Journal of Pharmaceutical Technology and Innovations
Extended Abstract
2020
Vol. 1, Iss. 1

The international debate on III-V Compound Semiconductor materials based HEMT devices for RF applications

Dr.T.D.Subash
Mangalam College of Engineering, Kottayam, Kerala, India

Due to tremendous advances in lithography, the semiconductor industry has followed Moore's law by shrinking transistor dimensions continuously for the last 30 years. The big challenge in VLSI is that continued scaling of planar silicon, CMOS transistors will be more and more difficult because of both fundamental limitations and practical considerations as the CMOS transistor dimensions approach tens of nanometers. To address the scaling challenge, both industry and academia have been investigating alternative device structure and alternative materials, among which III-V compound semiconductor materials as a promising candidates for future logic applications because of their light effective masses lead to high electron mobility's and high on-currents, which translates into high device performance at low supply voltage. Due to outstanding electron transport properties and high mobility III-V compound semiconductor materials are the better channel materials for future highly scaled CMOS devices.

Since its initial experimental demonstration at Fujitsu Labs in 1980, the compound semiconductor heterojunction-based high electron mobility transistor (HEMT) has been extensively employed in radio frequency (RF) applications, in which low-noise and high-frequency responses are required. Over the past few decades, research on group-III-nitride- and III-V-based HEMTs has received significant attention. Although III-nitrides belong to the III-V families, the stable structure of the group III nitrides, for example, the structure of GaN, is hexagonal wurtzite, and the structures of other III-V materials is cubic zinc-blende. GaN has attracted substantial amounts of attention as a basis for manufacturing high-speed and high-power electronic devices due to its wide bandgap, high electron saturation velocity, and high critical breakdown field. In particular, GaN-based HEMT, in the form of Al(Ga)N/GaN HEMT, has been regarded as the next-generation RF power amplifier for wireless communication and power converter in utility grid applications. Two main problems associated with GaN HEMTs are gate leakage and DC-RF dispersion (also referred to as knee-voltage walkout), which can be mitigated by implementing a metal insulator semiconductor (MIS) structure and proper surface passivation, respectively.

idea of depositing a layer that simultaneously serves as a gate dielectric layer and as a surface passivation layer leads to an in-depth analysis of ex situ Al2O3 by atomic layer deposition (ALD) and in situ SiNx by metalorganic chemical vapor deposition (MOCVD). For high-frequency power applications, several key HEMT quality parameters, including cut-off frequency (fT), maximum oscillation frequency (fmax), and maximum drain current, are linked to a number of important considerations in device design. An overview of HEMT devicescaling technologies that consider barrier thinning, advanced gate fabrication, and S/D resistance reduction is presented. Due to their tunable, wide, and direct bandgap (0.7–6.2 eV), III-nitride materials have also received significant attention for fabricating light-emitting diodes (LEDs) in the visible light spectrum as general lighting sources. A monolithic integration of GaN-based HEMT and LEDs that can eliminate the parasitic connection inductor and significantly minimize the LED driver size is demonstrated. A number of considerations in the design, growth sequence, and fabrication of this novel integrated system are discussed. The second section of this chapter presents a detailed overview of zinc-blende III-V based HEMTs. In addition to the diversity of III-V semiconductors that offer superior material selection feasibility for producing heterostructure-based HEMTs, several important types of III-V

HEMT types, including delta-doping HEMTs, “pHEMTs,” and “inverted” HEMTs, are described in detail. The status of state-of-the-art V-III HEMTs, which feature high electron mobility in the two-dimensional electron gas (2DEG) layer, are also reviewed, particularly in terms of fT and fmax. Considering the high electron mobility in III-V HEMTs, the potential for replacing the existing Si CMOS transistor channel with a III-V-based channel has garnered significant interest. A number of key considerations in terms of gate dielectric selection, source/drain engineering, and advanced gate design have been identified and reviewed. To facilitate high-level integration between III-V devices and advanced Si CMOS technology, high-quality III-V thin films on Si, which can be obtained by wafer bonding or heteroepitaxy, are required. The advantages and major challenges in terms of the heteroepitaxy of III-V compounds on Si substrates are discussed. Recent advances in the growth of III-V materials and heterostructures on Si using various buffer layers or nanopatterned growth are comprehensively summarized.

Biography:

Dr.Subash is currently a full time professor, Department of Electronics and Communication Engineering of Mangalam College of Engineering, Kottayam, Kerala. He was the active senior member of IEEE and Founding Chairman of IEEE Photonics Society Madras Chapter since September 2015. He completed his Bachelor of Engineering in Electronics and Communication Engineering and Master of Engineering in Embedded System Technologies from Anna University, India in the year 2008 and 2011 respectively. He completed his PhD in Nanoelectronics from Anna University, Chennai in the year 2016. He has 36 publications in International and National Journals and 25 papers in International and National Conferences in the area of Nanoelectronics, Nanoscale Device Modelling, Nanotechnology and Wireless Sensor Networks.

Note: This work is partly presented at 17th Nanotechnology and Nanomedicine Congress June 26, 2020 held at London, UK