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Late-Year News

A Bright Future for Silicon

Ordered nanocrystal arrays may provide a new platform to study and tailor the light-emitting properties of silicon. US scientists at the University of Texas at Austin and Cornell University have fabricated the first ordered arrays of silicon nanocrystals reported to date. Brian A. Korgel and colleagues developed a new chemical method to generate tiny silicon crystals—or quantum dots—with precisely controlled size and then relied on nature to organize them into regular structures. The new self-assembled arrays, which will be presented in the next issue of *ChemPhysChem*, could help researchers exploit the promising light-emitting properties of one of the most commercially important semiconductors.

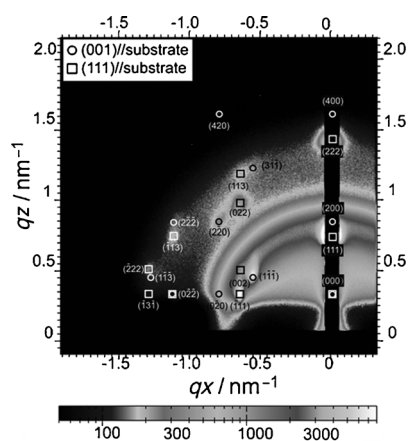


Figure 1. US scientists have fabricated the first ordered arrays of silicon nanocrystals reported to date.

Bulk silicon is used in a wide range of applications, mainly in the electronics industry, but it is a weak light absorber and an extremely poor light emitter, so it is not suitable for uses that require light emission. These properties change when the crystal shrinks to the nanoscale. Si quantum dots can exhibit very bright visible luminescence with size-tunable color, which makes them inter-

esting for the fabrication of light-emitting diodes (LEDs)—or even as a possible laser source. During the last years there has been great interest in understanding these unique properties and using them to create new technologies.

However, most of the applications require arrays of nanocrystals, and although there have been efforts to fabricate them, the collections of Si quantum dots obtained to date have been disordered, usually with a significant size distribution. Korgel and co-workers have now developed a new chemical method that allows them to obtain monodisperse silicon particles in the exact size range needed for nanoscale properties, such as bright light emission. “We have made the first ordered arrays, or superlattices, of nanoscale silicon crystals. These collections of tiny silicon crystals are self-assembled—much in the same way that macromolecules self-assemble in living organisms”, Korgel says. “This is necessary because the dimensions are far too small to be obtained using conventional means like the lithographic patterning techniques used to make integrated circuits”, he adds. The scientists also found that the new Si nanocrystal superlattices are much more thermally stable than other types of nanocrystal superlattices reported before.

Korgel’s team synthesized Si nanocrystals by thermal decomposition of hydrogen silsesquioxane (HSQ), followed by etching with HF, reaction with 1-dodecene, and size-selective precipitation of the obtained nanoparticles. The quantum dots were then dispersed in chloroform and finally drop cast. Two known techniques—called transmission electron microscopy (TEM) and grazing-incidence small-angle X-ray scattering (GISAXS)—were applied to study the ordering of the nanocrystals. “Because the order in these arrangements can influence the properties of the nanomaterials, silicon quantum dot superlattices provide a new playground for understanding and manipulating the properties of sili-

con in new and unique ways”, Korgel says.

Further information: <http://www.chemphyschem.org>

Nicholas Turro Dies at 74

Nicholas J. Turro, Professor of Chemistry at Columbia University, passed away on November 24, 2012, at the age of 74. He was a world-renowned researcher in the field of organic photochemistry and an excellent teacher and advisor. “He was the greatest mentor I know”, says Dr. Steffen Jockusch, who worked with Turro for more than 18 years, first as a Postdoctoral Research Fellow and then as an Associate Research Scientist. “Over the many years I worked in his research group, I have seen how he made all newcomers welcome and shaped them to become good, professional scientists when they left, no matter what their level was when they arrived”.



Figure 2. Nicholas Turro (1938–2012) (Credit: Columbia University).

Dr. Jeffrey Lancaster, a young Associate at Turro’s group agrees with this: “Professor Turro—‘Boss’ as he was affectionately known to his group—was a mentor in the truest sense”, he says. “He also apparently had a love for words that started with P; anyone who ever learned from him about ‘Professionalism’, ‘Paradigms’ and the differences between what is ‘Possible’, ‘Plausible’, and ‘Probable’ knows the clarity with which he could see, communicate, and educate others about scientific problems and their solutions. He will truly be missed by an extensive scientific family that he

and his wife, Sandy, nurtured together for over 55 years”.

Turro made important contributions to the understanding of the reaction pathways of intermediates. He studied the structure and dynamics of photochemically generated species, such as carbenes, singlet oxygen, radicals, radical pairs, and biradicals. His group also developed a new area of research called “supramolecular photochemistry” and made outstanding contributions to the field of spin chemistry. Turro’s “enthusiasm and unquenchable energy for science was truly inspiring”, Jockush says. “I was always amazed by how quickly he adopted new ideas, new research projects and new technology”.

Nicholas Turro earned his B.A. degree in chemistry (summa cum laude) at Wesleyan University (USA) in 1960, and his Ph.D. degree in organic photochemistry at Caltech in 1963. After spending a year as a Postdoctoral Fellow at Harvard University, he joined Columbia’s chemistry faculty as an instructor. He became Professor in 1969. The US scientist co-authored more than 900 research papers and published several influential books, including *Molecular Photochemistry* (1965) and *Modern Molecular Photochemistry* (1978). Turro received numerous prizes throughout his career and was recently selected as the recipient of the inaugural George S. Hammond Award from the Inter-American Photochemical Society.

Further information: <http://turroserver.chem.columbia.edu/>.

Hybrid Nuclear–Electronic Qubits

Scientists have found a way to make bismuth electrons and nuclei work together as quantum bits (qubits). The new results, published in the journal *Nature Materials*, could take us a step further in the development of quantum computers. The work was carried out by an international team based at the University of Warwick, UCL, ETH Zurich and the USA Sandia National Labs.

“Electrons and nuclei have a property called spin, and magnetic resonance imaging (MRI) works by controlling nuclear spins in our bodies”, explains Dr. Gavin Morley, lead author of the paper.

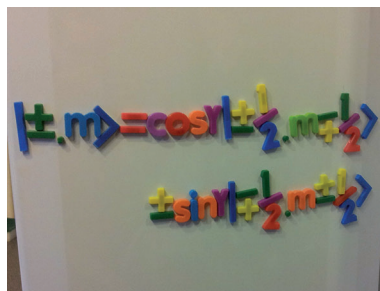


Figure 3. Hybridizing electronic and nuclear spin qubits makes quantum control much easier. This equation describes the pure states of bismuth-doped silicon for which the nuclear and electronic qubits become maximally hybridized at specific magnetic fields (courtesy of Gavin Morley, University of Warwick).

“In our new experiments, we have used magnetic resonance to control the quantum state of electron spins that are *hybridized* with bismuth nuclear spins in a silicon crystal”.

According to the researcher, this allows him and his team to manipulate the system orders of magnitude faster than previous work in the traditional *non-hybridized* regime. “We use these spins as qubits because we have found that they store quantum information for such a long time: we put them into superposition states and they retained their coherence for over 1 ms”, Morley told *ChemPhysChem*.

Information on our normal computers is stored as bits, which are either ones or zeros. Qubits—the building blocks of quantum computers—work differently: in a superposition state they try out being in a zero and a one at the same time. “If someone could build a large enough quantum computer, it could solve certain problems that are intractable with the computers we have now”, Morley says. “Using the hybrid regime would make it easier to build a quantum computer, because the fast control can finish before decoherence sets in and destroys the superposition and entanglement that are key to quantum computation”, he adds.

In the past, scientists have recorded continuous-wave magnetic resonance spectra of hybrid nuclear–electronic spin systems, but they have not been able to demonstrate quantum control of these systems. Now, Morley and co-workers

have achieved this by using pulsed magnetic resonance. “You can’t call it nuclear magnetic resonance or electron paramagnetic resonance, as the states we control are close to a 50:50 mixture of electronic and nuclear states. We call it pulsed nuclear–electronic magnetic resonance”, Morley says.

Source: <http://www2.warwick.ac.uk>. Further information: <http://www.nature.com/nmat>.

In the Next Issue of *ChemPhysChem*

2013 starts with a bumper issue of *ChemPhysChem*. In a Review, U. Pischel, J. Andréasson et al. discuss the future of information processing with molecules (DOI: 10.1002/cphc.201200157). The Minireview by W.-S. Yeo and I. Choi deals with self-assembled monolayers with dynamicity (DOI: 10.1002/cphc.201200293). J. Wang, F. Ding, and L. Ma report on recent progress and challenges in graphene nanoribbon synthesis (DOI: 10.1002/cphc.201200253). The Concept by S. Shaikhutdinov and H. J. Freund demonstrates that metal-supported aluminosilicate ultrathin films can act as a versatile tool for studying the surface chemistry of zeolites (DOI: 10.1002/cphc.201200826).

In the Articles section, B. Dietzek et al. study energy transfer in poly(methyl methacrylate) polymers (DOI: 10.1002/cphc.201200545) and J. Limtrakul et al. investigate the transformation of ethanol into ethene on a zeolite (DOI: 10.1002/cphc.201200786). Finally, in the Communications section, L. Echegoyen, M. E. Plonska-Brzezinska et al. carry out conductance measurements for functionalized carbon nano-onions using an STM-based molecular junction approach (DOI: 10.1002/cphc.201200624). The paper by B. A. Korgel and colleagues on ordered Si-nanocrystal arrays (featured above) can also be found in issue 1 (DOI: 10.1002/cphc.201200738).

Further information on our Early Views site at: www.chemphyschem.org.

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