ASSEMBLY SOLUTIONS FOR MICRO-OPTICAL SYSTEMS
Our Competencies

In several cooperative research projects as well as in multiple industry projects, Fraunhofer IPT has extended its expertise in the following areas covering the value-added chain of micro-optics assembly:

- **Micro and precision assembly:**
  Years of experience regarding the handling, alignment and adhesive bonding of micro-parts
- **Handling and manipulation:**
  Industry-proven gripper and precision manipulation technology for optics and micro-parts
- **Active alignment of micro-optics:**
  Multiple reference projects in the field of active alignment of micro-optics for laser systems
- **Adhesive bonding:**
  Analyses of UV-curing adhesives and integration in automated processes
- **Cooperation:**
  We cooperate with industrial partners in order to ensure optimum and sustainable customer support

We draw on these areas of expertise to offer a wide range of services to help our customers to identify the most suitable assembly solution for their needs.

Our Services

Fraunhofer IPT offers a broad service portfolio in the field of optics and micro-optics assembly. That includes services extending all stages of optics assembly solutions – from the analysis of individual assembly steps to the development and commissioning of assembly cells for the automated assembly of optical systems.

In order to find a systematic and sustainable approach for our customers, our projects usually include the following phases:

- Feasibility study
- Concept development
- Realization of concept

For each customer case, we individually tailor the optimal project structure considering our customer's objectives.

In recent years, we have developed several reference solutions for micro and precision assembly:

- Development of grippers for optics and micro-parts
- Customized micromanipulators meeting demands of highest motion resolution in six degrees-of-freedom
- Development and realization of assembly solutions on different automation levels
DEVELOPMENT OF GRIPPERS FOR OPTICS

Handling solutions for micro-optics and optical fibers

In recent years, gripping and handling solutions have been developed at Fraunhofer IPT for a wide range of optical components including optical fibers as well as other micro-parts. Our in-house ultra-precision machining research enables us to provide gripper nozzles, magazines and handling solutions for optical components of minimal size.

Hybrid gripping technology

In most cases, we apply vacuum grippers with specialized gripper jaws. If higher holding forces are required, we apply a hybrid gripping technology using vacuum combined with mechanical clamping forces.

MICROMANIPULATOR-TECHNOLOGY FOR HIGHEST STEP-RESOLUTION

Flexure-based parallel kinematical structure

The micromanipulator technology developed at Fraunhofer IPT is based on parallel kinematical structures and flexure joints. The actuators, which are commercially available, exploit the piezo-driven stick-slip concept. Parallel structures perform well in terms of stiffness and positioning accuracy. Flexure-based joints avoid negative influence of friction or play on the motion resolution. This allows for a step resolution of the micromanipulator in the range of 10 nm for translational movements and a few microrads for rotational movements.

Modular concept for customizable manipulators

The size of the micromanipulators can be optimized. A very compact construction space of about 100x100x100 mm³ can be achieved. Customer requirements in relation to larger workspace or a higher workload capacity can be met via customization.

Over the years several function modules have been created that can optionally be combined with the kinematical structure. For robust, automated gripper exchange routines, a pneumatic clamping mechanism can be integrated in order to secure the movable platform. A camera module can be integrated to provide a view of the gripping area for vision-based processes.

For the integration of our micromanipulators in third party machines we offer several control interfaces:

- High-level languages: C++, C#
- Network: TCP/IP
- Serial interface: RS232
Overview of assembly solutions

Fraunhofer IPT works out individualized concepts for highly sophisticated assembly solutions according to the needs of the customers. Depending on the production volume and the complexity of the assembly task we tailor customized solutions from manual and semi-automated work stations to fully automated systems.

Our solutions consist of an operator interface for the assembly station allowing manual operation of all actuators as well as monitoring of sensor signals and signal processing results. In most cases we use a positioning system like a robot or a Cartesian gantry system for covering a large workspace. For the fine-alignment, a customized micromanipulator is attached to the positioning system.

Operator workstations for semi-automated assembly

We combine commercially available standard equipment with our micromanipulator technology as well as with our experience in designing customized grippers in order to set up assembly workstations for assembly in a laboratory environment.

Flexible assembly systems for low-volume production

Low production volumes are common for high-tech photonic products. For this reason, concepts for flexible assembly systems have been developed at Fraunhofer IPT. The aim in this context is to be able to produce several products or product variants using the same equipment. This allows for fuller capacity utilization and therefore a higher return on investment.

Our approach is to define standardized interfaces for mechanics, for signals as well as for power and energy supply in order to be able to exchange tools and grippers frequently without incurring unacceptable change-over times.

High-volume turnkey production solutions

In cooperation with industrial partners we realize turnkey assembly solutions for complex micro-optical systems with the option of long-term support and maintenance through our partners.
PROCESS DEVELOPMENT FOR OPTICS ASSEMBLY

Scope of process development

The scope of process development support offered by Fraunhofer IPT comprises

- alignment strategies for optics
- parameter identification for adhesive bonding processes
- processes required for fully-automated assembly processes such as component pickup or gripper exchange

Development of automated alignment strategies for optics

In previous projects, we have successfully realized automated alignment strategies for several types of optics in laser systems:

- Collimation lenses (fast-axis, slow-axis)
- Focusing optics
- Resonator mirrors

Our approach for collimation and focusing optics follows a three-step alignment procedure optimizing the intensity distribution in the near-field and far-field.

- Pre-positioning:
  In the first step, the optical component is brought into position using absolute positioning accuracy of the macro-positioner.
- Passive alignment:
  In the second step, the component is aligned according to geometric features using machine vision.
- Active alignment:
  In the third and final step, the component is aligned while monitoring the near-field and far-field behavior of the component.

For resonator mirrors, the output power is maximized and the beam needs to operate in TEM_{00} mode. Therefore, the lasing threshold needs to be identified by moving the mirror in space in accordance with a “blind search strategy”. The output power is subsequently maximized by applying a “hill-climbing search strategy”.

Development of bonding processes

For best bonding results, the optimal process parameters have to be identified. For this purpose, we qualify adhesives for automated bonding including the analysis of shrinkage behavior in order to integrate the results into the alignment strategy.

Support of peripheral processes through sensor integration

Robust lens pickup processes can be realized via sensor integration such as machine vision. Fraunhofer IPT implements a control architecture building on re-usable function blocks for such tasks.

Scalability concept

We design our systems for scalability in order to support the product lifecycle from early assembly process development through to high-volume production. The key concept we apply is the re-use of crucial components such as micromanipulators and grippers. The concept is supported by our flexible software architecture allowing the exchange of peripheral components without re-implementing the assembly procedure.
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