Automated alignment of optical fibers reduces errors and cost in photonic chip production

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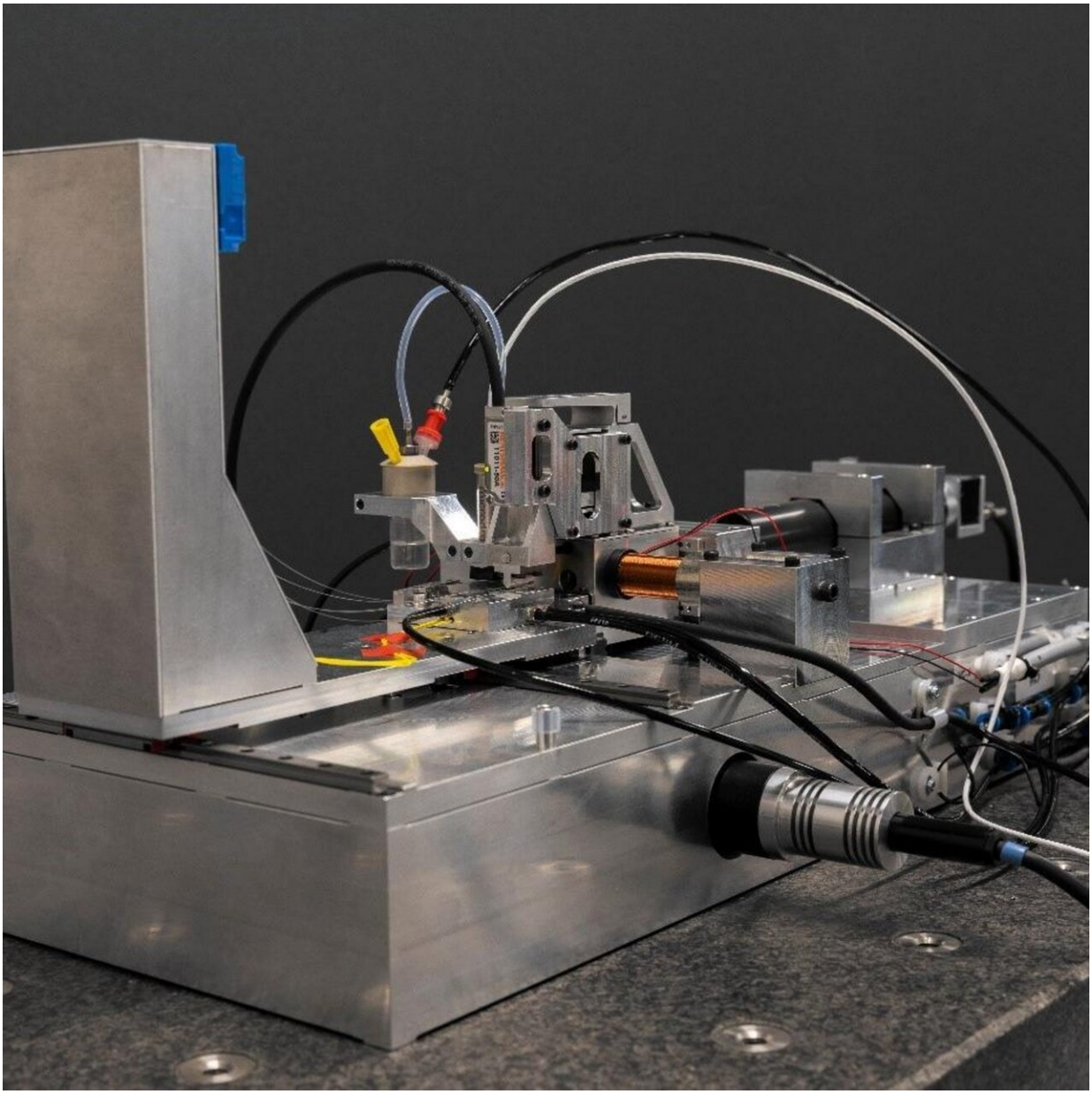

The realized fiber array assembly machine. Credit: Eindhoven University of Technology

Photonic chips can play be a crucial role in applications such as autonomous driving or medical imaging due to their capacity for extremely fast and energy-efficient data transmission. However, their adoption is currently held back by the considerable cost involved in the production of these devices. Ph.D. candidate Matthijs van Gastel has developed new ways of assembling photonic devices using glue, which is accurate at the sub-micrometer scale. The researcher at the Control Systems Technology group in the department of Mechanical Engineering defended his thesis on 25 March.

In today's society, the need for data transmission is growing exponentially. Photonic chips show great potential for energy-efficient data transmission with high bandwidth. These chips are relying on information transfer based on light as opposed to electrons in the conventional electric chips.

Photonic chips enable many new applications such as sensors for autonomous driving cars or new medical imaging techniques. An increasingly important issue for enabling large scale adoption of photonic chips is their assembly and packaging. These processes are currently estimated to account for more than 50 percent of the total cost of a photonic device.

Especially the coupling of optical fibers, which are used to guide light in and out of the photonic device, is critical as they require sub-micrometer alignment. Current fiber alignment methods can either not cope with

these alignment requirements or are not suitable for large-scale production. Furthermore, current methods are often labor intensive and time-consuming.

Optical fiber array

In his thesis Van Gastel describes the development of a new optical fiber array for efficient coupling of multiple fibers to photonic chips that is accurate at a sub-micrometer scale.

The first part of the thesis focuses on the development of the new optical fiber array. In this array multiple optical fibers are positioned next to each other and fixated to a glass plate using glue. Current fiber arrays struggle to reach the sub-micrometer accurate alignment for photonic chips since they are unable to compensate for the variance in production quality (so-called production tolerances) of optical fibers. In the new fiber array the position of the fiber is measured using a camera system to compensate for these production tolerances.

The glue can then be cured to fixate the fiber to the glass plate. Glue is prone to shrinkage that can disturb the fiber alignment. It also tends to slowly change shape over the years, which can disrupt the fiber alignment. The researcher performed simulations and experiments to investigate the suitability of the glue fixation process for fiber alignment. The results showed a very predictable behavior of the glue process making it suitable for optical fiber alignment.

Designing the fiber array assembly machine

The second part of the thesis focused on the design of an assembly machine for the newly developed optical fiber array. For this, the researcher used automatization, thus ensuring a high accuracy fiber

alignment while simultaneously reducing costs and increasing throughput.

The machine design consists of three translational motion axes to align the fibers on the substrate in the most critical alignment directions. The designed high precision motion axes are able to align the fibers with nanometer accuracy. Due to its compact and modular design, the alignment machine can be easily expanded to larger production lines.

From design to machine

During this Ph.D. research Van Gastel also built and tested a hardware realization of the machine design. The machine is able to assemble a 16-fiber array within four minutes, significantly faster than traditional fiber alignment methods, which can take between two minutes to one hour per single fiber.

Furthermore, the assembled arrays showed an approximately right to 18 times smaller alignment errors when compared to the currently employed fiber arrays.

This research can therefore be an important step for enabling large scale adaptation of photonic chips by providing a faster, more accurate and more cost-effective assembly process of optical fibers.

More information: Automated Sub-micron Accurate Optical Fiber Alignment for Photonic Applications. pure.tue.nl/ws/portalfiles/por …/20210325_Gastel.pdf

Provided by Eindhoven University of Technology