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REVIEW ARTICLE

PHOTONICS: TECHNOLOGY, APPLICATIONS & ITS ECONOMIC IMPACT

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Photonics: Technology, Applications & its Economic Impact

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INTRODUCTION

Photonics is the science and technology of generating, controlling, and detecting photons, which are particles of light – by emission, transmission, amplification, detection, and modulation of light. The 21st century will be as dependent on photonics as the 20th century depended on the electronics. Photonics explores a wider variety of wavelengths than the electromagnetic spectrum, from gamma rays to radio, including X-rays, UV and infrared light. The characteristics of the waves and photons can help explore the universe, cure diseases, and might even solve crimes.

Photonics has marked its place in a many technologies – from laptops to smart phones to medical devices. Various industries have been actively using this technology, be it consumer equipment (barcode scanner, printer, remote control devices), telecommunications (optical-fiber communications), medicine (correction of poor eyesight, laser surgery, surgical endoscopy, tattoo removal), industrial manufacturing (welding, drilling, cutting), construction, aviation, photonic computing etc.

One of the most useful and interesting use of this technology is in the field of Health Care and the Life Sciences - BioPhotonics. BioPhotonics is the interaction of living cells (Bio) with the electronic control or detection of light (Photonics). Within this market are several areas of focus, as briefly described below:

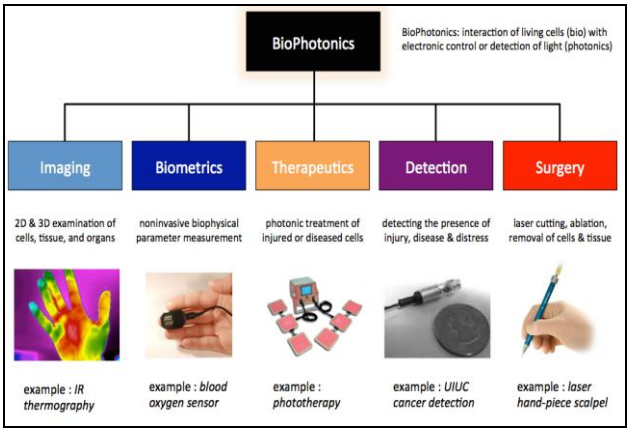

Figure 1 Biophotonics and its applications (Source: Applied BioPhotonics)

APPLICATION & EXAMPLES

BioPhotonics is used today for cutting-edge cancer research to cosmetic and beauty treatment, by virtue of the precision and hygiene levels that laser could bring in the manufacturing of sterile medical devices and equipment. Photonics has also proven useful in the fields of optical diagnosis, urology, neurosurgery, ophthalmology, dermatology, and bio stimulation.

The applications of light in health care and life sciences entail several main aspects:

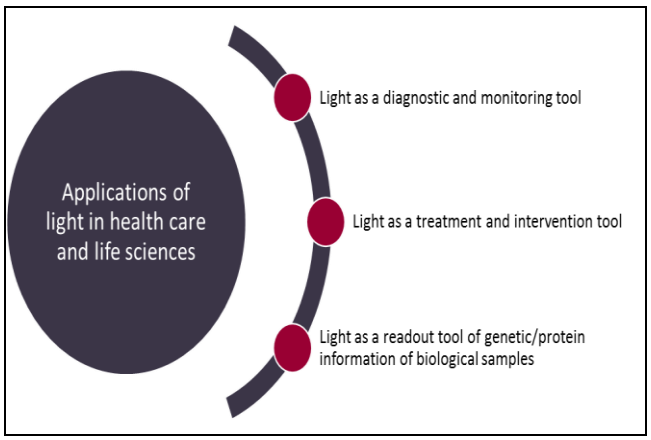

Figure 2 Applications of light in healthcare and life-sciences (Source: Kettering University)

Several major areas of applications include imaging technologies, understanding life from cellular down to molecular level, applications in the pharmaceutics industry, light as a therapy/intervention tool, applications in the medical industry, etc. This article focuses mainly on the medical applications of BioPhotonics and how it is changing the face of medical equipment industry

With the use of medical optics and photonic, the duration of patient's hospital stay can be reduced or eliminated, diseases could be diagnosed earlier for better cure, pain experienced by the patient is reduced, and a faster recovery could be expected. Different human tissues have different tendencies to absorb certain wavelengths of lights. Light could be targeted on specific areas on the surface of the tissues and parts of the body beneath the skin on a microscopic level. This limits the harm that could be caused to the rest of the body.

More recently, light applications - specifically lasers - have been used in **medical diagnosis** due to their non-invasive properties. Laser-based medical apparatus performs all routine diagnostics such as tissue oxygenation, early detection of tumors by fluorescence, and early detection of dental cavities.

- Optics and biophotonics are being explored in the field of optogenetics, where specific parts of the brain are treated are exposed to light and treated for addictions.
- A lot of research has been going on in the field of photodynamic theory that deals with skin cancer.
- Chronic pain could be treated with low level laser therapy.
- Surgical procedures have been successfully developed to use photonics for the removal of tattoos and treat complexion problems.
- Damaged neurons could be repaired non-invasively with lasers.
- Blood sugar levels could be tested with the use of skin probes, instead of needles.
- Blindness could be restored using prosthetic retina and nanomaterials.
- Photonics could be used to understand the aftermath of a concussion better using diffusion tensor MRI. It could also be used to find disease causing pathogens.
- It is being used for **Medical Lighting** largely to optimize the maximum brightness of the lamp & to input a good combination of illumination characteristics.
- Photonics is used for the laser processing of medical instruments, to ensure that **hygiene** is maintained.
- Photonic equipment have found its use in the **non-invasive temperature taking** where thermal imaging of fluids is done.
- Photonics is also being explored in the field of precise **neural simulation**. Optical simulation is more precise than the electric simulation and highly controlled, so that individual nerves could be activated by it and restricts nerve damage which could be caused by electric pulses.
- A new photonic technique has been developed for **laser bone imaging** recently. The newly developed technique will help in the prediction of future chances of development of osteoporosis.
- CancerScannerT, developed by the bioscience division of the US Department of Energy and further developed by SpectraPath Technologies has been going through clinical trials for **optical cancer detection**. It has been successful is determining malignant cells in animals and humans during the trials. Optical cancer scanning takes considerably lesser time for diagnosis as compared to current methods.
- A new **optical testing instrument** has also been developed by a company called VariDose, which is UK based. It has claimed to drastically reduce the time taken for pulmonary drug delivery analysis in the pharmaceutical industry.

New equipment have been developed for laser eye surgery and microscopy. Lot of research is going on

in the field of aesthetic treatment using photonics for skin problems.

IMPACT ON ECONOMY

Photonic technologies have major impact on the world economy with a current global market of €300 billion and projected market value of over €600 billion in 2020. Growth in the photonics industry more than doubled that of the worldwide GDP (gross domestic product) between 2005 and 2011.

The graphic below shows the breakdown of the Photonics world market in 2005, 2011, and 2020, including segmentation by industry with optics and medical technology as key segments.

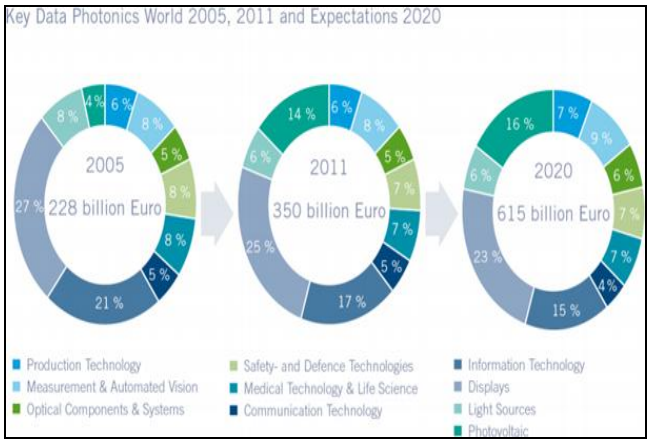

Figure 3 Photonics world market (Source: lightsources.org)

The graph below shows the expected global growth of different photonics segments from 2011 to 2020, and clearly shows that Medical & life sciences and Optics segments will continue to grow faster than average GDP of World.

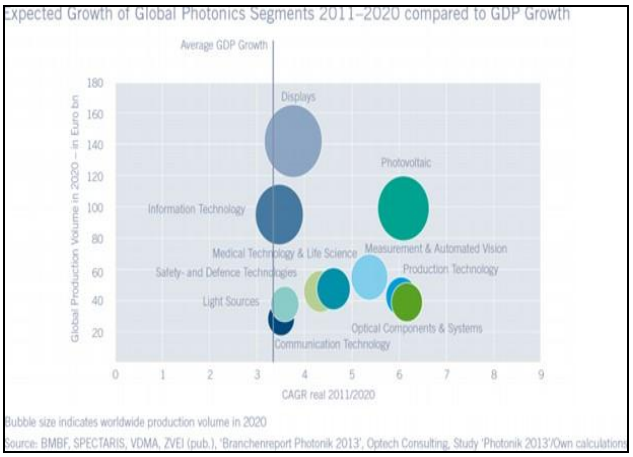

Figure 4 Growth of different photonics segments (Source: lightsources.org)

The two following bar graphs show the prognosis for the growing impact of photonics on key manufacturing industries and key end-use industries in 2020 versus 2010.

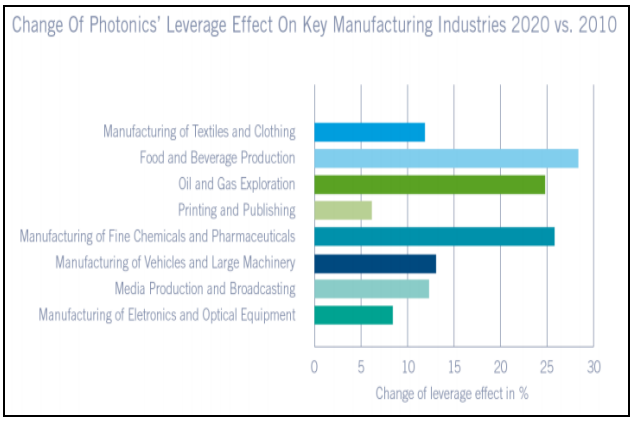

Figure 5 Impact of photonics on key manufacturing industries (Source: lightsources.org)

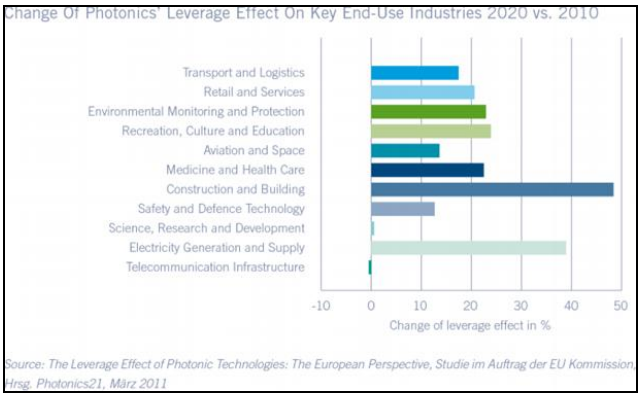

Figure 6 Growing impact of photonics on key end-use industries (Source: lightsources.org)

Businesses in the field of photonics and light-based technologies work on solving key societal challenges, such as energy generation and energy efficiency, healthy ageing of the population, climate change, and security. Even if the electromagnetic spectrum is invisible to our eyes, visible and invisible lights are a part of our existence. Photonics is everywhere and has been developing and expanding every day. All around the world, scientists and researchers have been performing cutting-edge research in the field of photonics. The scope of what photonics can bring to us is vast and can only be limited by lack of imagination.