Low-Cost and Creative Tools for Learning Nanoscience and Creating Nanostructures at Schools

Abstract:

Grab, pattern and trim. With motivation, patience and innovation, topped with focused laser beam system and optical tweezers, one can create beautiful 3D microstructures. With the hybrid of Quantum dot and Carbon Nanotubes, multicolour microstructures can also be created beautifully. Want to grow nanoscale metal oxide with minimum cost? Just prepare a hotplate, control the environment, polish the metal substrate and heat it up. Fascinating morphologies of wide variety of metal oxides will appear. In this article, we shared our experience touring around Nanomaterials Laboratory in NUS and conversing with Prof Sow Chorng-Haur about his passion for outreach and education to young students in nanoscience via low-cost, fun and interesting methods.

Impressed by the plenary presentation given by Prof Sow Chorng-Haur at Nanotech Malaysia 2009 (held in end October 2009) on low-cost fabrication of nanoscale metal oxide, NanoGlobe team visited Prof Sow on 20 Nov 2009 to find out more about him and his research activities. Prof Sow hosted our visit with great hospitality. He is an Associate Professor in the department of Physics at the National University of Singapore (NUS) with a team between 15-20 researchers and students. He is also a Fellow in NUS Teaching Academy. He is also an Assistant Dean for Outreach in the Science Faculty, and a member of NUS Nanoscience & Nanotechnology Initiative (NUSNNI).

We are most impressed by his passion for education and outreach. Besides undergraduate and graduate students, Prof Sow engages about 25 – 30 high school students to introduce nanoscience at early age and most importantly provide hands-on experience, fun and excitement in research. His teaching aspirations are to fuel students' enthusiasm in the discovery of scientific truths and nurture students' creative and innovative spirit in tackling fascinating problems. This is proven from the presence of "Our wall of crazy ideas" in his laboratory to allow his students expressing all ideas they have and subsequently discussing the possibility of those ideas. (Fig. 1)

We are fascinated by his approach to inspire young students through his simple and low-cost methods. One example is the use of only a hot plate at controlled environment to grow wide variety of nanoscale metal oxides with fascinating morphologies, such as nanowires, nanowalls, nanoflakes and nanorods. There is no other requirement than a polished surface of the substrate in this method.

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Another example is optical tweezers, which was assembled in-house by only integrating a laser source and an optical microscope. Through a focused laser beam, they are able to grab nanoparticles, generate micro and nanostructure patterns, and be used as characterization tool. Although it currently has the resolution of ~600nm, optical tweezers is much more affordable than focused ion beam (FIB) system (2 orders of magnitude more expensive) typically used in semiconductor industry and sophisticated laboratories. Therefore it is very suitable for his education purpose to motivate the young students in schools.

The fun of focused laser beam application for most students is to create micro-arts. Creative 3D structures such as micro-Stonehenge and micro-Great Wall (Fig. 2) are fabricated by graduate students during their vacation period. In hybrid nanomaterial systems, he explained that he can use aligned carbon nanotube (CNT) templates as natural 3D scaffold (CNT forest) for controlled assembly of various semiconducting nanoparticles quantum dots. The CNT forest acts as nano-sieve to sort out the quantum dots with a size difference of ~0.5nm. The focused laser beam can then be used to pattern these arrays of CNT preferentially decorated with the quantum dots, creating CNT/quantum dots multi-colour & multi-component 3D micro-sculptures. Many microstructure patterns have been created, such as micro-NUS logo, micro-pattern of Tai Chi, and micro-Singapore Island. (Fig. 3)

In the area of biophysics and biomechanics disciplines, the optical tweezers can also be used to characterize the mechanical & physical properties of red blood cells. For example, working in a team led by Prof Lim Chwee Teck, Division of Bioengineering, NUS, the team had shown the difference between a healthy and malaria-infected red blood cell. The optical tweezers can be used to stretch the blood cell and they found that healthy cell is very stretchable while the malaria-infected cell is very stiff and difficult to stretch. This method is thus very useful for diagnosis application. (Fig. 4)

Currently, Dr. Sow is one of the collaborators of a newly awarded SGD 10M Competitive Research Programme project led by Prof Subodh Mhaisalkar from NTU entitled Nanonets: New Materials, Devices for Integrated Energy Harnessing & Storage, funded by the National Research Foundation (NRF) of Singapore.

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Fig. 1. Prof Sow and Dr Liu in front of "Our Wall of Crazy Ideas"

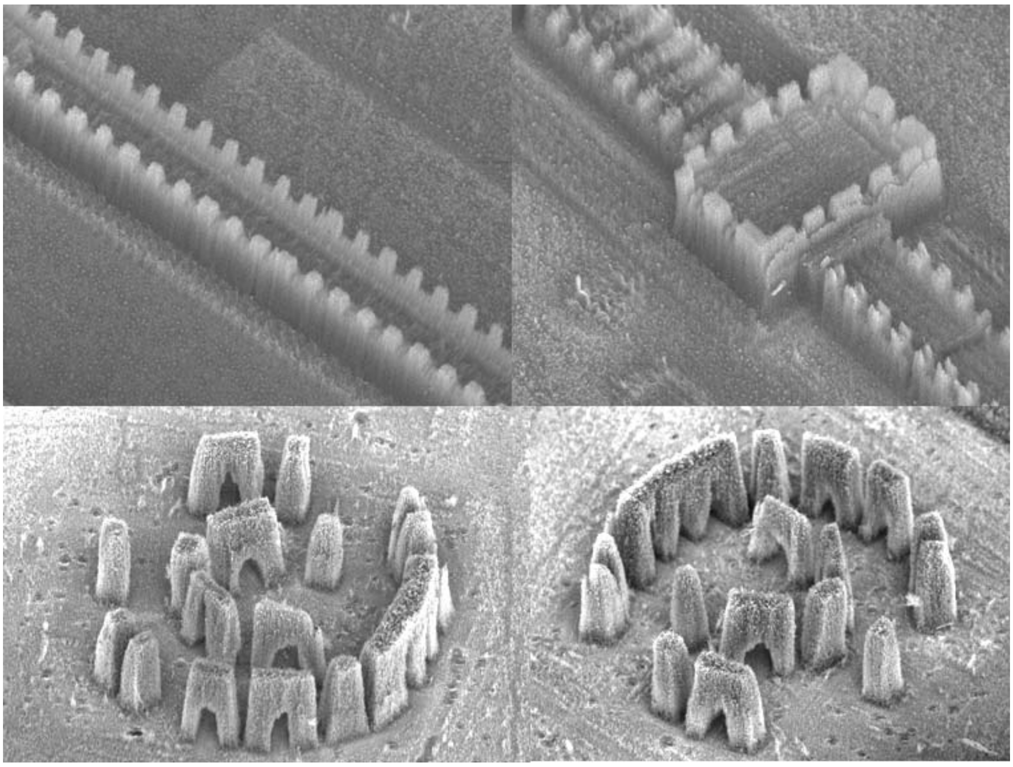

Fig. 2. Laser pattern CNT into 3D micro-Great Wall and micro-Stonehenge (*Source: Prof Sow CH, NUS*)

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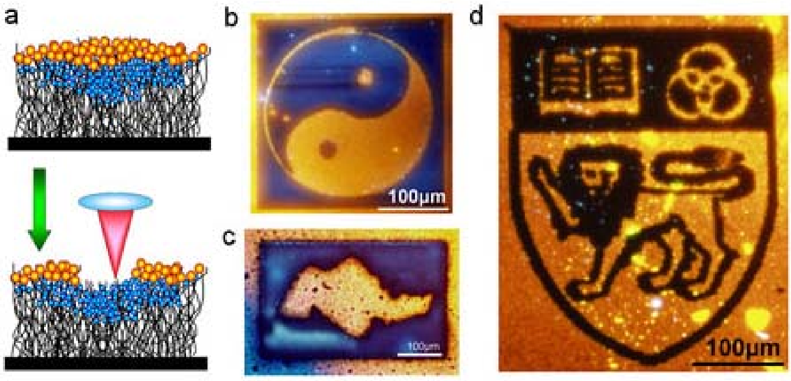

Fig. 3. (a) Schematic of the patterning process using optical tweezers for quantum dots decorated CNT. Fluorescent microscopy images of (b) Tai Chi pattern (c) Singapore Island (d) NUS logo (*Source: Prof Sow CH, NUS*)

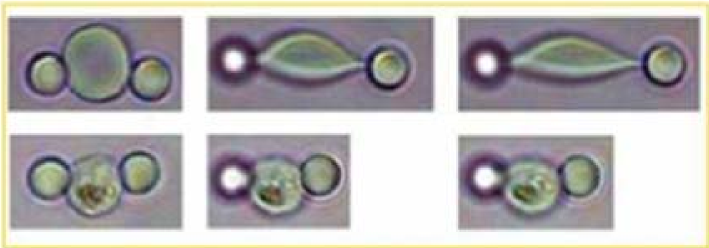

Fig. 4. Optical tweezers stretching of a healthy red cell (top row) and a stiffer red blood cell in a late stage of malarial infection (bottom row). *(Source: Prof CT Lim, Div of Bioengineering, NUS)*

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