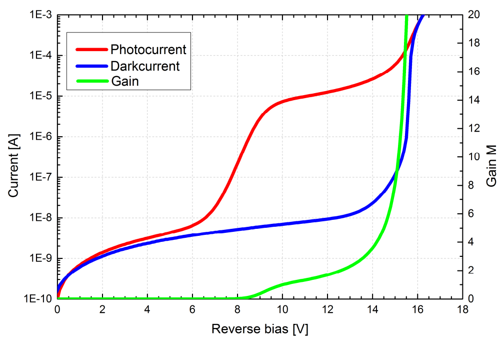

Fig. 1. Measurement of APD characeristics

The APD structure consisting of a cladding layer, the two parted absorber, the field controlling charge layer and a thin multiplication layer sandwiched between the p- and n-contact layers was grown on InP-substrate using MOVPE. The waveguide structure is placed under the n-contact. The mesa is processed by using wet- and dry-etching techniques. The UI-characteristics including the resulting gain is shown in Figure 1. The breakdown voltage is around U_{Br} = 16.0 V and a gain up to M=20 can be measured.

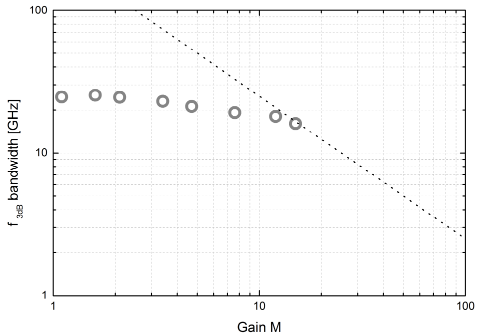

Fig. 2. Gain-Bandwidth-Product

The measured gain-bandwidth product (GBP) with its maximum at 250 GHz is presented in Fig. 2. For low gains M < 4 the bandwidth is above 20 GHz and still up to M=11 a bandwidth of 18 GHz was measured. Furthermore the responsivity shows just a low polarization-dependence as plotted for the unity-gain voltage (M=1) in Fig. 3. These low polarization dependent losses (PDL) in combination with its high sensitivity, high bandwidth and low power-consumption makes these APDs a good candidate for 4 x 25 -Gb/s applications in data-centers.

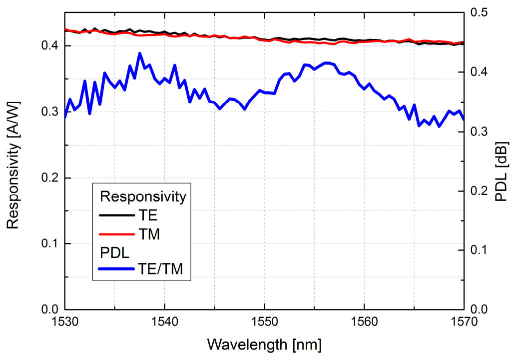

Fig. 3. TE- and TM-dependent responsivity at unity-gain

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