THz Photodiodes

Authors: Andrzej Jankowski and Andreas Stöhr — andrzej.jankowski@uni-due.de
Universität Duisburg-Essen, ZHO-Optoelektronik, Lotharstr. 55, 47057 Duisburg, Germany

Concept

The increasing interest in RF photonic signal generation in the terahertz (THz) and microwave frequency range requires high-speed and high-power optoelectronic devices, which surpass conventional electronics techniques. Photonic transmitters’ superior feature to transfer high-frequency, low loss, RF signal via optical fibers over long distances are thus key components in microwave-to-terahertz generation. Recent developments of a log-periodic toothed antenna integrated with a passive waveguide-coupled p-i-n photodiode based on InP substrate are of the great interest on the global market of wireless high-speed communication systems, where high output power are required for practical applications. This poster presents a new concept of a small-scale integrated photonic THz transmitter employing a log periodic toothed (LPT) antenna integrated with a passive waveguide-coupled p-i-n photodiode.

THz transmitter

The structure of the developed antenna-integrated photodiode can be seen above (a) where the passive optical waveguide (POW) and photodiode structure are presented. The device is based upon InP substrate grown by MOCVD (b). The photodetector consists of a partially p-doped, partly non-intentionally doped absorbing ternary layer. The photodiode is integrated with the POW waveguide, where InP is used as top and bottom cladding layer, while the core is based on InGaAsP. The fabrication process employed standard photolithography, wet and dry chemical etching, and PVD for metal evaporation. The passivation was performed with the usage of benzocyclobutene (BCB).

On the first photograph above a side of the n-contact mesa structure is shown (c); in order to avoid breakages of the metallization on the edges of the mesa, a BCB layer is applied. An air-bridge connection is used to establish the p-contact. A close-up view can be seen on the last photograph (e).

Measurement setup

The optical heterodyne signal is launched into the passive low-loss optical channel waveguide (POW) via a tapered optical fiber, guiding the signal to the active section where it is gradually absorbed, resulting in a distributed current generation along the detectors length that contributes to the overall current. In the measurement setup Schottky detectors are used in the frequency range from 30 GHz to 325 GHz.

Results and Applications

Results of the 60 - 70 GHz characterization of the developed components are presented on the left side. The new transmitter has an optimized layer structure as well as an improved antenna-feeding, lower loss POW, and an improved passive waveguide coupling efficiency (DC responsivity w/o AR coating ~ 0.12 A/W).

An example of application of the THz transmitter is presented on the left: high-speed wireless data transfer between neighboring buildings.