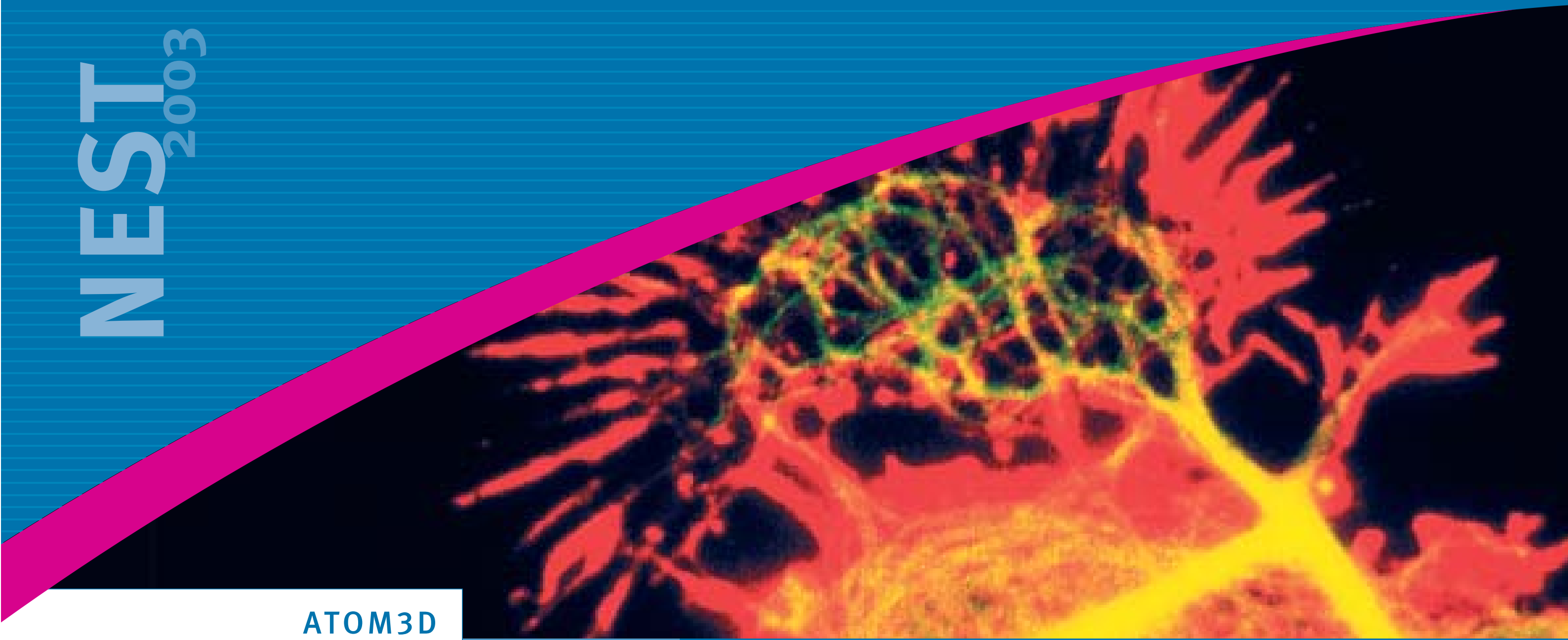

ATOM3D
NEST ADVENTURE

Being able to grasp tiny objects without physically touching them has many applications for handling delicate biological structures such as living cells. © Roche

Optical tweezers are tightly focused laser beams used to grasp and manipulate tiny objects such as single cells. In this ambitious NEST project, scientists from seven countries will extend tweezer technology to allow particles as small as molecules to be trapped, sorted, transported and even assembled into artificial crystals. In particular, these techniques will have applications in microfluidics, the technology which allows biochemical tests to be done with minute quantities of fluid – the so-called 'lab on a chip'.

Bright future for optical tweezers

Optical tweezers were invented by US physicists in the 1980s who discovered that a tightly focused laser beam could be used to trap microscopic objects, from 0.1 micrometres to tens of micrometres in size. Being able to grasp, move and rotate tiny objects without physically touching them has many applications for handling delicate biological structures such as living cells and their components, and has obvious implications for nanotechnology.

But the dexterity with which objects can be held depends ultimately on the wavelength of the laser light which is still not much shorter than a micrometre. Much finer tweezers will be needed if viruses and even single molecules are to be held. And physicists would dearly like to be able to handle multiple objects at the same time and place them anywhere they wish.

ATOM3D, coordinated by Kishan Dholakia of the University of St Andrews in Scotland, is an ambitious NEST project to create a whole new range of optical manipulating tools, with numerous applications in molecular biology and miniaturisation technology. Its seven partners bring a wealth of expertise in laser optics, electronics, microbiology, microfluidics and microfabrication.

Conveyor belt of light

The first priority of the project is to investigate how optical traps – the jaws of the tweezers – can be formed on nanometre scales, typically a thousand times smaller than today's traps. This part of the project, led by the Institute of Photonic Sciences in Barcelona, will try two approaches that should work in theory but which have not yet been demonstrated experimentally. One makes use of so-called 'evanescent' waves to trap particles in a 100 nanometre layer behind a reflecting surface. Another will investigate how interference holograms can be used to create not only multiple traps on nanometre scales but also an optical 'conveyor belt' to transport trapped particles.

A second work package, led by the University of St Andrews, will focus on 'tailoring the optical landscape', in other words, creating traps of any desired size, shape and number. Until recently, the only

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The seven partners involved in the project bring a wealth of expertise in laser optics, electronics, microbiology, microfluidics and microfabrication. © VIB

AT A GLANCE

Official title
Advanced techniques for optical manipulation using novel 3D light field synthesis

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- *France: Thales Research and Technology*
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way to trap more than one object at a time was to switch the beam rapidly between multiple sites, a feat that has been likened to a circus performer spinning plates on poles. More recently, diffractive optics have been used to make multiple, though static, traps. The team's aim is to improve commercial devices known as spatial light modulators (SLMs) in the hope of being able to rapidly mould the shape of the laser beam to create multiple traps of any desired form at any time.

Optically bound matter

They will also look at exploiting the well-known phenomenon of Brownian motion (the random jiggling of particles by molecules of the supporting medium) to move objects from one place to another and also to sort objects of different characteristics. Even more ambitiously, the team will investigate 'optically bound matter', artificial crystals of particles held together by light rather than the normal molecular forces.

> **New optical tweezers could be able to handle and move particles as small as molecules.**

The third major area of study concerns microfluidics, the technology of manipulating fluids on the nanometre scale – a kind of plumbing complete with valves, pumps, mixers and other devices. It has particular application in biomedical testing. A team led by Hungary's Biological Research Centre will build on the results from other parts of ATOM3D, to use optical tweezers to fabricate, assemble, operate and power microfluidic devices. An early application will be a microscopic 'lab on a chip' which can study the growth of individual cells by optically moving them between different environments.

Each work package will itself be multidisciplinary, drawing on the expertise of several partners. The project will finish with a public workshop to which other stakeholders in molecular trapping will be invited. Members of the consortium will also take part in workshops organised by complementary EU projects.

SIXTH FRAMEWORK PROGRAMME