Lateral p-i-n Photodiodes Fabricated in a Commercial GaAs VLSI Process

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An obvious first choice as a photodetector for GaAs MEtal-Semiconductor Field Effect Transistor (MESFET) integrated circuit technologies is the metal-semiconductor-metal (m-s-m) detector since it uses an interdigitated array of Schottky barriers on the surface of GaAs which is structurally very similar to the MESFET gate metal pattern. The basic MESFET process must be modified, however, so the m-s-m detectors do not receive the source-drain implant because this would degrade their performance; other minor changes are also necessary. We have worked with James Mikkelson, the Chief Technical Officer of Vitesse Semiconductor, to make minimally intrusive modifications to Vitesse's new HGaAs-IV IC process in an attempt to allow Vitesse to produce GaAs ICs with integrated high performance m-s-m photodetectors, but we have concluded that a far better approach is to fabricate lateral p-i-n photodiodes.

The HGaAs-IV process includes deep n-type isolation implants to define separated p-type wells with heavy p-type implants and ohmic contacts to individual wells. Careful analysis we have made of m-s-m detectors made in this process reveal that the underlying p-n junction is a source of serious problems. During the course of our work it was realized that underlying p-n junction could be converted from a lossy parasitic to the active portion of a detector by designing a lateral p-i-n detector using the HGaAs-IV process. This option was not available in earlier HGaAs processes and was thus not considered before, but the new process, with its isolation regions and ohmic contacts to both n- and p-regions, is well suited to realizing this device. Moreover, no modifications are required in the basic process, making it even more attractive than the m-s-m process.

Based on these considerations, during the past year lateral p-i-n photodiodes have been produced in a standard, unmodified commercial GaAs integrated circuit process (the Vitesse HGaAs IV process) and have been found to show excellent static and high frequency performance, being superior to m-s-m photodetectors fabricated in the same process modified to improve their performance. The p-i-n photodiodes show linear photoresponse of 0.25 A/W for inputs from under 1 µW to over 1 mW (the range measured), their dark current is under 200 pA, and their reverse breakdown exceeds 30 V. The 3 db frequency of 75 µm diameter devices with 2.0 µm p-to-n spacings exceeds 500 MHz with bias of 6 V or more. The impulse response is symmetrical with a full-width at half-maxium of under 130 ps.

These results are extremely encouraging in that the structures were not optimized, nor was the p-to-n spacing minimized; the high frequency performance of optimized, minimum geometry devices is predicted to be significantly better. This year we will be continuing this work with the fabrication of improved geometry devices.