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14. ABSTRACT
GaN Transferred Electron Devices (TEDs) have been investigated on SiC substrates. SiC thinning and via-hole technology have been developed and applied to GaN TEDs for improved performance. Low-temperature tests have been conducted for better understanding of velocity-field characteristics. Passive micromachined circuitry has been investigated and deep etched vertical wall structures were explored. Micromachined-to-waveguide transitions have been fabricated and a test circuit for a micromachined waveguide to planar circuit probe has been designed, fabricated, and tested at W-band.

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Progress Report: DARPA THz Project

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This project focuses on the development of GaN Transferred Electron Devices and micromachined circuits.

In the area of GaN Transferred Electron Devices we have been working on the following

Major effort was placed on the development and optimization of all the critical processing steps necessary for producing GaN-based Transferred Electron Devices. The include SiC wafer thinning, separation of fabricated diodes into discrete chips, mounting into cavities and etching of via holes for backside processing.

Lapping technology for SiC wafers has been set up and a lapping rate of ~50μm/hour has been achieved using BC powder. SiC wafers of ~350μm initial thickness have been successfully thinned down to ~50μm. Electrical testing of GaN devices after thinning revealed no degradation of electrical characteristics, including MMIC devices with pre-fabricated airbridges. We have attempted to use a scribing tool to separate the thinned GaN diode wafers into discrete chips but breaking took place along the hexagonal direction. Use of a trimming laser technique was also attempted. Ultra thin diamond blades have been used and allowed dicing of the GaN diodes. We have interacted with a Gunn diode company regarding diode packaging and have prepared samples for mounting at their facility. The devices prepared will be placed in packages that are compatible with cavity resonators.

In view of a complementary characterization of transport properties in GaN materials we have interacted with the Army Research Laboratory and determined a structure, which could be adapted to their measurement system and employs Schottky rather than p-n junction design.

Using SiC substrates with high thermal conductivity allowed us to bias GaN Gunn diodes under very high power conditions. However, the estimated value of the electric field within the active region for this devices was still lower (*125KV/cm*) than the threshold field, estimated by experimental techniques i.e. ARL (200KV/cm). By cooling the device down to *170K* in the cryogenic chamber we have obtained for the first time a very promising pulsed I-V characteristic which showed a definite current saturation at a voltage of ~23V and a current of ~2.2A.

We have designed GaN diodes with AlGaN launchers to study the impact of heterostructure launching on the dead zone and efficiency of operation. Layers of this type were grown by MOCVD and are currently processed.

The design of a planar Gunn oscillator has been initiated in collaboration with Linz University that pioneered this approach. This GaN Gunn circuit will allow to perform a comparative study of operation with the original vertical approach in terms of transport and thermal effects.

In the area of micromachined components for THz circuits we have been working on the following:

Passive micromachined circuits have been investigated for THz applications. We have three ongoing projects under the program. The first project is the development of microwave machined waveguides for high frequency applications. Hopefully these will replace difficult to machine conventional waveguides. We have optimized a deep etch process to fabricate vertical wall structures. This process have been used to fabricate prototype WR3 waveguides for operation between 220 and 325 GHz. We have also designed and fabricated WR3 tunable shorts. Typical micromachined structures are sometimes difficult to characterize. We have fabricated waveguide flanges to allow connection between the micromachined circuits and existing measurement systems. These WR3 circuits are ready for measurements.

The second project is a complete micromachined waveguide to planar circuit probe. This structure will allow integration of semiconductor devices with micromachined structures. A test circuit has been designed, fabricated and RF tested in W band with excellent results. Finally, we have started on the design of a micromachined THz power combiner. This circuit will combine waveguides, tuning elements, transitions and antennas in a single circuit as a test structure for more complex circuits. The initial design work on this structure has started.

Recent Publications

1. E. Alekseev and D. Pavlidis, GaN-based Gunn Diodes: Their Frequency and Power Performance and Experimental Considerations, Topical Workshop on Heterostructure Microelectronics, Kyoto, Japan, August 20 to 23, 2000, pp. 46-47
2. A.K. Panda, D. Pavlidis, E. Alekseev, DC and High-Frequency Characteristics of GaN-based IMPATTs, To appear in: IEEE Transactions on Electron Devices
3. A.K. Panda, D. Pavlidis, E. Alekseev, Noise Characteristics of GaN-based IMPATTs, To appear in IEEE Transactions on Electron Devices
4. E. Alekseev, D. Pavlidis, W. E. Sutton, E. Piner and J. Redwing, GaN-based Gunn Diodes: Their Frequency, Power Performance and Experimental Considerations, Submitted to the Journal of the Institute of Electronics and Information and Communication Engineers (IEICE), Japan
5. James P. Becker, Yongshik Lee, Jack R. East and Linda P.B. Katehi, "A Fully Packaged Finite-Ground Coplanar Line-To-Silicon Micromachined Waveguide Transition," Proceedings of IEEE 9th Topical Meeting on Electrical Performance of Electronic Packaging, Oct 2000. IEEE#00TH8524, pp. 273-276
6. James P. Becker, Yongshik Lee, Jack R. East and Linda P.B. Katehi, "A Finite Ground Coplanar Line-To-Silicon Micromachined Waveguide Transition, submitted to IEEE Transactions on Microwave Theory and Techniques, Special Issue.