Perspectives, Opportunities and Future of Compound Semiconductor Technologies in India

Dhrubes Biswas[1,2] (Senior Member, IEEE)

[1]Department of Electronics and Electrical Communication Engineering, Indian Institute of Technology – Kharagpur, India
[2]Rajendra Mishra School of Engineering Entrepreneurship, Indian Institute of Technology – Kharagpur, India
dhrubes@gmail.com , Ph: +91-9830709611

KEYWORDS: mobile markets, solar photovoltaic, LEDs, secondary device markets

India is the second fastest growing economy in the world, with robust free market in a technology savvy, strong middle class driven population of 1.35 billion people. The government has put semiconductors and nanotechnology as base drivers of telecommunication, education delivery, computation and media, manufacturing sector driven by automotive, energy, healthcare diagnostics, alternative energy and energy efficient illumination systems apart from consumer electronics usage leading to an inclusive society.

Electronic consumption in India is doubling every three years, out of which around $43 billion will be in semiconductor components by 2016. This has provided aspirations for creating in general new fab infrastructure in India, with increased interests in compound semiconductors. India has become a global product design hub, with over 100 foreign IC design and embedded software companies have already set up design centers in India such as ST Micro, Freescale, AMD, Intel, Infineon, Cypress, Connexant, IBM, TI, ARM, Analog Devices, Alliance, Broadcom, Silicon Laboratories, and domestic companies such as Wipro and Sasken. Against this backdrop of opportunities, conventional fab costs have skyrocketed, with complex manufacturing technology implementations at progressively smaller nodes makes it capital and know-how intensive. This has necessitated customized semiconductor policies to address "beyond the normal Moore's" approaches, which by default invokes compound semiconductors that are sustainable for emerging economies. Recently the government has announced new fab policies which have direct subsidies to the tune of $2 billion. This has put India on a high speed track for developing semiconductor infrastructure in tune with the rest of the VLSI ecosystem.

The extraordinary growth of the Indian wireless industry is well assorted across fixed and mobile wireless as well as in wireless infrastructure in the fast growing economy. India is expected to have 1.3 billion mobile subscribers in 2014, with 2010 sales of over $2 billion, with 10 million handsets sold per month, while the number of 3G mobile subscribers is expected to grow at a CAGR of around 80% between 2011 and 2013. The smart-phones are healthy 20% of the market and is expected to drive the use of compound semiconductors, with a staggering CAGR over 75%. Added to this are the momentous growth of telecommunication markets, evidenced by recent $24 billion 3G spectrum sale, hurled by the need to rapidly upgrade the average teledensity of 55% with over 650 million subscribers (90% wireless) as well as bridge the rural-urban divide of 112% vs 24%. This will bring a mix of Wimax, LTE and newer technologies to provide a variety of services that increases the footprint of compound semiconductors. It is important to observe the perfect free market conditions in the industry with over 8 service providers and over a billion consumers. They are further powered by the advantages of a unlocked SIM card as well as empowered by cellular number portability legislations.

The traditional push from the Wireless sector is getting a timely traction from the applications in automotive, consumer, and health sectors of the burgeoning Indian economy. The healthy consumer electronics segment of 21% of the semiconductor market has added vitality from popular DTH and HDTV services along with intelligent home appliances. The sleeping driver is the automotive electronics market of over $2 billion, growing at over 30% CAGR to over $3 billion next year, with fancy GPS enabled sensor loaded cars and electric vehicles with power convertors enabled by compound semiconductors. The industrial electronics market also adds to the strength of the opportunity to over half a billion dollars in 2014, with a considerable non-silicon component.

The government's major e-governance initiatives contributed to over $2 billion to the overall semiconductor market with unique identification (UID) driven smart card services and education technologies apart from a robust PC sales of over 3 million units with 50% in laptops, that has a lot of headroom for compound semiconductor devices. This is topped by over $14 billion in medical devices with enormous growth in healthcare delivery infrastructure,

which is key factor to its inclusive growth necessary for stable economic future.

Added to these, is green initiatives lead by the high brightness LED market in India currently over $11 billion with double digits CAGR, complemented by the solar PV installation base increasing 10 folds from current 100MW capacity by 2012, with substrate business of about $2 billion is at 20% of the LED chip market which will be over $9 billion. The complementary solar market is leaping forward as well with over 1.5GW of current solar PV production capacity that is ramping to over 4 GW in next 3 years, aided by a generous government policy, as obvious in the "solar mission" initiatives. The market is transitioning from polycrystalline silicon driven PV to upside of CIGS as well as other compound semiconductors including wide bandgap devices as well. Both the LED and Solar markets have seen significant upside of European and far-east Asian players along with a healthy Indian business groups making it a competitive marketplace that will be healthy over the years. The local players are enthused with diversification prospects that are concomitant with the high economic growth levels across industry segments. The government is ushering inclusive growth to bridge the energy divides' by integrating setting up of Solar photovoltaics in greenfield projects as well as Green-initiatives, together with low-carbon high efficiency advanced LED illumination strategies in industrial applications, followed by home lighting solutions.

Amidst this opportunity, a review of existing autonomous national fabrication infrastructure and upcoming scenarios will be discussed. Federal facilities are functional for both silicon (SITAR & SCL, Semiconductor Complex Limited) and compound semiconductor technologies (GATECH), working in design, wafer fabrication, testing, packaging, quality assurance and reliability testing for investigation and development of semiconductor materials, solid state devices and various electronic components/sub-systems, including MEMS based system manufacturing and applications support. Existing national implementations of microwave, RF, Mixed signal analog projects will be analyzed under various government organizations. The current trend of entry of private players such as Astra Microwave (P) Ltd., ARMS (Advance Radio Mask), HFCL (Himachal Futuristic Communication Ltd.), Power Wave and TCS will also be reviewed, especially in the RF and mixed signal analog sectors. The significance of newly established centers of semiconductor excellences in major Indian Institute of Technology's and in Indian Institute of Science, as well as in upcoming educational clusters will create the much needed bridge between the under-nourished educational centers and over-burdened technology players while the economy is growing a furious pace in spite of several constraints that are being removed due to the movement of the leading edge of the growing technology space. The global R&D and design centers of ARM, TI, Agilient, Freescale, Synopsys, Cadence, National Semiconductor, Intel, M/ACOM, RFMD etc. as well Indian players such as Sasken, Wipro, MindTree and TCS etc. has created a healthy user and promoter of the education-enterprise relationships under the umbrella of the industry groups such as NASSCOM and India Semiconductor Association with significant governmental support from its various ministries, including global governmental collaborations.

The discussions will include judicious selection of process mixes in India compound semiconductor fab strategies for sustainable product stream that is of utmost importance for a sustainable fab strategy. Detailed discussion of university level R&D infrastructure, with five MBE cluster tool, two MOCVD cluster tool and extensive compound semiconductor facility at Indian Institute of Technology, Kharagpur, in semiconductor fabrication will be presented, which will not only provide for highly skilled manpower supplies to the nation, but creates IPs in semiconductor processes, initially in niche areas, sustainable through a combination of contract research and government support. Once this is functional, advanced design infrastructure in RF, Mixed Signal, HV Power, Sensors/actuators/Bio Chips, will get engaged into the fab infrastructure of India and other emerging economies.

ACKNOWLEDGEMENT
Market research by private and government organizations associated with Indian Institute of Technology, Kharagpur, and support from Department of Information Technology, Government of India, and Nano-Mission, Department of Science and Technology, Government of India, and Indian Institute of Technology, Kharagpur, India, and my graduate students, particularly Partha Mukhopadhyay.