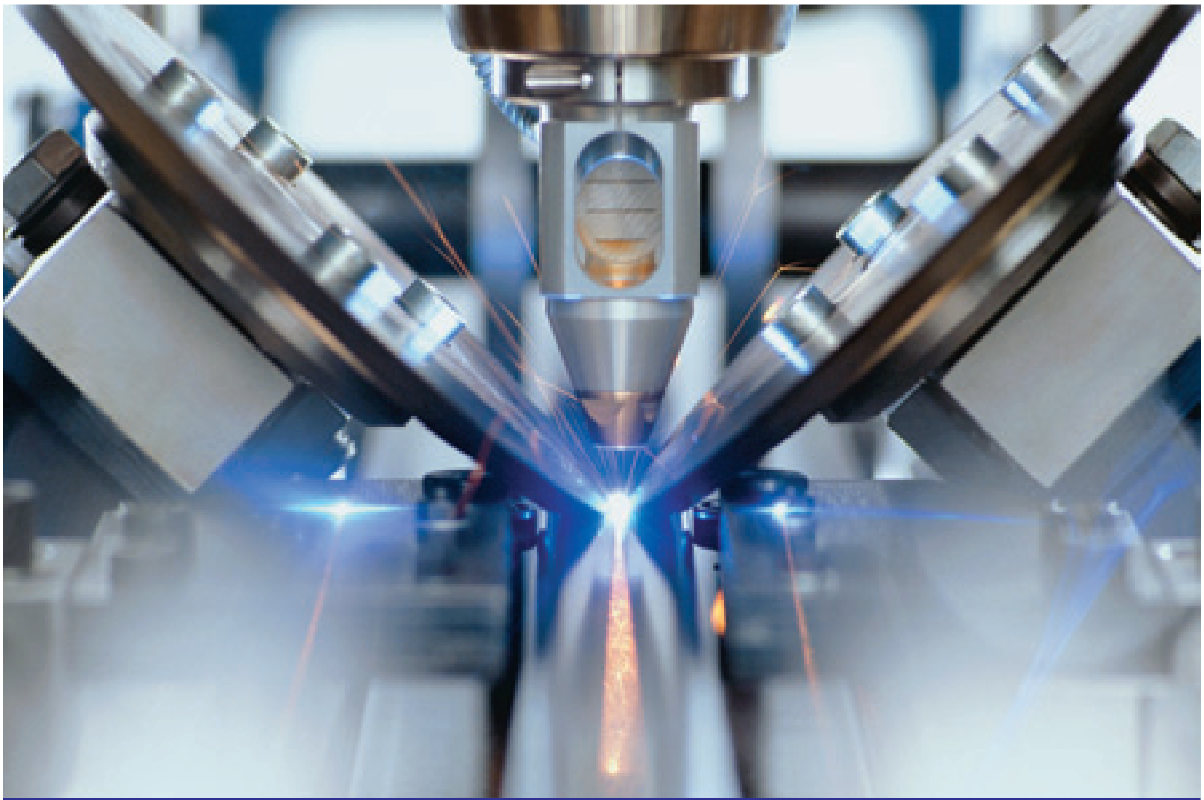
Photon technology

The comprehensive interpretation of “photonics” includes an incomparably large spectrum of technologies and applications. Originating from the photon and created equivalent to electronics, it had first been used with optoelectronic applications. Today photonics stands for the modern so-called “optical technologies”. The properties of the photon to transmit energy and information without moving a mass allow fascinating technical solutions. Laser light opened the doors to novel scientific disciplines. Quantum optics, non-linear optics and atomic optics are fascinating new worlds with rules and properties very different from those intuitively known to mankind.



Sunlight is a basic precondition for life on Earth. Since humans have walked the earth they have followed the rhythm of the sun, moon and star light. By taming fire man created his first artificial source of light. For the evolution of mankind, this was a very important step. But only after hundreds of thousands of years did the technological breakthrough of optics occur. Early scientists learned to understand the concept of classic light and invented spectacles, the telescope and the microscope, among others. Mankind started to utilize light by inventing optical instruments that allowed the discovery of the universe, bacteria and photography. Electricity enabled another breakthrough. With easy and efficient electrical lighting mankind became emancipated from the sun.

The "light revolution" came with the invention of the maser and the laser. The laser has become a basic artificial light source for science and industry. It is light of a new quality that can be adapted to specific needs. Light finally not only enables vision but it has become a versatile tool. This breakthrough is envisioned by many statements that call the 21st century the "century of the photon."

The center of a new technology

The photon, the light quantum postulated by Einstein, is the combining element of all photonic disciplines. The difference to classic light and optics is the utilization of the specific properties of the photon that are not available with "ordinary" thermal light.

The key property of laser light is the coherence that results in high spectral and spatial resolution as well as interference phenomena. Interference is the basis for holography and various imaging techniques. It is now possible to create laser light pulses a million or even billion times shorter than a billionth of a second. The single frequency property of laser light is used in detection and measurement applications. In manufacturing technologies the high spatial resolution enables contact-free, high performance cutting and welding of various materials including stainless steel by focusing high power laser light onto a small spot. The high frequency and spectral purity of laser light allows the coding and transfer of huge amounts of data. Single photon emitters allow the utilization of the quantum properties of the photon, for example for quantum cryptography.

Despite the very different applications, all photonic disciplines have in common the interaction between light and material. Photonics therefore goes far beyond the boundaries of light. The spectrum of "light optics" ranges from infrared to ultraviolet. In contrast, the more energetic X-rays and the "tera incognita" of the terahertz waves between microwaves and infrared light also belong to the photonic spectrum. And even the atomic laser can be linked to photonics. "Atomic optics" has become possible only with laser light. While in optics material is used to manipulate light, here light manipulates material.

Photonics research is indispensible for future economic growth

The economic impact of photonics cannot be underestimated. Already today, photonic technologies play an important role in many key industry sectors like production, information and communication, imaging and detection. Photonic systems from laser machines to components for infrastructure and consumer products worth hundreds of billion of Euros are shipped around the world. While the markets of established photonic applications are still rapidly growing, many more applications are yet to come. These new applications currently in development in science and industry are indispensable for our future economic growth.

Research and industry are tightly interconnected. Basic research builds the underlying structure for innovations that industry can distribute in the market. While the long term success of industry is based on excellent research, only economic success enables the society to finance research. This basic relation is very relevant for photonics. Today, we can hardly estimate the impact of all the photonic research – parts of which are illustrated in this book. But we know that it is of key importance for our future economic success. The German government has realized the importance and initiated a national research program for "optical technologies".

A short trip through photonic research at the Universität Stuttgart highlights the various links and interactions in which new applications are born. Once, the laser was called a solution for an unknown problem. But then it helped to invent previously unthinkable new methods and gain spectacular new insights. The example of the laser shows that even though science needs some orientation towards marketable results, free basic research is very important for the discovery of new technologies. This is the domain of state-

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funded research. There is no doubt that the close collaboration of science and industry is important, but this should not result in shrinking funding for basic research!

Excellent photonic cluster in the Stuttgart vicinity

The region surrounding the Universität Stuttgart provides every opportunity for successful photonic research, development, production and marketing. Research is represented as well as the complete value chain from the specialized supplier to the user. Local utilization of regional competence and knowledge pairs with global marketing of the products. This so-called photonic cluster has also been identified through an early study for the German state of Baden-Württemberg on strategic future investments. The study led to strategic funding of basic research by the Landesstiftung Baden-Württemberg and the founding of Photonics BW as the local photonic network.

The photonics research at the Universität Stuttgart and neighboring research institutes is an example of an excellent science cluster. Compared to other national optics locations, it is marked by the largest interdisciplinary network and a strong penetration of photonics in manufacturing technologies and engineering that allows very efficient transfer of basic research into innovations. The interplay of quantum optical basics, applied photonics, material research, production technologies and engineering are an important advantage of the Stuttgart photonics cluster.

The photonic challenges are manifold and interdisciplinary as is apparent on the following pages. The extension of the fundamental barriers of photonic components falls into the domain of physical basics. Then there is the need for the extension of technical barriers and finally the extension of the process capabilities of photonics systems and processes. •

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