10 Gbit/s Monolithic Integrated MSM-Photodiode AlGaAs/GaAs-HEMT Optoelectronic Receiver

V. Hurm, J. Rosenzweig, M. Ludwig, W. Benz, R. Osorio, M. Berroth, A. Hülsmann, G. Kaufel, K. Köhler, B. Raynor, and Jo. Schneider

Fraunhofer-Institut für Angewandte Festkörperphysik,
D-7800 Freiburg, Germany, (Phone: 0761-5159-555)

Several research groups have reported on the technology of monolithic integration of **MESFETs on GaAs** with photodetectors for light of 0.85 µm wavelength. In this paper we present the first photoreceiver which is based on a metal-semiconductor-metal (MSM) photodiode and **AlGaAs/GaAs HEMTs**.
The photoreceiver was fabricated using our established 0.5 µm recessed-gate process for double delta-doped quantum well HEMTs /1,2/. The following mean values for the enhancement and depletion HEMT parameters respectively have been obtained: threshold voltage: 0.1 and -0.5 V, transconductance: 500 and 390 mS/mm, source resistance: 0.7 and 0.6 Ωmm, transit frequency: 35 and 30 GHz. This process now includes photodiodes. A deep wet etch was used to deposit the photodiodes on an undoped GaAs buffer layer. The 1 µm wide photodiode fingers with 1.5 µm spacing were defined by electron-beam lithography and subsequent lift-off of Ti/Pt/Au Schottky metal. The DC responsivities of the photodiodes to light of 0.84 µm wavelength were 0.25 A/W for 4 V and 0.35 A/W for 10 V bias voltage, respectively. The dark current at 4 V was less than 2 nA for a photodiode with an active area of 25x25 μm^2.
The monolithic integrated optoelectronic receiver consists of a MSM-photodiode, a transimpedance amplifier, and a 50 Ω output buffer. The transimpedance stage is composed of two enhancement transistors (gate widths 40 µm), two 1 kΩ NiCr thin film load resistors, and a 500 Ω NiCr feedback resistor. The output stage is a source follower with a constant current load (gate widths 80 µm). All high frequency measurements on the receiver were performed on-wafer using CASCADE probes. The photodiode was irradiated by 0.84 µm light from a high speed ORTEL laser diode via a single mode fiber. The current driving the laser diode was modulated to obtain up to 0.8 mW peak-to-peak modulated optical signals. The -3 dB bandwidth for sinusoidal modulated incident light lies at 8.2 GHz. The circuit response to pulse-modulated non-return-to-zero (NRZ) optical signals was tested at data rates up to 10 GBit/s using an ANRITSU pulse pattern generator. The eye diagram of the output voltage demonstrates that the optoelectronic receiver operates successfully for a 10 Gbit/s NRZ pseudorandom data stream of length 2^7-1 bits.

/1/ K. Köhler, P. Ganser, K.H. Bachem, M. Maier, J. Hornung, and A. Hülsmann, Proc. Int. Symp. GaAs and Related Compounds, Jersey, 1990, Inst. Phys. Conf. Ser., 112, p. 521, 1990.
/2/ A. Hülsmann, G. Kaufel, K. Köhler, B. Raynor, K.H. Glorer, E. Olander, B. Weismann, J. Schneider, T. Jakobus, Proc. Int. Symp. GaAs and Related Compounds, Jersey, 1990, Inst. Phys. Conf. Ser., 112, p. 429, 1990.

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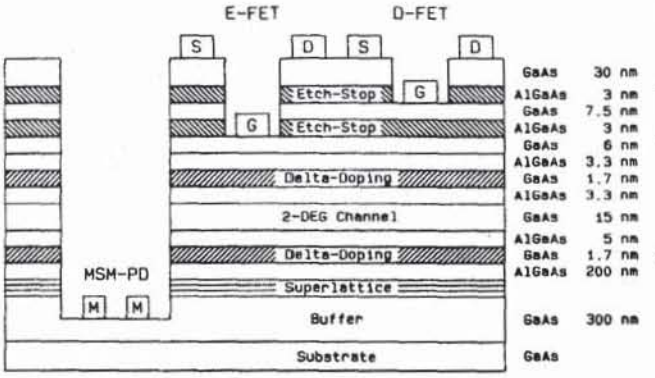

Fig. 1
Schematic cross section of a MSM-photodiode integrated with recessed-gate AlGaAs/GaAs HEMTs. Airbridges (not shown) connect the photodiode to the enhancement and depletion transistors.

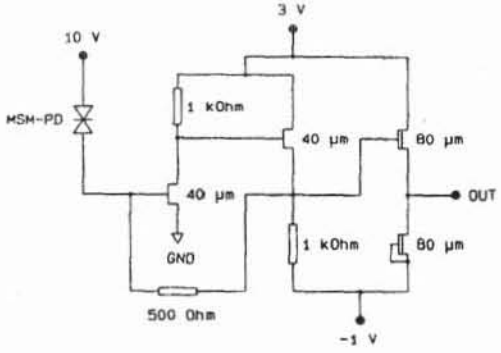

Fig. 2
Circuit diagram of the photoreceiver. The receiver consists of a MSM-photodiode (25x25 µm²), a transimpedance amplifier with two enhancement transistors and three NiCr thin film resistors, and a 50 Ω output buffer with two depletion transistors.

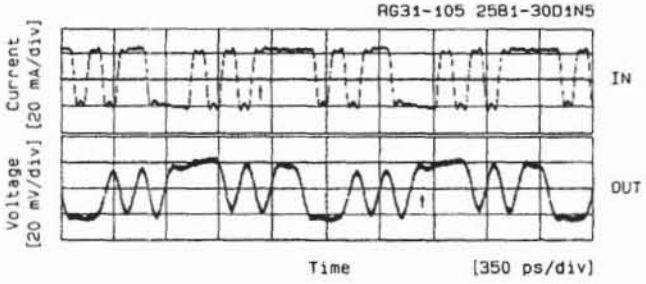

Fig. 3
10 GBit/s non-return-to-zero (NRZ) waveforms of the pulse-modulated laser diode current and the photoreceiver output voltage. The time-delay, indicated by the two arrows, is due to the measurement equipment.

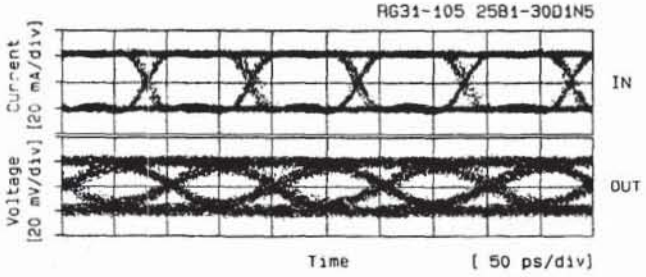

Fig. 4
Eye diagrams of the laser diode current and the photoreceiver output voltage for a 10 GBit/s NRZ pseudorandom data stream of length 2^7-1 bits.