

Assembling nanowires is a HOT topic

NANOWIRES

Semiconductor nanowires can be independently moved and assembled into complex structures using holographic optical traps (HOTs) [Agarwal *et al.*, *Opt. Lett.* (2005) **13**, 8906]. The new method developed by the groups of Charles M. Lieber and David G. Grier at Harvard and New York Universities, respectively, offers a way to control the orientation and assembly of nanosized structures rationally in three dimensions. The team's holographic approach creates the large number of optical traps necessary to capture and manipulate multiple nanowires. A computer-generated hologram is imprinted into laser light using a spatial light modulator, and the light is then focused to form the desired array of optical traps. Each of the traps can be moved independently in three dimensions by projecting a sequence of holograms.

CdS nanowires 50-150 nm in diameter and 10-40 μm in length were suspended in fluid between a glass microscope slide and coverslip. The team demonstrated the translation and rotation of individual nanowires using HOTs before cutting, organizing, and fusing several wires into complex structures. Cutting or fusing nanowires together was achieved by applying higher laser powers through well-focused traps.

Lieber and Grier believe that further advances in holographic trapping technology will improve the approach, making it faster and more parallel. The HOT technique could also be used with other functional building blocks, such as nanotubes or nanoparticles, to form larger, hierarchical systems in conjunction with chemically directed self-assembly steps.

Jonathan Wood

Microreactor speeds synthesis of molecular probe

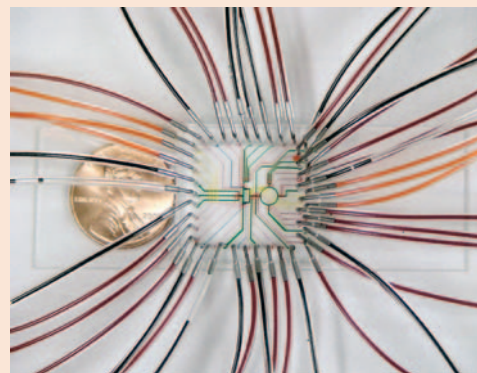
MICROFLUIDICS

Continuous-flow microreactors have great potential for controlling chemical reactions in small volumes. The advantages of such systems for automated syntheses on the nanogram to microgram scale, particularly for sensitive compounds, have now been demonstrated by researchers from the California Institute of Technology, the University of California, Los Angeles, Stanford University, Fluidigm, and Molecular Imaging.

They fabricated a microfluidic circuit that performs five sequential steps to synthesize a radiolabeled molecular probe for use in positron emission tomography (PET) [Lee *et al.*, *Science* (2005) **310**, 1793].

PET is a medical imaging technology that dramatically improves the diagnosis of cancer, has been shown to detect Alzheimer's disease before symptoms are seen, and can determine which patients with heart disease will benefit from bypass surgery. The most widely used radiolabeled probe is a modified form of glucose, fluorodeoxyglucose ($[^{18}\text{F}]\text{FDG}$), which was used in 3 million clinical PET studies worldwide in 2005. It is used in only nanogram amounts and its brief half-life of 11 min makes rapid synthesis of doses essential, so $[^{18}\text{F}]\text{FDG}$ is an appropriate choice for microreactor synthesis.

The integrated microfluidic platform, made up of channels, chambers, and valves, first concentrates a dilute $[^{18}\text{F}]\text{fluoride}$ solution. The solvent is then exchanged from water to acetonitrile to allow the third step – fluorination of D-mannose triflate – to occur in



Microfluidic circuit used to synthesize a molecular label for PET.

anhydrous conditions. Solvent exchange back to water occurs before the final step, acidic hydrolysis of the fluorinated intermediate product, produces $[^{18}\text{F}]\text{FDG}$.

The microfluidic device accelerates the synthetic process, taking just 14 min (compared to the 50 min of commercial synthesizers), and reduces the quantity of reagents and solvents required. Sufficiently large amounts of the radiolabeled probe were produced to be used in PET imaging of a tumor-bearing mouse. The researchers believe that this platform technology will simplify, lower the cost, and deliver a diverse array of molecular labels for imaging various diseases.

Jonathan Wood

Sizing nanoparticles in microfluidic channels

CHARACTERIZATION

Daniel T. Chiu and colleagues at the University of Washington have developed a technique to determine the size of nanoparticles that can be used in microfluidic systems [Kuyper *et al.*, *J. Am. Chem. Soc.*, doi: 10.1021/ja0569252]. Confocal correlation spectroscopy (CCS) is used for on-chip sizing of fluorescent and nonfluorescent nanoparticles that are 5.5-150 nm in size.

Synthesis of nanoparticles in microreactors or microfluidic systems allows their size to be controlled precisely and enables a range of reaction conditions to be sampled simultaneously. Generally, the nanoparticles can only be characterized afterwards using conventional light-scattering or electron microscopy equipment. The ability to determine size in the microfluidic channels of the chip would offer real-time readout and the ability to optimize reactions. However, of the available methods, light scattering would require concentrated samples and scanning probe techniques would not work for nanoparticles free in solution. "We developed this technique,

in part, because there is no generalized method currently available for sizing dilute concentrations of nanoparticles confined to small volumes, such as those found in microfluidic systems," explains Chiu. He believes CCS will have particular advantages in characterizing colloids, polymer beads, and biological particles such as viruses, vesicles, and DNA. The setup introduces an L-shaped dead end into a microchannel that catches some of the particles flowing past. In this dead volume, the nanoparticles move solely by Brownian motion. A laser in confocal geometry is focused on the dead volume, and backscattered photon bursts are recorded as nanoparticles pass through the laser probe volume. Autocorrelation curves for the photon bursts are used to determine the size of the particles.

"Currently, we are pushing this method to measure even smaller particles, as well as applying this method to biological studies," says Chiu.

Jonathan Wood