Abstract for an Invited Paper
for the MAR09 Meeting of
The American Physical Society

Beyond Moore's Law: Heterogeneous Integration of III-N Semiconductors and Si CMOS Electronics[1]

TOMAS PALACIOS, Massachusetts Institute of Technology

Moore's law has been one of the main drivers behind the unprecedented development of semiconductors in the last forty years. However, this economical and technological paradigm that has helped to create modern Si electronics is now jeopardizing its future. Traditional Si scaling is not only becoming unaffordable, but the performance improvement due to scaling is diminishing. Our group is working on an approach different from Moore's law to increase the performance of electronics: the heterogeneous integration of different semiconductor materials on the same wafer. In this paper, we describe our work on the seamless integration of GaN-based devices and Si electronics. While Si electronics has shown unsurpassed levels of scaling and circuit complexity, nitride semiconductors offer excellent optoelectronics and high frequency/power electronic properties. The ability to combine these two material systems in the same chip and in extremely close proximity would allow unprecedented flexibility for advanced applications. Using wafer bonding technology, virtual Si (001) / GaN / Si (001) substrates have been fabricated for the first time. Due to the high thermal stability of GaN, Si CMOS electronics can be processed in this new substrates without affecting the nitride layers underneath the surface. After the Si devices are fabricated, the Si material is removed from the regions where nitride devices are needed. Then, the nitride devices (transistors, LEDs, lasers or sensors) are processed at room temperature and, finally, an interconnection layer forms the final hybrid circuits. Using this new technology several hybrid circuits are currently being developed, including high power differential amplifiers and normally-off power transistors. These advanced circuits are just a few examples of the potential of heterogeneous integration and how the close integration of Si and other materials enables a vast array of new exciting opportunities for electronics.

[1]This work has been partially supported by the DARPA Young Faculty Award, monitored by Dr. Mark Rosker.