10.15 CWC7

Cell manipulation by using diamond micro-particles as handles for laser tweezers

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Summary

In the early 1970s Ashkin and his coworkers pioneered the optical trapping of smaller dielectric particles with laser beams[1]. Laser optical traps or optical tweezers have then found wide applications in various fields including acoustics, biology, biomedicine, and microchemistry. Optical tweezers are directly used to micromanipulate cells and intra-cellular organelles, or by coating beads with materials like myosin, optical tweezers are used to control the moving of beads which are treated as handles for cell manipulations. Due to the isotropic or symmetric properties of cells or beads, cell rotational control is hardly achieved in a laser optical traps. In this presentation we will demonstrate the cell manipulation, including not only the linear translations but also rotations, by using irregular-shaped diamond particles as handles for optical tweezers.

The light source for the laser tweezers is a fundamental Gaussian mode Ti:sapphire laser with linear polarization at a wavelength of 790 nm. The laser beam was strongly focused by a microscope objective lens (Leitz PLAN 50X, NA 0.6) onto the micro-objects. We adopted 15-25 μm synthetic monocrystalline diamond micro-particles manufactured for lapping and polishing applications as our manipulation handles. Due to its shape asymmetry[2], we can easily observe 360 degree rotation as a results of non-zero net torque contributed from the forces at each surfaces. By vertically moving the laser focal plane inside the diamond micro-particles, we can change the net torque induced by the optical forces so as to control the rotational speeds, rotation directions, or even stop the rotations of the particles. Linear movements of the diamond particles can also be easily achieved by moving the laser beam horizontally. We coated the irregular-shaped diamond micro-particles with poly-L-lysine as handles for cell manipulations. Figure 1 shows the rotational movement of biological cells by using diamond micro-particles as handles for laser tweezers. We have used mesophyll protoplasts from *Arabidopsis thaliana* for demonstration. Independent movements of linear translations and controllable rotations can be easily achieved, indicating the potential application of irrelagur-shaped particles for the micro-manipulation of biological cells.

[1]. A. Ashkin and J. M. Dziedzic, *Appl. Phys. Lett.* **24**, 586 (1974).
[2]. E. Higurashi, H. Ukita, H. Tanaka, and O. Ohguchi, *Appl. Phys. Lett.* **64**, 2209 (1994).

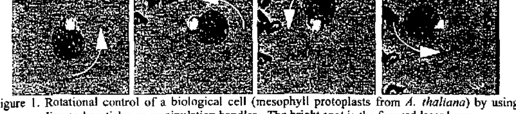

Figure 1. Rotational control of a biological cell (mesophyll protoplasts from *A. thaliana*) by using diamond particles as manipulation handles. The bright spot is the focused laser beam.

08.30-10.30 CWD – Optoelectronic Systems Integration

Presider: R. Baets, *University of Ghent, BELGIUM* **THALIE**

08.30 CWD1 (Invited)

Terabit/s parallel optical connections to silicon CMOS chips: lessons learned from the SPOEC technology demonstrator

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Summary

Theoretical estimates suggest that the physical limit on electrical data communication rates between silicon chips is of the order of a few Tbit/s for connection lengths of over ~ 100 mm [1]. The semiconductor industry predicts that this level of input-output is likely to be required in the next ten years [2]. Free-space optical connections to silicon VLSI potentially offer much higher data-rates than electrical interconnects and are promising for future high-performance electronic systems.

We have assembled the components of an optoelectronic 16 Gbit/s crossbar switch [3] designed to include, internally, an optical data rate to a hybrid InGaAs/silicon chip in the Tbit/s regime. Input to the demonstrator is by an 8 x 8 VCSEL array [4] operating at 250 Mbit/s/channel. These 64 channels are fanned out 8 x 8 times, using diffractive optics, to give the high overall data rate (Tbit/s) onto the hybrid switching chip. This chip includes an array of 4096 InGaAs-based p-i-n detectors solder-bump bonded to silicon CMOS. The detectors connect directly to a matching array of photocurrent receivers distributed across the silicon chip. The custom-designed 0.6 μm CMOS performs packet routing of the incoming data, under the control of an optically-distributed clock, and the routed signals are output optically via differential modulator pairs, interlaced between the detectors on the InGaAs chip. Tests of the assembled optical system show the required performance. Initial results from full-system experiments will be presented.

For the large photocurrent receiver array exploited in this technology demonstrator (4096 in total) the overall power consumed is about 10 watts. Scaling calculations [5], taking into account the expected advances in VLSI technology, show that future 0.1 μm technology should permit arrays of similar receivers to dissipate as little as 0.3 W/(Tbit/s). Combined with high-performance VCSEL or modulator transmitters, this approach offers a high efficiency interconnect technology capable of avoiding the limitations imposed by electrical chip-to-chip connections.

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[2] "The National Technology Roadmap for Semiconductors" Semiconductor Industry Association, San Jose, California (1997)
[3] A C Walker, M P Y Desmulliez, M G. Forbes, S.J Fancey, G S Buller, M R Taghizadeh, J A B Dines, C R. Stanley, G Pennelli, A R Boyd, P Horan, D Byrne, J Hegarty, S Eitel, H -P Gauggel, K -H Gulden, A Gauthier, P Benabes, J L Gutzwiller, and M Goetz, "Design and Construction of an Optoelectronic Crossbar Switch Containing a Terabit/s Free-space Optical Interconnect," " *IEEE J Selected Topics in Quant Electron* Vol 5, No 2, pp 236-249 (1999)
[4] S Eitel, S J Fancey, H-P Gauggel, K-H Gulden, W. Bächtold and M R. Taghizadeh "Highly Uniform Vertical Cavity Surface Emitting Lasers Integrated with Microlens Arrays" submitted for publication in *IEEE Photonics Technology Letters* (September 1999)
[5] M.G Forbes, PhD Thesis, Heriot-Watt University (1999)