Project number: IPD100014
Project name: Integrated UV-RGB Beam Combiner, interconnection technology for ultraviolet (UV) and visible wavelengths (UV-RGB)
Goal: to develop a solution for fiber-chip and fiber-fiber coupling for UV and visible light

The result of an earlier IOP project on ultra-precision alignment for photonic systems, where MEMS actuators in a chip align and fix the position of one fiber with respect to another (TU Delft, IOP Precision Engineering, Henneken/Tichem).

Inter-connection technology for UV and visible wavelengths

In health and life science applications such as microscopy and spectroscopy, advances have been made by combining light from different laser sources into a single fiber output. While photonic chips for integrating several light sources are currently available, low-cost, high-quality interconnection technology is lacking, especially for submicron-wavelength photonics. The IOP project 'Integrated UV-RGB Beam Combiner' aims to fill that gap. The envisaged technology would also enable new products such as an image projector as small as a packet of cigarettes.

More and more applications in health and life sciences employ combinations of visible light (RGB – red, green and blue) and ultraviolet light (UV). In confocal microscopy for instance, three-dimensional structures are constructed from images that are obtained with light of different wavelengths. Similarly, flow cytometry – a technique for counting and examining microscopic particles such as cells and chromosomes – is also based on the usage of more than one wavelength. The required wavelengths in those types of applications are produced by numerous different single-laser sources and then combined into one single fiber output. "Combining light of several wavelengths is not a problem in itself," says Dannis Brouwer, Assistant Professor of Engineering Technology at the University of Twente. "Photonic chips that do that are readily available, produced by companies such as LioniX, for example.
The issue lies in how to couple the interfacing fibers to one another or to the integrated optical chip. The current solutions are bulky and expensive. The industry is in need of low-cost, highly reliable and accurately aligned pluggable connections. That is why Willem Hoving of XiO Photonics, a University of Twente spinoff, initiated this project."

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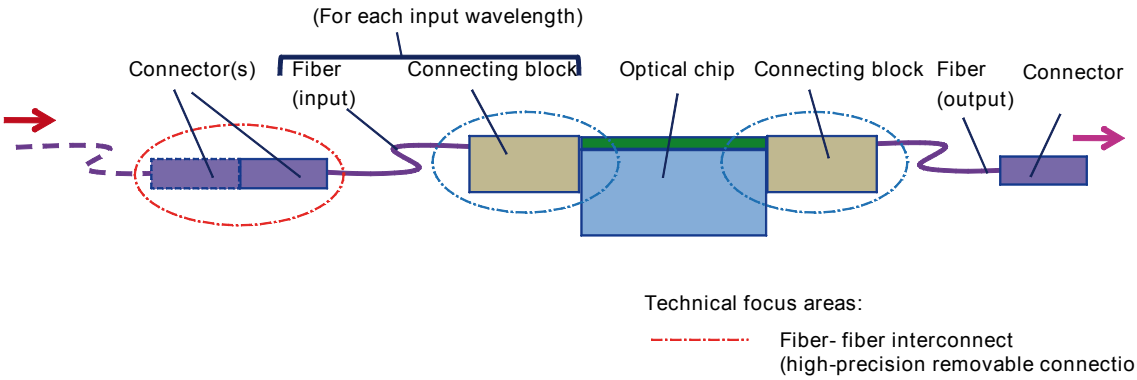
Alignment

The need to combine visible light with ultraviolet light only complicates matters. The current connectors for coupling fiber to fiber or fiber to chip primarily use adhesive bonding - glue - as an interconnecting technique. "Glue is very sensitive to light with a short wavelength, such as UV light," Dannis Brouwer explains. "When exposed to such short wavelengths, glue degrades rapidly. As a result, first the alignment of the fiber (or fibers) and ultimately also the connection itself are lost."
The sensitivity of glue to UV light is not the only problem, however: the limited capacity for alignment precision of the current interconnection technology is another. During the process of bonding, heat and/or shrinking induces stress on the fibers that need to be connected. That makes it extremely difficult to maintain the required submicron alignment accuracy, which results in a very low yield when producing connectors. "This is currently a real problem in the photonic industry. To solve it, you will need to be able to correct or adjust the alignment of the fibers during the bonding process."

Spot welding

The IOP project 'Integrated UV-RGB Beam Combiner' will research several approaches to tackling the problems with both the bonding and the alignment. Two Dutch universities – the University of Twente and the Delft University of Technology – will each focus on their own area of technological expertise to come up with solutions. The researchers in Delft are specialised in micro- and nano-scale assembly with a focus on ultra-precision alignment for photonic systems. Therefore they will look into the possibility of using silicon-based microfabrication technology and microelectromechanical systems (MEMS) to integrate functions for aligning and fixating the position of the fiber with respect to the optical chip. One proposal is to create a modular system that would be able to fine-align and fixate a single fiber; multiple optical outputs could be realised by placing several of those modules next to each other. The research involves the design of both the total package layout and the functional partitioning (i.e. where to place alignment and fixating functions and features), the design and realisation of suitable MEMS actuators and the development of methods for fixating the chip once it is aligned with respect to the optical chip. The researchers at the University of Twente will study the use of laser energy for bonding and aligning.

System for confocal microscopy using four lasers. (Photo: Nikon)



The proposed interconnection solution contains connecting blocks on either end of an integrated-optical chip, coupling it to input and output fibers, as well as pluggable connections between fibers.

Dannis Brouwer: "Continuous or spot welding based on laser energy is a more reproducible process than adhesive bonding. It allows you to model exactly what will happen to the fiber when it is heated locally. Based on the model, we hope we can anticipate whatever misalignment there will be and then make the necessary adjustments in advance. Since the optical fiber has a certain polarisation that needs to be maintained, we will have to examine the alignment in six degrees of freedom both during and shortly after the welding." The project will include both the realisation of a measurement setup to check the models and the use of artificial ageing to check the behaviour of the connectors in the long run (over several years).

Direct interest

Four companies are heavily involved in this project: XiO Photonics, Tyco Electronics, IMS and Coherent Europe. Their involvement ensures that the solutions proposed by the universities will target the product-related problems that these industry partners foresee. XiO Photonics designs and fabricates integrated optical products such as integrated laser-beam combiners and spot-size converter chips. Tyco Electronics, a manufacturer of interconnection products for telecom and datacom, is interested in employing combinations of visible and UV light in connection with the new medical division it is setting up. IMS makes industrial mechanised systems for fiber-chip alignment and assembly. Coherent Europe is a world leader in laser products and deeply embedded in the high-end market segment for both UV and visible-light lasers. "They all have a direct interest in the results and plan to implement them into new products," says Dannis Brouwer. "Apart from using the interconnection technology in health and life science applications, there are also ideas for products such as pocket-sized image projectors and light sensors. We will all be very happy if we can find a way to align and fixate fibers without the need for adjustment afterwards."

Participants:
- University of Twente
- Delft University of Technology
- XiO Photonics
- Tyco Electronics
- Coherent Europe
- IMS

Contact:
Dr ir D.M. Brouwer
T: +31 (0)53-489 48 45
E: d.m.brouwer@utwente.nl