Performance of $\text{In}_{0.47}\text{Ga}_{0.53}\text{As}$ metal–semiconductor–metal hybrid receiver at 1.55 $\mu$m

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We report on the performance at 1.55 $\mu$m of a hybrid receiver combining an $\text{In}_{0.47}\text{Ga}_{0.53}\text{As}$ metal–semiconductor–metal photodetector (with buried AlInAs buffer layer) with a GaAs MESFET preamplifier. A bit error rate of $10^{-9}$ is measured at 1 Gbps with nonreturn to zero pseudorandom bit sequence ($2^{15} - 1$) at a received optical power of $-19$ dBm. Modification of the preamplifier design and a reduction of bond pad size could improve the sensitivity by $\sim 6-7$ dB.

Metal–semiconductor–metal (MSM) photodetectors promise to be important components for systems in optical interconnect and optical networking owing to their ease of fabrication and simplified packaging through O/E integration. InGaAs MSM photodetectors with a buried AlInAs buffer layer have been grown, fabricated and characterized at 1.3 $\mu$m [1]. It is shown that the presence of this buffer layer dramatically reduces the parasitic capacitance, enhances carrier collection and, more importantly, effectively eliminates low-frequency gain, which is a common problem associated with MSM photodetectors. Here, we report the performance at 1.55 $\mu$m of a hybrid receiver combining the MSM photodetector with a GaAs MESFET preamplifier. Device characteristics of the MSM detector at 1.55 $\mu$m will also be discussed.

Details of the structure, MBE growth and fabrication of the InGaAs photodetector are given in [1]. Briefly, a 1 $\mu$m $\text{In}_{0.51}\text{Ga}_{0.49}\text{As}$ active layer is grown on top of a semi-insulating InP substrate (inset in Fig. 1). The structure includes a buried AlInAs layer to reduce the capacitance at the substrate–InGaAs interface and to enhance the carrier collection. There is also a graded InAlAs top Schottky contact layer to reduce the dark current. The area between the fingers is covered with an SiNx antireflection coating optimized for low reflection loss at 1.3 $\mu$m. A typical device used in this study is 150 $\mu$m in diameter ($D$) and has an approximate finger width ($w$) of 1.5 $\mu$m and spacing ($s$) between fingers of 2.5 $\mu$m, resulting in 38% shadowing. Figure 1 shows the DC responsivity as a function of spectral range of the MSM detector at 300 K and 77 K. In the experiment, light from a quartz lamp was...
focused onto a 1/2-m spectrometer with 2-mm slits, giving a spectral resolution of 160 Å. A spectral filter was positioned at the spectrometer exit slit to eliminate shorter wavelengths resulting from higher diffraction orders. The light was then directed into a 20:1 microscope objective that focused the light into a 50-μm core multimode fibre optic cable. The end of the cable was butt-coupled to the MSM detector. The light power versus wavelength was measured with an optical power meter and was of the order of 80 nW for the entire wavelength range. At 300 K and bias voltage, $V$, of 5 V, the responsivity extends beyond 1.60 μm, while at 77 K the cutoff is at 1.5 μm. The responsivity is nearly flat from 1.2 out to 1.6 μm and then drops off to nearly zero by 1.7 μm. Taking into account the 38% finger coverage, we obtain an intrinsic responsivity of about 0.64 A W$^{-1}$ at 1.55 μm. We calculate that an AR coating optimized for the 1.55 μm range would result in about 5% improvement. We also note that the dark current at 77 K and 5 V is only 550 pA, while at 300 K, the dark current is about 41 nA.

Figure 2 shows the DC response versus optical intensity of the detectors at 1.553 μm. As was reported earlier at 1.3 μm, there is early saturation of the response at < 1 V. This is an indication that the layer is depleted and that it does not suffer from an internal gain mechanism or charge pile-up at the Schottky barrier interface. After saturation, we observe a linear photoresponse versus illumination intensity. We note that the device performance showed some variation across the wafer, particularly in regard to carrier collection efficiency, resulting in some pronounced increases in responsivity with voltage. We believe that this can be minimized in future devices with improved processing and is not a problem with the device structure. The pulse response of the devices (inset in Fig. 2) was obtained using a gain-switched 1.553-μm laser with an FWHM of 46 ps. The gain-switched pulses were generated by biasing a high-speed distributed feedback laser diode (bandwidth ≈ 6 GHz) with a DC current and electrical pulses (FWHM ≈ 57 ps). The electrical pulses were generated by passing a sine wave through a