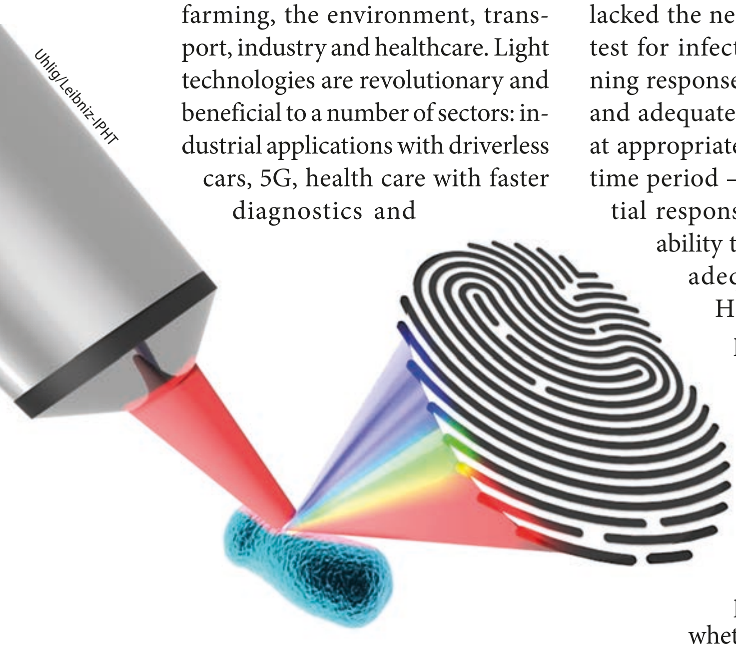
Commitment to photonics

Strong investment will help to prepare us against future pandemics.

Jürgen Popp

By harnessing photonics – technologies that are based on light – we are producing solutions in fields as varied as next-generation farming, the environment, transport, industry and healthcare. Light technologies are revolutionary and beneficial to a number of sectors: industrial applications with driverless cars, 5G, health care with faster diagnostics and green technologies or environment are all made possible by the generation, detection, manipulation, emission, transmission, modulation, processing, switching, amplification, and sensing of light.



The inelastically scattered light of a laser provides a molecular fingerprint of the pathogen under investigation.

The threat of infectious diseases and antimicrobial resistance is just one case to illustrate that now is the time to commit to strong investments in photonics. Fast, clean and precise, photonics can build advanced diagnostics, pervasive monitoring and innovative e-health applications that can detect body signals, symptoms and diseases at very early stages.

Detecting with light

Covid-19 has shown that we have been unprepared for a pandemic. Nations all over the world have lacked the necessary capacities to test for infectious diseases, meaning responses have been delayed and adequate measures not taken at appropriate times. This critical time period – the testing and initial response – determines our ability to control or respond adequately to a threat. Here, photonics can provide unique solutions like no other technology owing to its speed. Photonics can deliver instantaneous information about the health status of patients to determine whether they are suffering from a condition caused by a virus or a bacterium. Results can be determined on-site, in-situ without having to send samples to a laboratory and await analysis.

Infectious diseases can have a number of causes, including bacteria, viruses, fungi, or parasites, and can be transmitted from person-to-person, or animal-to-person.

There are many infectious diseases that pose a danger to our species, like Influenza, AIDS, Malaria, Tuberculosis, SARS, Ebola or Zika. This serious threat requires drastic, urgent solutions and has been highlighted by Covid-19. With the global pandemic caused by SARS-CoV-2, Covid-19 will be added to the three infectious diseases that account for the top ten leading causes of death worldwide.

Even before Covid-19, according to the World Health Organization, the situation was worse in low-income countries, with five infectious diseases being a leading cause of death among the top ten.

Photonics projects tackling infectious diseases

In Europe, the Photonics Public Private Partnership is funding many research projects to develop tools and techniques for infection diagnostics. The CoNVat consortium, for example, is developing an ultrasensitive laser sensor that detects coronavirus at the earliest point of infection in minutes. Originally developed to look for bacterial infections or cancer biomarkers, it uses photonics to detect infections in patients with a small amount of the virus and will diagnose in real-time with high specificity from a low concentration sample. Looking at tiny molecules, the new point-of-care detector examines virus RNA using miniaturized chips – or 'nanophotonic biosensors' – from a simple nasal or saliva swab.

Similarly, the RAIS consortium was making a bold bid to reduce the mortality rate from sepsis by more than 70 % with their new detector using photonics to identify E. coli bacteria from a tiny drop of blood, producing a diagnosis in less than thirty minutes. Programmed to detect micro-ribonucleic acids (microRNAs), interleukins and other specific proteins associated to sepsis, the detector uses light to look for those specific small biomarkers. A small blood sample taken from a thumb or forefinger is sufficient for this rapid 'microarray' detector. The blood sample is then separated in a centrifuge so that a clinician can examine the plasma, the part of the blood sample where all the proteins are contained.

Advanced diagnoses

In the following, a few recent collaborative projects are presented where the Leibniz-IPHT was/is involved as coordinator or a partner.

A powerful method for diagnosis of infection and sepsis has been explored within the EU-funded project 'HemoSpec'. From a small amount of blood, the photonic-based algorithm can differentiate patients with sterile inflammation, infection and sepsis with high accuracy. The algorithm is based on valuable information of the leukocyte's activation state that can be extracted non-destructively and label-free using Raman spectroscopy. The technology is currently in translation together with the industry.

In order to provide the basis for a future decentralized application of biophotonic technologies such as Raman spectroscopy as a novel diagnostic tool in hospitals and doctor's offices, the EU COST action 'Raman4Clinics' brought spectroscopists, clinicians and device manufacturers from all over Europe together to perform a large scale cross-laboratory study. This study assessed the comparability of configurations of 35 Raman spectroscopic devices with different configurations in 15 institutes within seven European countries. Statistical data analysis played an important role in achieving comparability.

The European Union is currently funding the Innovative Training Network 'IMAGE-IN: Imaging Infections' within the Marie Skłodowska-Curie Actions to educate the next generation of scientists who can advance imaging technology for medical applications.

In further national funded projects, spectroscopists advance optical-spectroscopic methods for fast antibiotic susceptibility testing in close collaboration with physicians and life science researchers. The aim is to reveal the infection-causing bacterial pathogen and its antibiogram within three hours directly from a minimal amount of the patient's sample (urine or blood).

The joint research project 'ReHwIN' of academic (Jena University Hospital, Leibniz IPHT) and industrial partners (Jenoptik, Grintech, BiFlow, Biophotonics Diagnostics) focusses on nosocomial urinary tract infections. The final photonic analysis system will combine microfluidic processing of a urine sample with a miniaturized and sensitive Raman spectroscopic readout platform and data analysis with artificial intelligence. The collaborative project 'InfectoXplore' is part of the BMBF-funded InfectoGnostics research campus, a public-private partnership breaking new ground in the diagnosis of infections. The team of industrial (mibic GmbH, Biophotonics Diagnostics) and academic (University of Applied Sciences Jena EAH, University Hospital Jena, and Leibniz-IPHT) partners tackles bloodstream infections which require rapid therapy to prevent sepsis. Within InfectoXplore, positive blood cultures will be analyzed and a personalized photonics-based diagnostic algorithm will be developed that enables a quick tailored antibiotic therapy.

Step up funding

While Europe has a wealth of researchers working on cutting edge photonics techniques, we cannot simply rest on our laurels. We need to ensure we are prepared against the next pandemic with a collective commitment to fund photonics, a global industry predicted to be worth € 696 billion by 2025. The Chinese government increased its investment in photonics every year by 40 %, to reach € 1 B in 2020 while the South Korean government increased its spending to € 2.8 B per year. But the EU only commits € 100 million on photonics every year. The German government took the initiative and is now investing more than € 120 M in the Leibniz Center for Photonics in Infection Research in Jena, to force the introduction of photonic technologies and platforms in infection diagnostics and therapy, which may revolutionize the diagnosis and treatment of infectious diseases. For the sake of defending ourselves against future pandemics, now is the time for Europe to commit to a programme of strong investment in photonics.

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