Present Situation and Trend of Compound Semiconductor Industry in Japan

Akihiro Tsumura, tsumura@sangyo-times.co.jp

Sangyo Times, Inc. The Semiconductor Industry News Editorial Dept, Editor in Chief
TMM Bldg 3F, 1-10-5 iwamoto-cho, Chiyoda-ku, Tokyo, 101-0032, Japan, +81-3-5835-5896

ABSTRACT

The activity of compound semiconductor (CS) materials in Japan is introduced. The overall CS business in 2011 was $3.4 billion including both RF and Opto devices in Japan. The wafer business, mainly GaAs, InP, and GaP, has decreased in 2011. The SiC substrate, however, showed 10% increase with 6 inch increasing its share gradually in 2012. Over 90% of GaN substrates in the world market have been produced in Japan. In 2012 market will see more bonded wafers being used with their lower cost by Japanese vendors. The availability of one inch diamond wafer is becoming more prevalent and expected to commercialize within 10 years.

INTRODUCTION

As the demand for wireless infrastructure, mobile devices, and next generation power devices increased, the usage of compound semiconductor wafers have increased as well.

Japan has a long history of compound semiconductor manufacturing in both devices & substrates. Opto devices like light emitting diodes (LEDs), laser diodes (LDs), photo coupler/photo interrupter, are the largest products in terms of unit volume. More specifically, LED continuously shows strength in growth and in revenue.

SiC and GaN, is expected to grow much faster than other types of materials. New type of the wide bandgap materials such as bonded wafers and diamond are being developed with much interest. This paper introduces current state of business and R&D focused on these wide bandgap materials in Japan.

OVERALL ACTIVITY

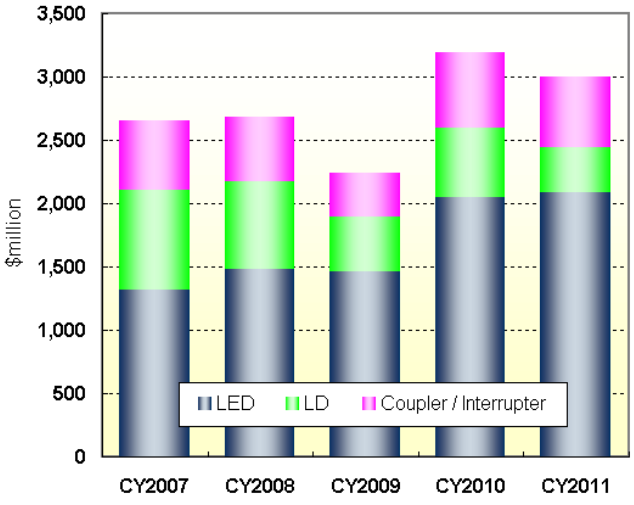

Figure1. Compound Semiconductor devices gross output in Japan *CY2011 stands for gross from Jan '11 to Nov '11

Fig.1 shows the gross output of CS devices in Japan. Sales in 2011 was around $3.2 billion. Figure 2 shows the sales breakdown for GaAs, InP, GaP, and others by year. These three materials, InP, GaP, and GaAs, are still the main products for Japanese wafer manufacturers, but the gross revenue is much lower compared to before sub-prime loan crisis.

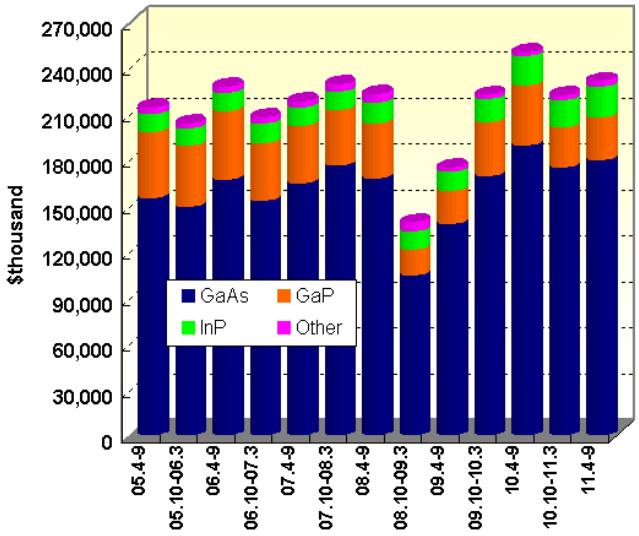

Figure2. Japanese manufacturer's compound Semiconductor wafer gross sales

In terms of applications, the sales is decreasing except for IC's (Fig.3). The reasons for decrease are, 1) more and more LEDs are being manufactured on sapphire substrate, 2) LD manufacturing continues to move out of Japan for lower cost, 3) The industry is moving to newer materials such as SiC and GaN.

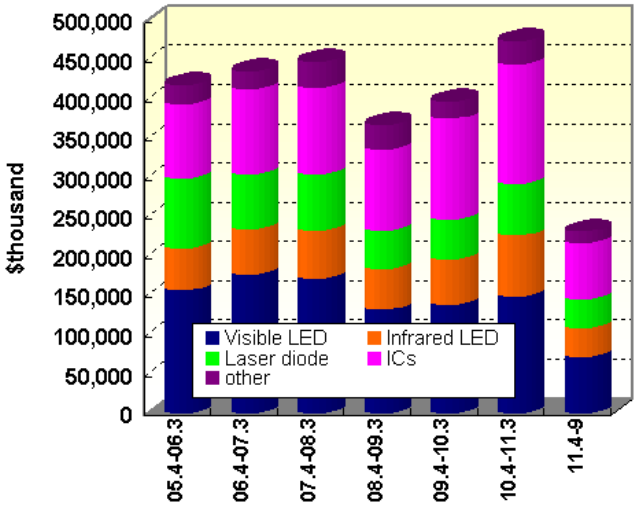

Figure3. Japanese manufacturer's compound Semiconductor wafer gross sales by applications

WIDE BANDGAP MATERIALS

According to "The semiconductor Industry News", compound semiconductor wafer market (GaAs + Sapphire+SiC+GaP+GaN) in CY2011 was estimated be $1.32 billion (100 B¥), a 7.7% growth compared to previous year (see Figure 4).

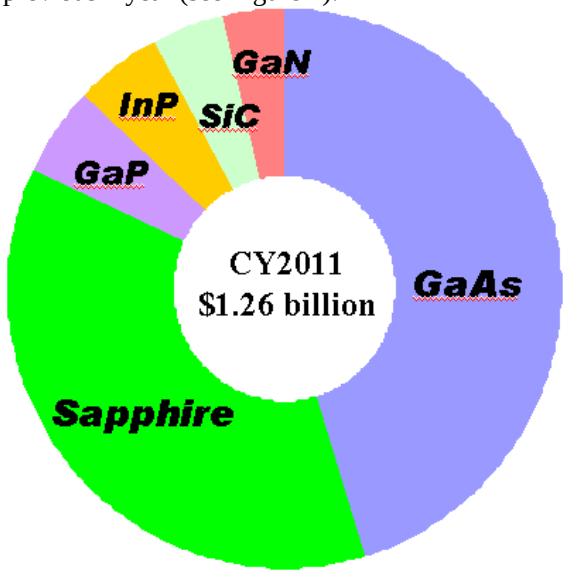

Figure 4. Compound Semiconductor Wafer Market

SiC

We estimated SiC wafer market size to be ¥4.4 billion yen, an increase of 10% year-on-year in 2011. 60% of the total market consist of 4H・n type for power device, 30% is 6H・SI type for high frequency device, and 10% is 6H・n type for LED (see Figure 5). For 2012, 6 inch 4H・n type will be the hottest market. Since the 6 inch matches existing process line in fab manufacturing, it will accelerate the SiC power device transition from Schottky Barrier diode to MOSFET. However, SiC epitaxial growth is also important for mass production of SiC devices. Some device manufacturers have epitaxial in-house growth to control process and improve yield. Some SiC wafer manufacturers have in-house epi growth as well. The importance of epi growth cannot be understated. The growth will have strong influence in the development and production of SiC substrate.

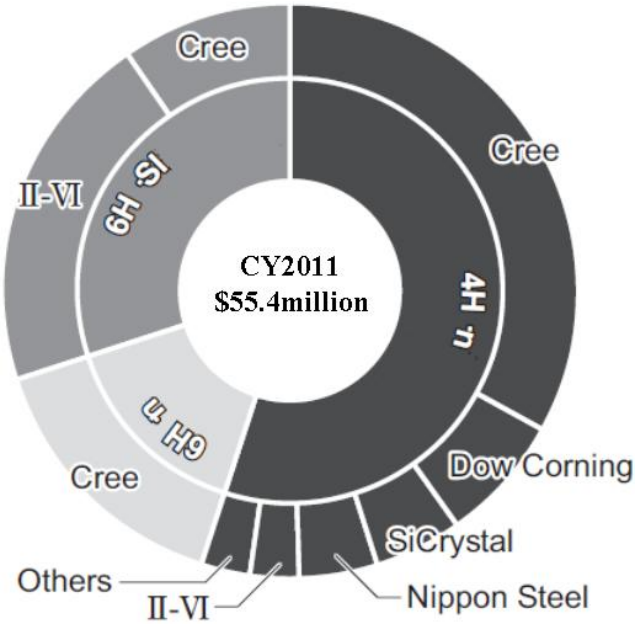

Figure 5. SiC Wafer Market

GaN

For the GaN bulk wafer market, it is estimated that the Japanese manufacturers have more than 90% world share. Sumitomo Electric Industries Ltd., SEI, has majority of share, followed up Hitachi cable, Ltd and then Mitsubishi Chemical Corporation. In 2011, NGK Insulators Ltd entered the market as the newest member of bulk supplier.

The largest application for GaN bulk wafer is blue laser diode for Blu-ray Disc. Other potential applications include HB-LED, high-voltage, and high-speed ICs; however, the high price of GaN bulk wafer has kept the material from proliferating into volume and other applications. Although GaN bulk is the material for HB-LED, the rapid price decrease of LED chips has forestalled the mass production by the Japanese manufacturers. However, the Japanese wafer manufacturers are already developing new crystal growth process, such as Na flux or hydrothermal synthesis method, to compete in the market.

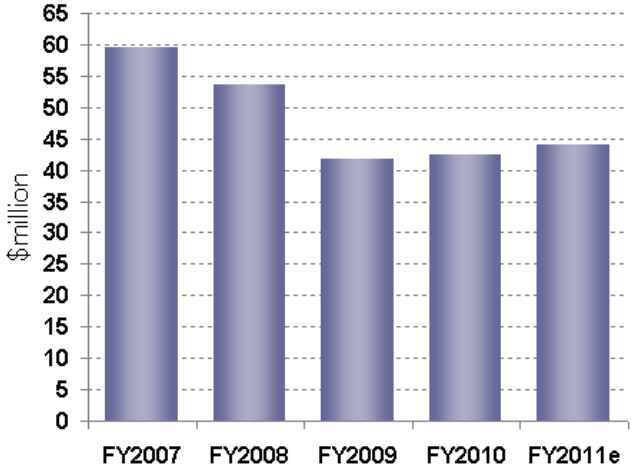

Figure6. GaN bulk wafer market

Bonded Wafer

To improve the performance and in order to achieve price competitiveness, bonded wafer shows promising technology. The technology can solve the bottle neck associated with compound semiconductor wafers. In 2012 for the first time, some manufacture will release the bonded wafers to mass production.

In order for GaN bulk wafer to see any high volume, it must be price competitive. SEI, the top supplier of GaN bulk wafer, has partnered with SOITEC, France, to combine SEI's GaN epi technology with SOITEC's SmartCut technology. This will help commercialize large diameter wafer with low cost GaN bonded bulk wafer.

NGK is planning to commercialize LiTaO3 bonded Si wafer for SAW filter. This bonded wafer can minimize thermal expansion compared to LiTaO3 bulk wafer. This feature leads to improved temperature characteristic of SAW filter and manufacture multi-band/multi-mode for smartphones. NGK is planning to commercialize the bonded wafers for wavelength conversion devices, filters, and sensors.

If these bonded wafers are accepted in mass production sometime in near future, it is possible that some of the GaN bulk for sapphire application and market share will decrease. Also we expect to see 6 inch sapphire mass production to achieve price reduction.

DIAMOND

Diamond has the physical properties superior to the other compound semiconductor materials such as band gap, breakdown field strength, electron mobility, and thermal conductivity. It is ideal material for high powered devices in terms of heat and pressure resistance. There are still many obstacles to overcome but in recent years a 1 inch single crystal wafer has been produced. The drive to commercialize the technology from R&D stage has accelerated; however, the roadmap will take more than 10 years for mass production.

Table.1 Activity of Diamond wafer in Japan

Organization	Contents
AIST	Microwave plasma CVD for single crystal diamond wafer growth. Venture company, EDP corporation has established in 2009.
Aoyama Gakuin University	R&D in diamond hetero epi growth. Succeed 1inch wafer in 2005. Venture company, AGD material Co., Ltd. has established in 2007.
NTT Basic Research Laboratories	R&D diamond thin film & devices with Waseda University.

CONCLUSIONS

The compound semiconductor wafer is recognized as an important strategic material for Japan. Therefore, a lot of wafer manufacturers have placed extensive R&D resources to continue improving existing technology and in parallel, develop new and exotic materials. The benefit from these activities will help the device manufactures as well as wafer suppliers to keep pace with the demand and the growth the industry.

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