Microassembly with Nanometer Resolution

Assembly of Terahertz Frequency Mixers

Our microassembly stages are well known for their precise positioning and handling capabilities. Handling of optical fibers the size of a single hair is a standard application. But you can even go further...
The following text describes a task that required sensitivity and manipulation skills far beyond what was realizable before. The assembly of substrate bars with a profile of 35 µm x 80 µm could only be done with the Nanomotor-based devices, because other tools would have damaged or flipped away the components.

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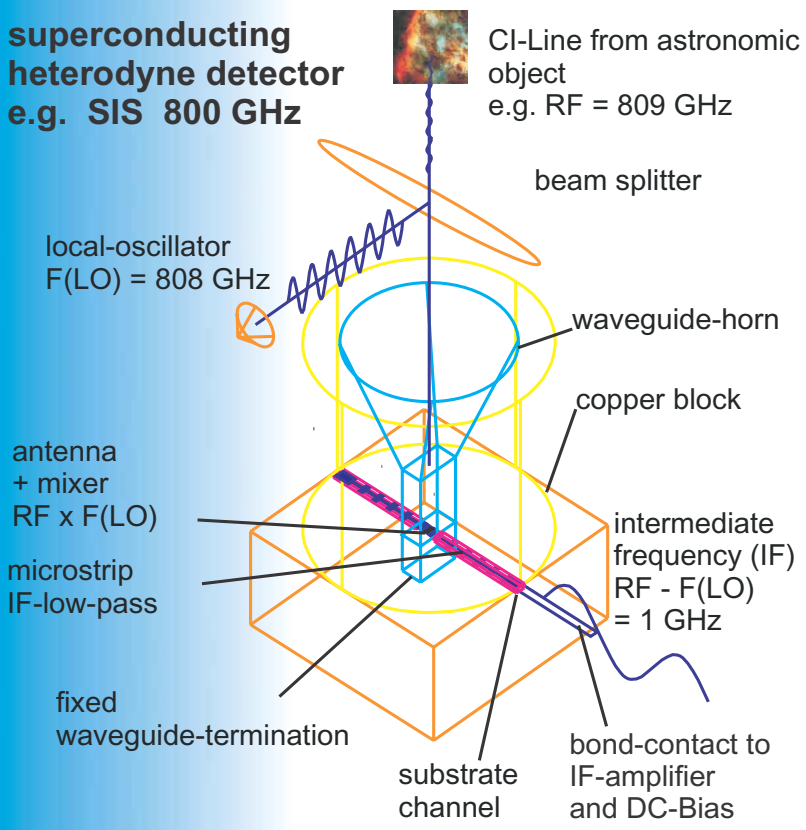
KOSMA

Dept. of Physics I
University of Cologne



The Customer

The "Superconducting Devices and Mixers Group" at KOSMA (Kölner Observatorium für Submillimeter Astronomie), I. Department of Physics at the University of Cologne, designs, develops and fabricates superconducting devices. They are used as heterodyne frequency detectors and local oscillators for highly sensitive receivers for spectroscopic analysis in astro-physics. The assembly of these devices requires very sensible and precise manufacturing techniques that have been realized by the use of a Nanomotor-based assembly stage.

The Task

In order to minimize the loss of 800 GHz HF-Power inside of the receiving waveguide, the total dimensions of the fused quartz mixer substrates have to be 80 µm by 35 µm (width x height) and 2 000 µm long. The manual mounting of these devices into the substrate channel is rather difficult, not reproducible and ends mostly by breaking the device. For array and satellite applications on the other hand, a reliable and reproducible mounting procedure is of utmost importance. The requirements for the coming 1.9 THz receiver for the SOFIA-aeroplane will be even higher. Another point of concern is the sensitivity of some of the devices against electrostatic discharge, being much higher than the sensitivity of semiconductor devices.

The Solution

That is why the KOSMA group used a Klocke Nanotechnik microassembly stage. The main problem is gripping the fragile device. The two fingers of the

Klocke Nanotechnik

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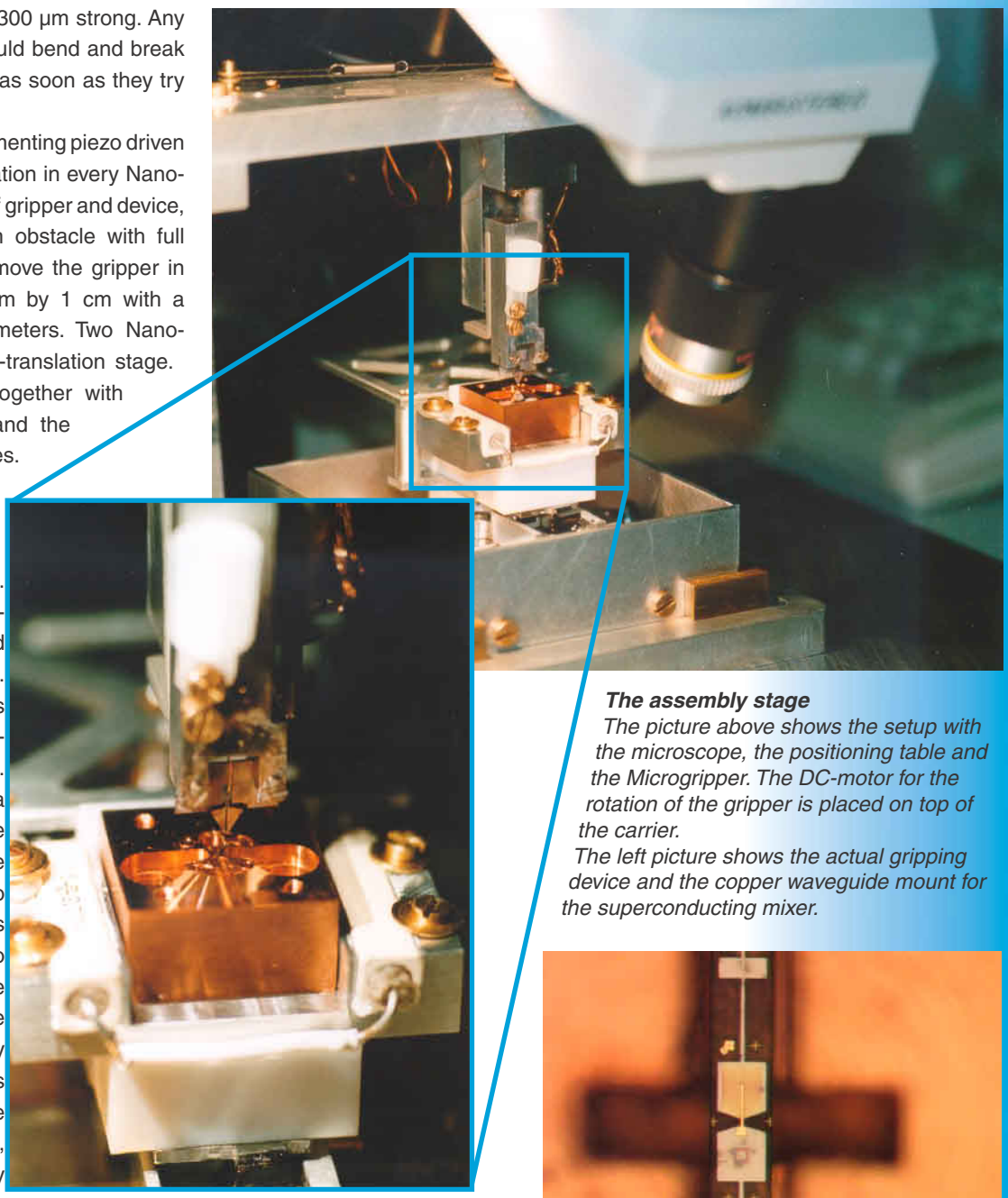
gripper are just 200 µm by 300 µm strong. Any standard stepper motor would bend and break these fingers or the device as soon as they try to grip it.

The solution came by implementing piezo driven Nanomotors®. A force limitation in every Nanomotor® secures the safety of gripper and device, even if the gripper hits an obstacle with full speed. The Nanomotors® move the gripper in a volume of 2 cm by 2 cm by 1 cm with a resolution of a few Nanometers. Two Nanomotors® are driving an x/y-translation stage. It moves the mixerblock together with its PID-controlled heater and the storage box for the devices.

The heater can melt the thermoplastic glue (crystalbond™) to fix the substrate in the channel. Crystalbond becomes viscous at about 90°C and solid after cooling down again. One Nanomotor® controls the z-movement of the gripper and one the gripper itself. The gripper is rotated with a standard DC-motor. A needle can be attached to the z-drive to handle the glue to cut remaining copper burrs close to the waveguide or to move the device while the glue has not hardened. The system can be controlled by keyboard or by a 5 axis control panel. To secure the safety of the handled mixers, the setup is thoroughly grounded. Even the extremely sensitive Hot Electron Bolometer could be mounted without loss.



The assembly stage
The picture above shows the setup with the microscope, the positioning table and the Microgripper. The DC-motor for the rotation of the gripper is placed on top of the carrier.
The left picture shows the actual gripping device and the copper waveguide mount for the superconducting mixer.

Mounting the Devices

In a first step micrometer sized glue-drops are placed at controlled places of the substrate channel to secure a reproducible mounting of the device. Then a device is taken out of its box with the gripper and positioned inside the substrate channel. With the Nanomotor-controlled needle the device can now be aligned parallel to and precisely centered in the waveguide (right fig.). The precision is only limited by the resolution of the optical microscope. When the glue has hardened, the mixerblock is ready for bonding the electrical connections.

The result
The superconducting detector is precisely aligned within the waveguide

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