

Cover: A collage of images from various contributions to this Special Issue of *Advanced Materials* is shown on the cover. Structures ranging from tetrapods, multi-wall tubes, and belts to arrays of nanowires and nanorods, and vortices in nanorod liquid crystals are represented. Cover design by Brian Mayers.

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Guest Editorial

In this Editorial for the Nanowires Special Issue of *Advanced Materials*, Younan Xia and Peidong Yang welcome you to this survey of the fast-moving area of nanowire research. Communications and Research News articles covering vapor-phase, solution-based, and template-directed routes to the synthesis of nanowires, self-assembly with nanowires as the building blocks, and new physics associated with 1D nanostructures can all be found within.

Y. Xia,* P. Yang*

Adv. Mater. **2003**, *15*, **351** ... 352

Chemistry and Physics of Nanowires

Review

Current research activities concentrating on one-dimensional (1D) nanostructures—wires, rods, belts, and tubes—are comprehensively reviewed. Chemical methods of synthesis are introduced and a range of growth mechanisms discussed in terms of shape control. The generation of heterostructured nanowires is detailed, as is the range of unique properties of 1D nanostructures. The assembly of 1D nanostructures into functional devices is also mentioned. The article concludes with perspectives on future research and related issues.

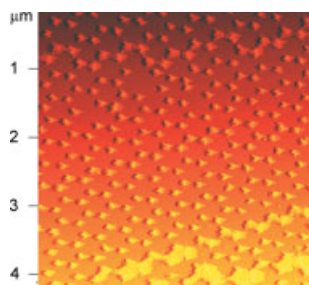
Y. Xia,* P. Yang,* Y. Sun, Y. Wu, B. Mayers, B. Gates, Y. Yin, F. Kim, H. Yan

Adv. Mater. **2003**, *15*, **353** ... 389

One-Dimensional Nanostructures: Synthesis, Characterization, and Applications

Communications

A study on the electron relaxation dynamics and thermal cooling of colloidal gold nanoparticles (see Figure) in air and water finds that the local energy exchange with the surrounding medium occurs on the picosecond time scale, comparable with the electron–phonon relaxation, while a slow heat dissipation by water ensures that the particles remain heated for hundreds of picoseconds.



S. Link, D. J. Hathcock, B. Nikoobakht, M. A. El-Sayed*

Adv. Mater. **2003**, *15*, **393** ... 396

Medium Effect on the Electron Cooling Dynamics in Gold Nanorods and Truncated Tetrahedra

Aligned metal nanoparticles are connected using a second metal to produce bimetallic wires. The nanoparticles are electrodeposited along the step edges of a highly oriented graphite surface and, after being given a protective coating, joined by long nanowires which are also electrodeposited. Beaded structures are produced, such as the nickel/molybdenum oxide wire shown the Figure.



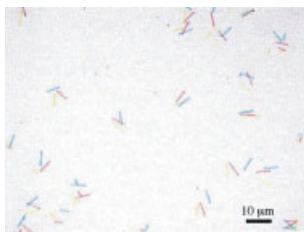
E. C. Walter, B. J. Murray, F. Favier, R. M. Penner*

Adv. Mater. **2003**, *15*, **396** ... 399

“Beaded” Bimetallic Nanowires: Wiring Nanoparticles of Metal 1 Using Nanowires of Metal 2

Communications

Surface diffusion coefficients (D) have been measured for gold nanorods suspended in water on planar gold substrates. The Figure shows the composite image of sequential optical micrographs at 15 s intervals. The variation of D is more dependent on rod length than predicted by the Stokes–Einstein equation, consistent with a frictional interaction between the rod and the surface.

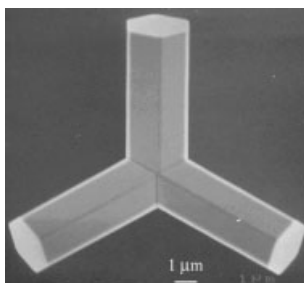


S. K. St. Angelo, C. C. Waraksa,
T. E. Mallouk*

Adv. Mater. **2003**, *15*, **400** ... 402

Diffusion of Gold Nanorods
on Chemically Functionalized Surfaces

The deterministic growth of different shapes of ZnO crystals from nanometer to micrometer scale is reported. Tetrapods (see Figure) and dendrites have been synthesized by simply adjusting the reaction temperature and the partial pressure of oxygen within the system. Size control of these structures can be achieved. ZnO nanoribbons are also easily accessible.

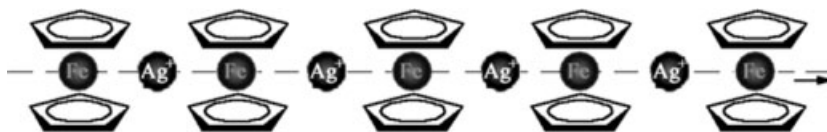


H. Yan, R. He, J. Pham, P. Yang*

Adv. Mater. **2003**, *15*, **402** ... 405

Morphogenesis of One-Dimensional ZnO
Nano- and Microcrystals

A polymer-surfactant-assisted sandwiched reduction route to silver nanowires is described based on the sandwich organometallic compound ($\eta^5\text{-C}_5\text{H}_5$)₂Fe, in which there is obvious steric hindrance when the iron atoms reduce silver cations to elemental silver (see Figure), leading to a preferred direction. The formation of nanowires occurs in a layered solution with the assistance of poly(ethylene glycol).

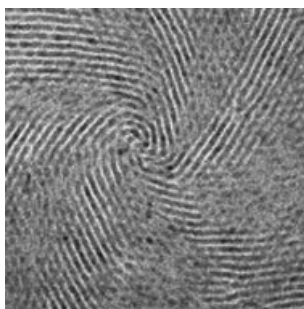


Y. Xiong, Y. Xie,* C. Wu, J. Yang, Z. Li,
F. Xu

Adv. Mater. **2003**, *15*, **405** ... 408

Formation of Silver Nanowires Through
a Sandwiched Reduction Process

The macroscopic alignment and superlattice structures of CdSe nanorods in a nematic liquid-crystalline (LC) phase are determined by the phases that form prior to complete solvent evaporation (e.g., vortex structures in linear arrays, see Figure). By controlling the phase of the LC solution and its orientation using pre-treated surfaces or external fields, it may be possible to achieve fine control of order in deposited nanorod films.

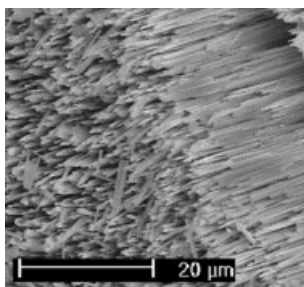


L.-S. Li, A. P. Alivisatos*

Adv. Mater. **2003**, *15*, **408** ... 411

Semiconductor Nanorod Liquid Crystals
and Their Assembly on a Substrate

Very long and highly oriented potassium-doped tungsten oxide nanowires (see Figure) can be synthesized using the simple technique presented here. The mechanism of nanowire formation is investigated and a vapor–liquid–solid mechanism is proposed. This novel method can be easily scaled up and can also be extended to the preparation of nanowire arrays of other materials.



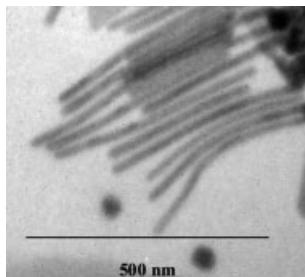
H. Qi, C. Wang, J. Liu*

Adv. Mater. **2003**, *15*, **411** ... 414

A Simple Method for the Synthesis
of Highly Oriented Potassium-Doped
Tungsten Oxide Nanowires

Communications

By using seed-mediation and careful control of pH, gold nanorods of high aspect ratio (~18–25, 20 in the Figure) have been produced by surfactant-directed synthesis. The yield is high (~90 %) and the method can be readily adapted for scaling up.

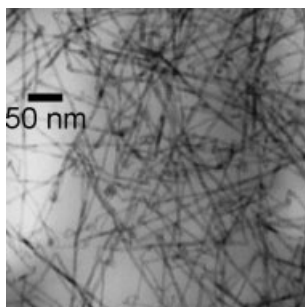


B. D. Busbee, S. O. Obare, C. J. Murphy*

Adv. Mater. **2003**, *15*, 414 ... 416

An Improved Synthesis of High-Aspect-Ratio Gold Nanorods

GaAs nanowires exhibiting narrow diameter distributions and small diameters within and near the strong-confinement regime can be generated using the solution–liquid–solid (SLS) mechanism (see Figure for 5.99 nm diameter wires). A relationship between the mean diameters of the nanowires and the indium catalyst nanoparticles from which the nanowires are grown is furthermore established.

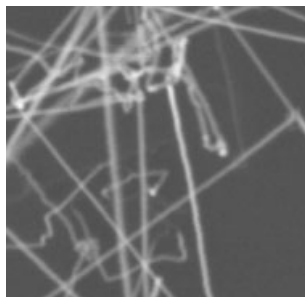


H. Yu, W. E. Buhro*

Adv. Mater. **2003**, *15*, 416 ... 419

Solution–Liquid–Solid Growth of Soluble GaAs Nanowires

GaN nanowires with diameters in the quantum-confinement size regime (4–10 nm, ~10 nm in Figure) are prepared on large-area substrates through catalytic reaction of Ga and NH₃ in a hot-filament chemical vapor deposition system. The synthetic method is reproducible and could be applied to the growth of other semiconductor nanostructures.



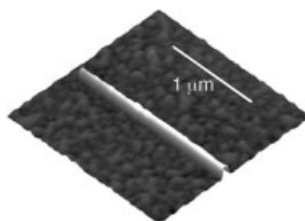
X. Chen, J. Xu, R. M. Wang, D. Yu*

Adv. Mater. **2003**, *15*, 419 ... 421

High-Quality Ultra-Fine GaN Nanowires Synthesized Via Chemical Vapor Deposition

Research News

The synthesis and characterization of barium titanate nanowires are reported. Pristine nanowires have diameters ranging from 5 to 70 nm, (see Figure) lengths exceeding 10 μm, and perovskite structures with a principal axis aligned along the wire axis. Local non-volatile electric polarization can be induced and manipulated on nanowires as small as 10 nm in diameter.

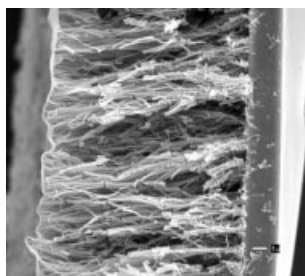


J. J. Urban, J. E. Spanier, L. Ouyang, W. S. Yun, H. Park*

Adv. Mater. **2003**, *15*, 423 ... 426

Single-Crystalline Barium Titanate Nanowires

The combination of sol–gel processing with electrophoretic deposition provides a new method for the growth of oxide nanorods. Both single metal oxide and complex oxide nanorods have been grown with uniform size (45–200 nm in diameter and 10 μm in length) and near-unidirectional alignment over large areas. The Figure shows TiO₂ nanorods ~180 nm in diameter.



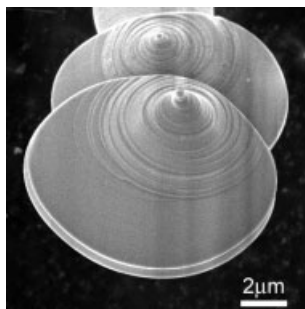
S. J. Limmer, G. Cao*

Adv. Mater. **2003**, *15*, 427 ... 431

Sol–Gel Electrophoretic Deposition for the Growth of Oxide Nanorods

Research News

Novel nanostructures of semiconducting oxides are reviewed. It is shown that nanobelts, nanowires, and nanodiskettes (see Figure) of materials such as zinc oxide, gallium oxide, silica, and tin oxide can be fabricated using a vapor phase evaporation method. Two applications of these materials—in field-effect transistors and as gas sensors—are highlighted.

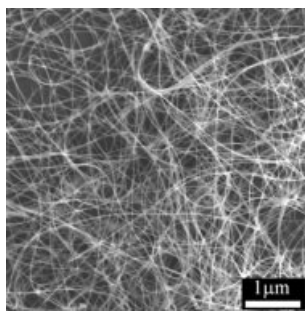


Z. L. Wang*

Adv. Mater. **2003**, *15*, 432 ... 436

Nanobelts, Nanowires, and Nanodiskettes of Semiconducting Oxides—From Materials to Nanodevices

Semiconductor nanowires of silicon and germanium, 4–30 nm in diameter and micrometers in length, can be produced in high temperature supercritical fluids with more size control and higher product yields than are offered by gas phase vapor–liquid–solid (VLS) methods. Such nanowires (see Figure for crude product) are promising candidates for a variety of new technologies, including computing, memory, and sensor applications.

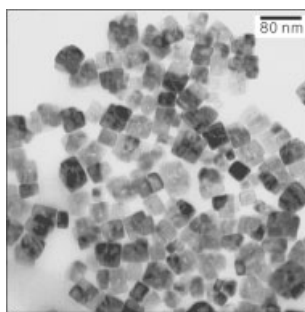


T. Hanrath, B. A. Korgel*

Adv. Mater. **2003**, *15*, 437 ... 440

Supercritical Fluid–Liquid–Solid (SFLS) Synthesis of Si and Ge Nanowires Seeded by Colloidal Metal Nanocrystals

The shapes of novel nanocrystals, including 1D nanorods and the MnS nanocubes shown in the Figure, can be controlled by balancing parameters such as the nucleating seeds, kinetic control, temperature, and selective activation energy modulations of surfaces through the use of capping molecules. Here, the anisotropic structural evolution and key growth parameters for the shape control of various semiconductor nanocrystals is examined.

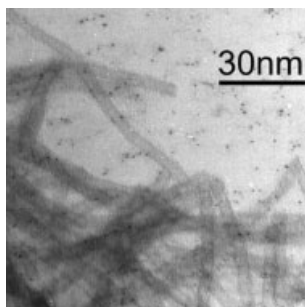


S.-M. Lee, S.-N. Cho, J. Cheon*

Adv. Mater. **2003**, *15*, 441 ... 444

Anisotropic Shape Control of Colloidal Inorganic Nanocrystals

Lamellar surfactant–metal compound meso-structured materials are used as templates to prepare long-shaped metal nanostructures in a general procedure. Subsequent treatment of these composites by various methods produces nanostructures such as bismuth nanotubes (see Figure), or tungsten, copper, or cobalt nanowires.

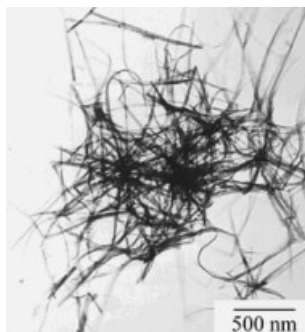


J. Wang, Y. Li*

Adv. Mater. **2003**, *15*, 445 ... 447

Rational Synthesis of Metal Nanotubes and Nanowires from Lamellar Structures

The preparation of nanowires as long as 100 μm at low temperature is possible using solvothermal synthesis. Under the pressure generated by solvothermal reactions, the as-prepared nanowires are well crystallized. A variety of nanowire structures, including CdS–CdSe core–sheath nanowires and very long CdS nanowires, as well as the solvothermal closure of PbS nanowires, are discussed.



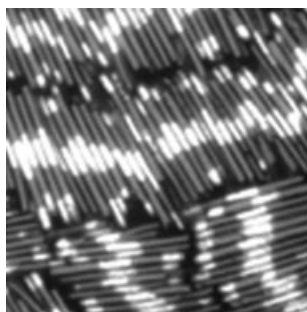
K.-B. Tang, Y.-T. Qian,* J.-H. Zeng, X.-G. Yang

Adv. Mater. **2003**, *15*, 448 ... 450

Solvothermal Route to Semiconductor Nanowires

Research News

Variations in composition along the length of striped nanowires (see Figure) can be used to incorporate electrical functionality, optical contrast, and/or desired surface chemistry. These particles are interesting as building blocks for nanoscale electronics and as bar-codes for both biological and non-biological tagging applications.

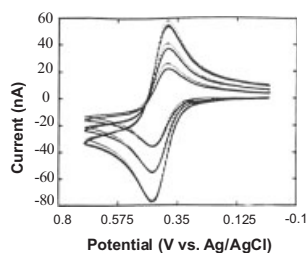


C. D. Keating,* M. J. Natan*

Adv. Mater. **2003**, *15*, 451 ... 454

Striped Metal Nanowires as Building Blocks and Optical Tags

Gold nanowires and nanotubes are formed by the electroless deposition of Au onto a porous polymeric template. Short deposition times lead to nanotubes, whereas longer times lead to nanowire formation. Investigations into potential use as nanoelectrode ensembles (see Figure) and for chemical separation membranes are presented.

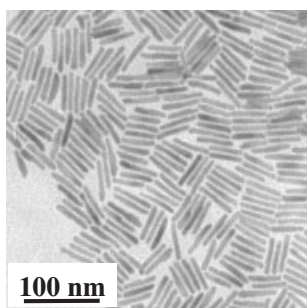


M. Wirtz, C. R. Martin*

Adv. Mater. **2003**, *15*, 455 ... 458

Template-Fabricated Gold Nanowires and Nanotubes

The growth of elongated, one-dimensional (1D) CdSe nanocrystals (see Figure) is found to be a kinetically controlled phenomenon. The 1D growth of wurtzite CdSe proceeds at high monomer concentration following the formation of small tetrahedral “magic-sized” cores of fixed composition. The proposed model is compared to experimental results.

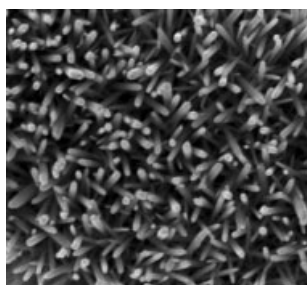


X. Peng

Adv. Mater. **2003**, *15*, 459 ... 463

Mechanisms for the Shape-Control and Shape-Evolution of Colloidal Semiconductor Nanocrystals

Strict control of precipitation and dispersion conditions makes it possible to generate well-defined and well-oriented ZnO nanoparticles (see Figure) of variable size and shape on various substrates. No template, membrane, organic surfactant, or applied external field is required, and consequently, the design of thin films with complex architecture over a large area is cleaner, faster, and less expensive.



L. Vayssieres*

Adv. Mater. **2003**, *15*, 464 ... 466

Growth of Arrayed Nanorods and Nanowires of ZnO from Aqueous Solutions

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