Nanomotors for Liquid Handling

Transport of smallest drops

To enter the micro - and nanoword more than a scale-down by a factor of some thousand is necessary. The simple question „How can I move a drop?" becomes a problem not only for chemistry, biology medicine, pharmaceutics and polymer industry. But this challenge leads to innovative solutions in the field of analytics.

This article was presented in the magazine:

innovation

Nr. 11, 8/99

Live Science, high-throughput screenings and diagnostics long for fast and reliable analysis of more and more samples. At the same time the use of chemicals is to be minimized. To reach this task it is necessary to spend and transport smallest amounts of liquids precisely. For analysis it can be necessary to inoculate these samples each with another liquid.

Therefore many orders of liquids would be wasted in pumping systems and hoses than used at the sample. After spending one drop the system must be cleaned. This problem gets worse, if each of the „cups" has a diameter of e.g. 1 - 10 microns – at a depth of only one molecule. An automatic solution can be realized by the following steps:

- Preparation of micro-tips with controlled shapes.
- Vary the adhesion forces of these micro-tips, for example by coating with polymers. Basic research in this field is made at many centers, e.g. at the Institute for polymer research in Dresden, Germany.
- Transport in at least 3 directions with nanometer resolution, as compact as possible. For this task the Nanomotors from Klocke Nanotechnik and manipulators made out of them are predestined (see Fig. 1).
- Arrays of positioners in smallest space and an automatic process. This is also made possible by the small dimensions of the Nanomotors.

Fig. 1: A Nanomotor, the smallest and most precise linear motor worldwide.

The Tip

A certain geometry - like a pyramid with a cut tip - captures a drop by a mixture of capillar atraction and adhesion, when it is immersed into a source reservoir. The tip can be driven deep into the liquid that adheres only at the front end of the tip. The sharp edges avoid that the liquid adheres behind the front end of the tip and a well defined extremely small drop is gripped.

After the transfer to a target position the tip touches another container, that is formed to absorb the drop from the tip by adhesion or capillarity. On the way back the tip can be cleaned at a third position chemically or thermally. This can be done fast because of the small dimensions.

If the whole process is repeated with constant speed, the evaporation rate of the drop is constant and does not influence the process quality.

Drop Arrays

With semiconductor technologies polymer surfaces can be modified precisely to form tiny sensors.

By liquid handling using adhesion smallest drops can be placed exactly onto a surface. Gravity does not matter in this microworld, adhesion is much stronger and can be varied by surface modifications. With this method different liquids can be placed on smallest areas to form active surfaces. Later such an array can be used as sensor, each point of it allows to analyse a specific material in a sample.

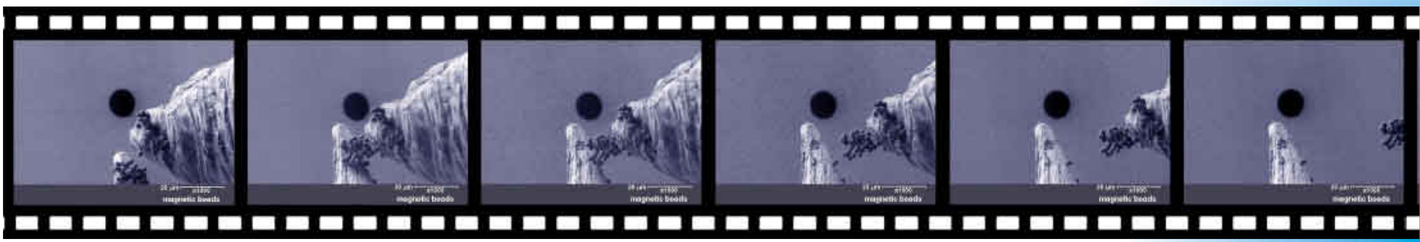

Fig. 2: Transfer of micro-particles between two Nanomanipulators by changing forces from adhesion to magnetism.

Transport with Nanomanipulators

An example for the transport of a 1 micron small object is shown in the sequence of Fig. 2. With a Nanomanipulator a cluster of particles is gripped by adhesion and moved towards the bigger tip of a second Nanomanipulator. Here the exchange of these particles takes place with the help of a stronger force. In this case it is the magnetism of the bigger tip. The second manipulator moves the cluster out of the picture. The particles are so small that a scanning electron microscope was necessary to visualize this process.

The transport of a single drop only by varying the strength of adhesion could be achieved already with the Nanomanipulator of Fig. 3. The Nanomanipulator takes a drop out of a reservoir with its tip. The linear table moves a glass capillary tube as target under the manipulator, that drives its tip into the tube. At the moment the drop touches the margin of the tube it is swallowed into it. With this method the Nanomanipulator can spend the claimed minimum amounts of liquids precisely onto surfaces. So the sensor arrays described above can be produced automatically in high resolution and reproducibility.

Fig. 3: A Workbench for Nanobiology, made out of a Nanomanipulator and a linear table from Klocke Nanotechnik, Aachen.

„Workbench“ for Nanobiology

Another application of the Nanomanipulator is the „Patch Clamp Manipulator“ for Life Science. The Patch Clamp Manipulator is well known from TV pictures of cells that are captured with this tool, pierced and fertilised artificially. The manipulator moves a thin glass capillary tube in a volume of about 25 x 25 x 25 mm^3 for this application. The idea to realize such a manipulator with Nanomotors is obvious and offers a much better resolution with reduced requirement of space. Even inside of a Patch Clamp Head there is space enough for a Nanomotor, see Fig. 4.

This additional degree of freedom allows to measure the mobility of molecules that leave a single cell. Compared with conventional manipulators the Nanomanipulator shown in Fig. 3 is about a factor of 100 smaller in volume, thermally compensated and has the resolution of a scanning probe microscope. Combined with a linear table out of Nanomotors a workbench for Nanobiology is formed, that can work with objects much smaller than a cell.

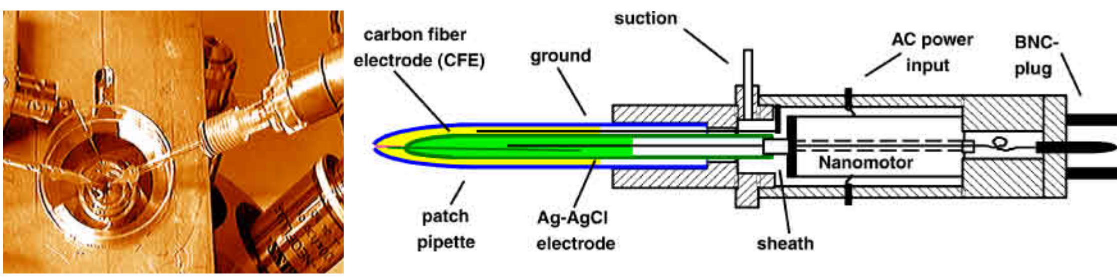

Fig. 4: A Nanomotor inside of the head of a Patch Clamp Manipulator.

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