The Role of Optoelectronics in a Sustainable Future

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Thoughtful Analysis, Actionable Information

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Executive Summary

It can be argued that green photonics technology and markets have been around for many years as a large portfolio of engineers and scientists have strived for energy efficiency, cleaner solutions, and improved health in their designs. Over the past three years, the subject has become topical, political, and to some extent cultural. This report explores the optoelectronics expectations for green photonics technology, and forecasts the associated markets through 2020. The cultural impact for a green, clean, and energy efficient lifestyle is just beginning. Over the next decade, many innovative new products will emerge in a variety of industries that will better define and demonstrate green photonics technology. It is clear to many that a broad range of products and services that the economy will utilize over the next decade will contain optoelectronics (interchangeable with the term photonics), either as key components or as components that enable better and more efficient systems.

According to OIDA, the global optoelectronics market for 2008 was $356 billion. The green photonics share of the global optoelectronics market is estimated to be 8.1%, or $28.9 billion. Green photonics technology is already making an impact; this impact is expected to accelerate quickly over the next decade.

The compound annual growth rate (CAGR) for global optoelectronics for 2009-2020 is forecast to be 3.1%. The green photonics share, however, is expected to be a very encouraging 19.6%. These growth rates translate into $493 billion in revenue for optoelectronic components by 2020, of which $261 billion (or 53%) is the green photonics market share. Near term, the overall global optoelectronics market is forecast to decline by 1.4% in 2009, while the green photonics market is expected to grow 26.5%.

The contribution of photonics is considered green if

- generates or conserves energy
- reduces greenhouse gas emissions
- reduces pollution
- yields an environmentally sustainable outcome, or
- improves public health

The methodology in determining the green photonics forecast starts with the base optoelectronics forecast. Each sub-segment of optoelectronics components is then analyzed using the above green criteria. Assuming a product class achieves the green criteria, then all the sub-segments are aggregated for a market segment total. Each optoelectronics component that meets the green criteria is then forecasted for at least a decade, in this case to 2020. It is expected that over the next decade, the criteria for green will become more stringent, and therefore some of the green photonics penetration rates will decrease.

The major segments of optoelectronics are flat panel displays, optoelectronics components, optical input/output devices, optical fiber communications, optical precision lens and lasers, solid state lighting, and optical storage. Two of the hottest areas in green photonics technology are actually in the optoelectronics components segment and are listed as high brightness LEDs and solar photovoltaic cells.

As an example, a major driver for green photonics might be a product such as the personal informational medic: a portable digital accessory that works similar to a mobile phone but has

capabilities for virtual medical sensing and monitoring, perhaps even telemedicine. This product vehicle allows less paperwork, enables online procedures, diagnosis, monitoring, even sensing, and can display information in a portable compact unit. Perhaps this unit will include photovoltaic cells to enhance batter life. The display in the unit will likely be a more efficient LCD or more probably a lower power consuming organic LED display. Clearly, product concepts are still evolving, but the cultural interest in driving green photonics solutions is starting to be seen. Issues of power consumption for data centers are already being addressed by the optical communications industry, as is the design of more efficient fiber optic transceivers and transponders, either by using new photonics technology such as silicon photonics or compound semiconductor photonic integrated circuits.

Lighting is becoming an exciting area with the recent technological progress of high brightness LEDs, allowing lower power consuming lighting solutions. LEDs are beginning to be seen in traffic lights, residential lighting, and even as back lights to televisions and displays. Organic LEDs are now being utilized in many small display products such as mobile phones, PDAs, and applications that are sensitive to battery life. Over the past year, many display manufacturers have geared up for larger organic LED display products that include televisions and notebook computers. In a decade, new innovative products using organic LEDs will include novel lighting designs, perhaps on flexible substrates that emulate wallpaper. Solid state lighting has the potential to save significant amounts of power when used in projects at the national level, such as street lights. LEDs are already improving the power consumption and reducing toxicity with infrastructure projects in cities throughout the world. Health issues can be addressed by photonics through the use of high brightness LEDs that emit in the ultra-violet. These UV LEDs can purify water and replace mercury-filled UV lamps that are used today. The use of LEDs actually will allow new and creative portable products to be designed that work on batteries and permit off-grid operation. Third world countries will be more able to utilize a battery, photovoltaic solar cell, and LED for simple lighting scenarios. Optical sensors will also be found in new green roles in applications as diverse as pipeline monitoring, sensing wind turbine control, and oil extraction.

Green photonics technology over the next decade will not only assist in current optoelectronics products, but will open opportunities for new and creative products to be designed. The markets for green photonics technology will grow quickly, even with the slowing of penetration due to more stringent criteria. The momentum will promote better understanding and acceptance of a more energy efficient, cleaner, and richer lifestyle for everyone.

This report explores a few of the exciting opportunities for green photonics technology. The green photonics industry is just beginning–the growth profile is exciting. Many emerging product opportunities will leverage the green photonics initiative. By 2020, green photonics technology will be implemented in so many products that some will take the design philosophy for granted.

Green Applications of Optoelectronics

The growing emphasis on environmental and economic sustainability has resulted in mounting interest in clean technology applications of optoelectronic devices and systems. In this report, the contribution of optoelectronics is considered "green" if it generates or conserves energy, reduces greenhouse gas emissions, reduces pollution, yields a more environmentally sustainable outcome, or improves public health. Examples of green optoelectronics include photovoltaic (PV) power generation, high efficiency solid state lighting, displays with reduced power consumption, high efficiency optical data transceivers, and ultraviolet water (UV) purification. The impacts of these optoelectronic solutions are renewable energy sources, reductions in energy consumption, reductions in carbon dioxide emissions, and improved human health.

The need for green solutions is a strong driver for optoelectronics industry growth. This potential for industry growth is promoting strong investment in green optoelectronics by companies, venture capitalists, and governments. Federal, state and local government are forging new policies to promote green tech objectives. In addition to the direct impact of green optoelectronics, the optoelectronics industry is adopting green design goals and employing green manufacturing practices resulting in further green outcomes. While the development of green optoelectronic industries such as solar photovoltaics, solid state lighting, and UV water purification are at a relatively early stage, the addressable markets are very large and underpin the world's economy and sustainability. The size of the markets at stake and investors reaction to the opportunities may explain why some observers view the current investment climate in these technologies as a bubble. Nevertheless, revenue from products such as photovoltaic generating modules and solid state lighting are already substantial and growing at a rapid rate.

1 Market Overview and Trends

The market for products incorporating green optoelectronics technologies includes several segments as shown in Table 1. The technologies listed in Table 1 have been under development for quite some time but the unifying element is that these technologies are now being developed aggressively to deliver green market solutions.

Technology	Underlying Technology	Application	Impact
Photovoltaics	xSi, pSi, aSi, CdTe, CIS, CIGS	Power generation	Renewable energy, reduced carbon emissions, reduced pollution
Solid State Lighting	LEDs, OLEDs	Illumination, Displays	Reduced energy consumption, reduced mercury pollution
Ultraviolet Disinfection	UV LEDs	Purification of drinking water, waste water, industrial water, food and air	Improved water quality, Improved public health, reduced mercury pollution
Optical Data Transport and Processing	VCSELs, Si photonics	IT data centers	Reduced energy consumption
Optical Sensors	Fiber optics, Bragg gratings, Lasers, Detectors	Energy extraction, Gas sensing, environmental monitoring,	Reduced energy consumption, Reduced pollution, Reduced green house gas emission
Low Power Displays	OLEDs, LEDs, MEMs, Electrophoretics, LCDs	Information and Entertainment Display	Reduced energy consumption
Green Optoelectronic Manufacturing	Many	Many	Reduced energy consumption, reduced water consumption, Reduced pollution, Reduced green house gas emission

Table 1: Technology, Application, and Impact of Green Optoelectronics Market Segments
Source: OIDA

The major technology segments can typically be broken down further into underlying material or device technologies. In all cases, the beneficial impact of the green optoelectronic technology can include one or more of a renewable energy source, reduced energy consumption, reduced green house gas emission, improved public health, reduced water consumption, or reduced pollution.

1.1 Photovoltaics

Photovoltaics (PV) have been under development for decades and have seen relatively wide spread deployment world wide. However, photovoltaics have supplied a relatively small portion of world energy production. Figure 1 shows that solar photovoltaics contributed less than 0.1% of world energy production in 2006.

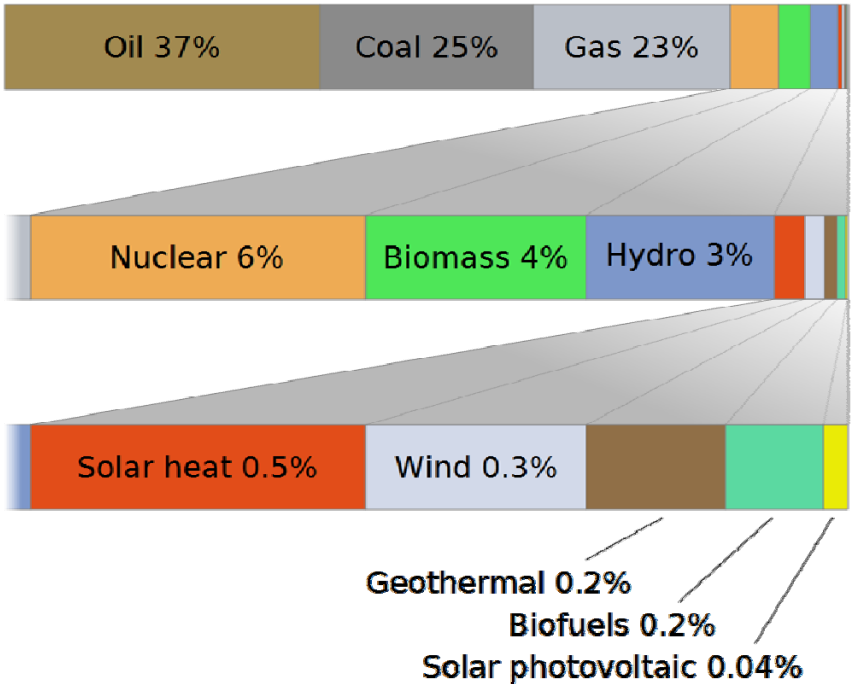

Figure 1: World Energy Source by Type, 2006

Source: REN21 2006 Global Status Report on Renewables, BP 2006 Statistical Review, Wikipedia

Market interest in photovoltaics, as well as support for PV development and deployment by governments, have fluctuated over the preceding decades. Recent government policies and goals for renewable energy portfolios, and market interests driven in part by the rising price of energy sources including oil (see Figure 2), have strongly stimulated the market for photovoltaics development and deployment.