Assembly and Calibration with Nanometer-Precision

The Microbench for the Micro-Assembly of Sub-λ Lightsources

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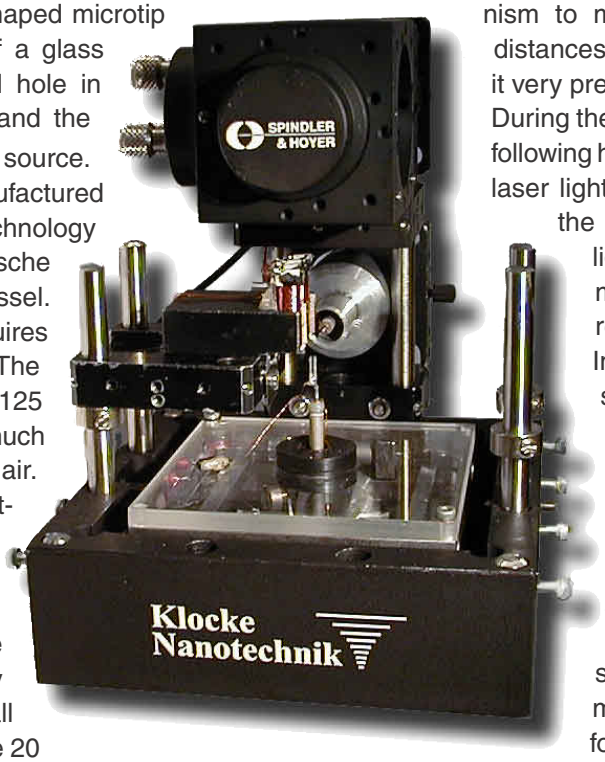
For over a decade optical scanning near field microscopy has been making light microscopy without the resolution limitations of the Rayleigh limit possible. Instead of visualising the sample with a lens system in geometrical optics, a scanning near field microscope moves a miniaturised lightsource over the sample. The measured values of transmission or reflection of the sample are converted to a magnified picture of the surface by a computer. The lateral resolution is thereby limited by the dimension of the light source. To realize the smallest details a small light source is necessary. These „sub-λ" light sources are smaller than the wavelength of the light emitted by them.

The departments for optical scanning near field microscopy at the 2. Physikalischen Institut, RWTH Aachen and at the Institut für Experimentalphysik, Freie Universität Berlin developed a new method to produce such light sources: a pyramid-shaped microtip is glued to the end of a glass fiber. A 150 nm small hole in that tip forms a lens and the tip works as sub-λ light source. The microtips are manufactured with semiconductor technology at the Institut für technische Physik, Universität Kassel. The gluing process requires the highest precision. The whole glass fiber with 125 µm diameter is not much thicker than a human hair. And the core transporting the light has a diameter of only 3 µm. For emmitting light out of the microtip the core must be placed exactly under the 150 µm small hole in the center of the 20 µm microlens.



For that sophisticated task the researchers chose a product of the company Klocke Nanotechnik, Aachen: Their XYZ-Manipulator moves - driven by five piezoelectric linear motors - computer controled over a volume of 10 x 10 x 5 mm^3. Although the stroke is macroscopic the resolution of the linear motors is more than microscopic: it is far below the submicron scale.

So it is possible with only one drive mechanism to move material large distances as well as to adjust it very precisely.

During the adjustment and the following hardening of the glue, laser light is coupled through the glass fiber and the light emission of the microtip is measured.

In this way it is possible to control the precise adjustment of the microtip and glass fiber continuously.

To realise a flexible assembly of the detector in short time and in a mechanically rigid form, the researchers took a familliar and often used part of their Laboratory equipment: the SPINDLER & HOYER Microbench - kit.

The XYZ-Manipulator was easy to integrate into

Klocke Nanotechnik

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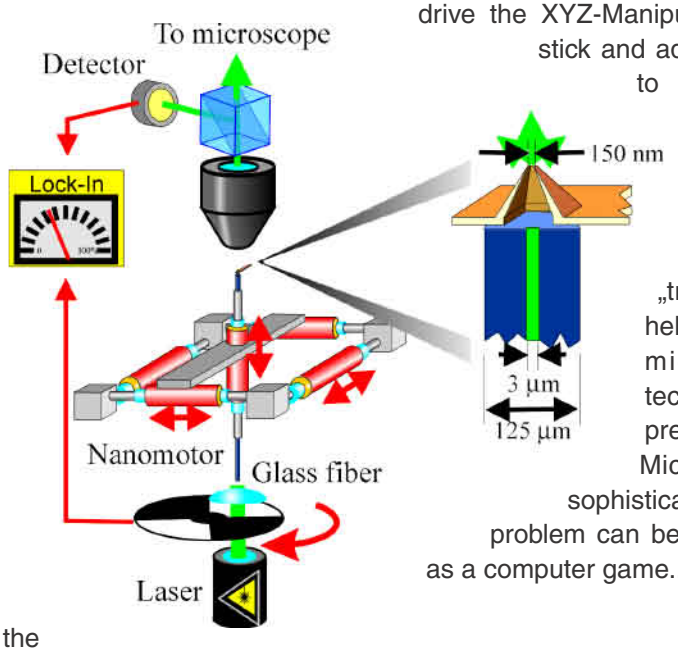
the Mikrobench system and out of a standard set of lenses, a beam splitter cube with positioning table and the components of the Mikrobench mechnanics, the whole detector was built in a few hours. Due to the beam splitter the microtip and glass fiber were visible during adjustment through a microscope.

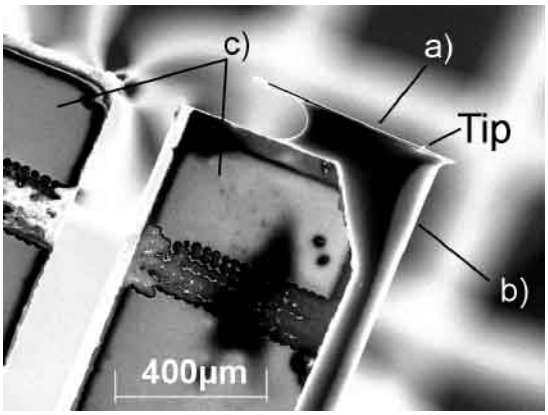


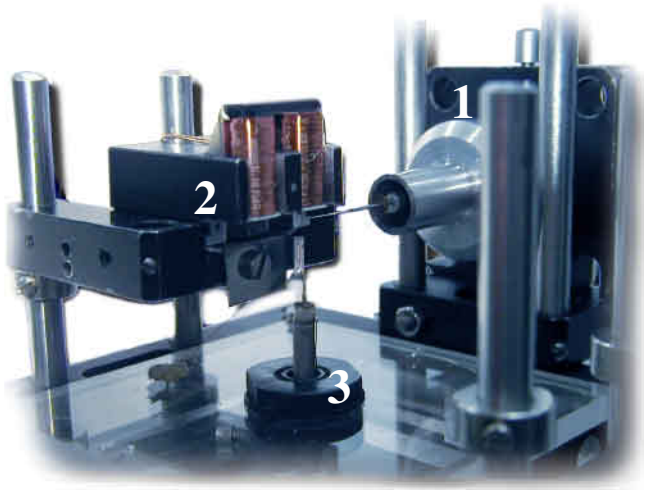
The Micro-workbench was exhibited at the Hannover industry Fair in April 1998, where it received much attention. At the research exhibition of the Ministry of Education and Research (bmb+f) visitors could drive the XYZ-Manipulator via a joystick and adjust glass fibers to microtips. Most sucessful at this were the youngest guests, who profited from the Game-Boy „training“. With the help of modern micropositioning technology and the precision of the Microbench, a sophisticated assembly problem can be solved as easy as a computer game...

- - - Additional details of the gluing process that were not published in the original article: - - -

The assembled components are:
a) Cantilever with microtip
b) Glass fibre
c) Shear force sensor

The amount of glue spent into the 100 µm x 400 µm wide gap between the parts a, b and c is critical: too much glue and the shear force sensor is damped. Not enough glue and the cantilever of the microtip can oscillate freely. In both cases the device would be destroyed.





The glue is spent with a Nanomanipulator (1). The microtip is fixed in an electromagnetic holder (2), the shear force sensor is moved with the xyz-positioner (3).

With this equipment small objects like pinholes or lenses can be assembled onto the end of a fibre with Nanometer resolution.

Precision made in Aachen:

Klocke Nanotechnik

Germany:
Pascalstr. 17
52076 Aachen

Phone: +49-2408-95099-20
Fax: +49-2408-95099-26

www.nanomotor.de
info@nanomotor.de