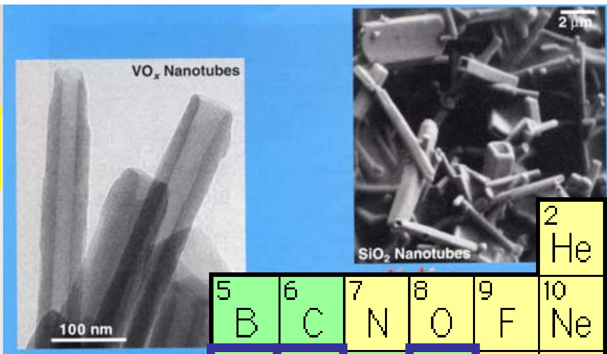
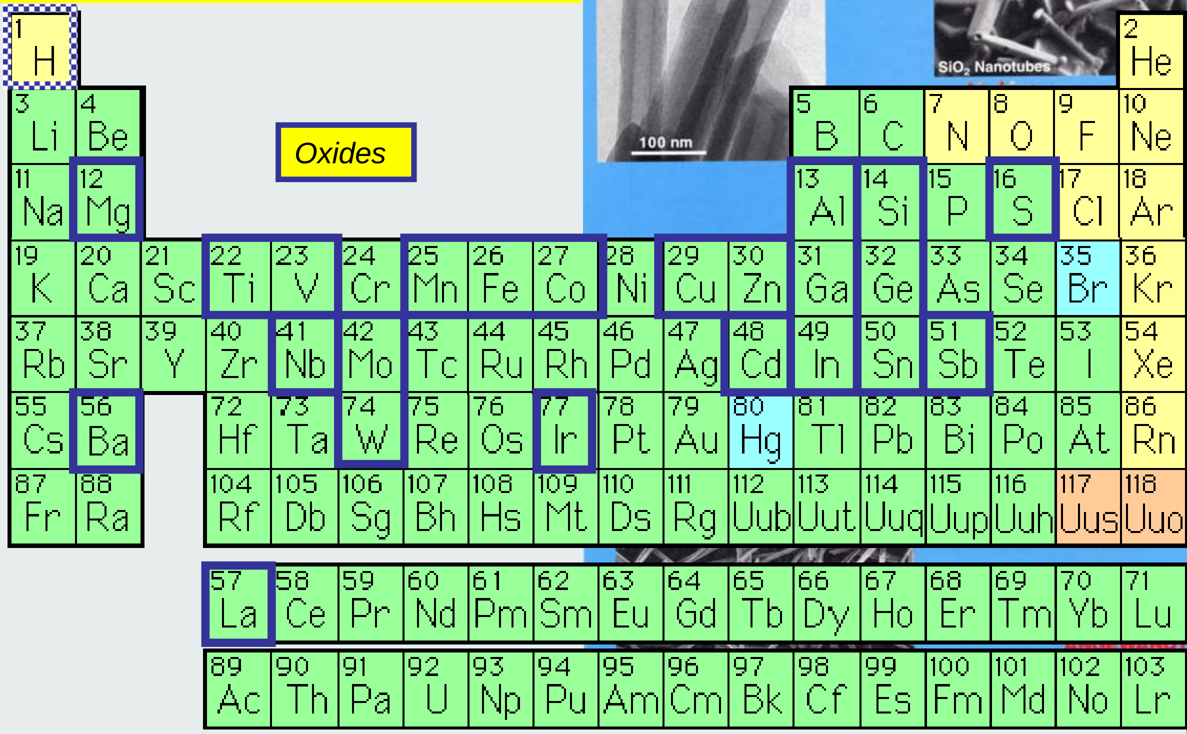
# Oxidic Nanorods

G. R. Patzke, F. Krumeich, R. Nesper,
*Angew. Chem. Int.Ed. Engl.* 14 (2002) 2447







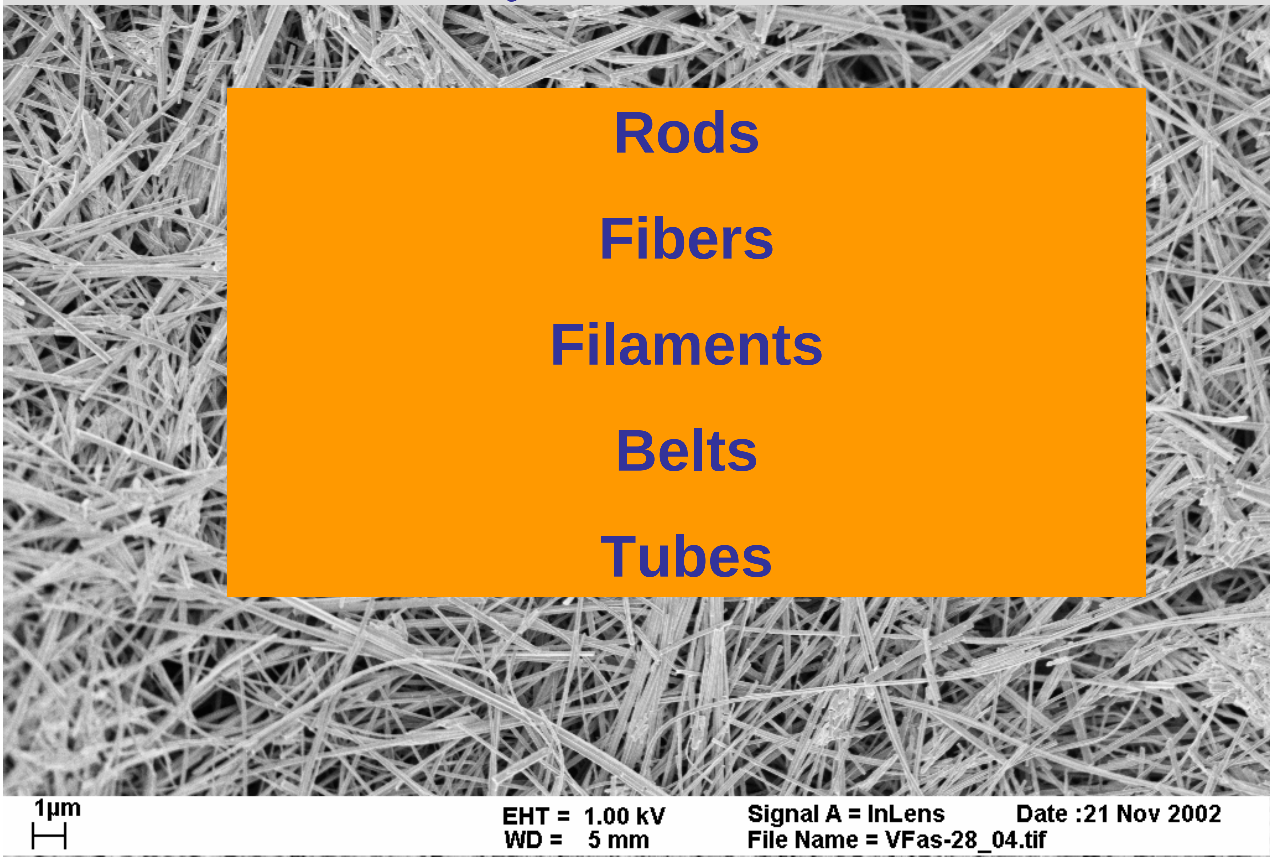

# Rods, Fibers, Filaments

Table 1. Synthetic routes for oxidic nanorods (published since 1995).

| Oxide | Synthetic route | Ref. | Oxide | Synthetic route | Ref. |
|---|---|---|---|---|---|
| $BaCrO_4$ | Fusion of reverse micelles and microemulsion droplets | [122] | $MnO_2$ | Template method with alumina membranes | [127] |
| $BaSO_4$ | Precipitation from aqueous solution in presence of polymers | [123] | $MnO_2$ | Hydrothermal synthesis | [142] |
| $BaWO_4$ | Reversed micelle templating method | [124] | $MoO_3$ | Template-directed reaction of molybdic acid and subsequent leaching process | [143] |
| CdO | Evaporation of metal oxide powders at high temperatures | [125] | $MoO_3$ | Templating against carbon nanotubes | [65] |
| $CdWO_4$ | Hydrothermal treatment of $CdCl_2$ and $Na_2WO_4$ | [126] | $MoO_2$ | Templating against carbon nanotubes | [65] |
| $Co_3O_4$ | Template method with alumina membranes | [127] | $PbTiO_3$ | Sol-gel electrophoresis, deposition in polycarbonate membrane | [144] |
| CuO | Room temperature reaction of $CuCl_2\cdot 2H_2O$ and NaOH with PEG 400 | [128] | $RuO_2$ | Templating against carbon nanotubes | [65] |
| $Fe_2O_3$ | Thin-film processing method | [129] | $Sb_2O_3$ | Microemulsion method for the system AOT–water–toluene[a] | [145] |
| $Fe_3O_4$ | Sonication of aqueous iron(II) acetate in the presence of $\beta$-cyclodextrin | [130] | $Sb_2O_5$ | Microemulsion method for the system AOT–water–toluene[a] | [145] |
| $Ga_2O_3$ | DC arc discharge of GaN powders in $Ar/O_2$ mixture | [131] | $Sb_2O_5$ | Templating against carbon nanotubes | [65] |
| $Ga_2O_3$ | Gas reaction method starting from Ga and $O_2$ at 780 °C | [132] | $SnO_2$ | Annealing of powders generated from inverse microemulsions | [146] |
| $Ga_2O_3$ | Physical evaporation at 300 °C from a bulk gallium target | [133] | $SnO_2$ | Evaporation of metal oxide powders at high temperatures | [125] |
| $Ga_2O_3$ | DC arc discharge (GaN, graphite, nickel powder) | [134] | $SiO_2$ | Helical mesostructured tubules from Vortex-Assisted Surfactant Templates | [147] |
| $Ga_2O_3$ | Electric arc discharge of GaN powders mixed with Ni and Co | [135] | $TiO_2$ | Sol-gel template method employing alumina membranes | [148] |
| $Ga_2O_3$ | Heating of Ga with $SiO_2$ powder and a $Fe_2O_3$ catalyst | [136] | $V_2O_5$ | Vanadium pentoxide gels | [149] |
| $GeO_2$ | Carbon-nanotube confined reaction of metallic Ge | [137] | $V_2O_5$ | Templating against carbon nanotubes | [65] |
| $In_2O_3$ | Evaporation of metal oxide powders at high temperatures | [125] | $WO_3$ | Templating against carbon nanotubes | [65] |
| $In_2O_3$ | Growth from Au droplets | [138] | YBCO | Laser ablation of a high $T_c$ superconductor $YBa_2Cu_3O_7$ | [150] |
| $IrO_2$ | Templating against carbon nanotubes | [65] | ZnO | Gas reaction employing Zn and $H_2O$ | [151] |
| $K_2Ti_6O_{13}$ | Calcination of KF and $TiO_2$ | [139] | ZnO | Evaporation of metal oxide powders at high temperatures | [125] |
| MgO | Vapor-solid growth process with in situ generated Mg vapor | [114] | ZnO | Catalyzed epitaxial growth | [152] |
| MgO | Heating of $MgCl_2$ at 750 °C in mixture gas ($Ar/H_2$) ■■not $O_2$? ■■ | [140] | ZnO | Self-organization of nanoparticles | [153] |
| $Mg(OH)_2$ | Solvothermal treatment of Mg, $H_2O$, and ethylenediamine | [141] | | | |

**G. Patzke, F. Krumeich, R. Nesper, Angew. Chem. 2002, 114, 2554**

# Anisotropic Particles




# Growth Conditions



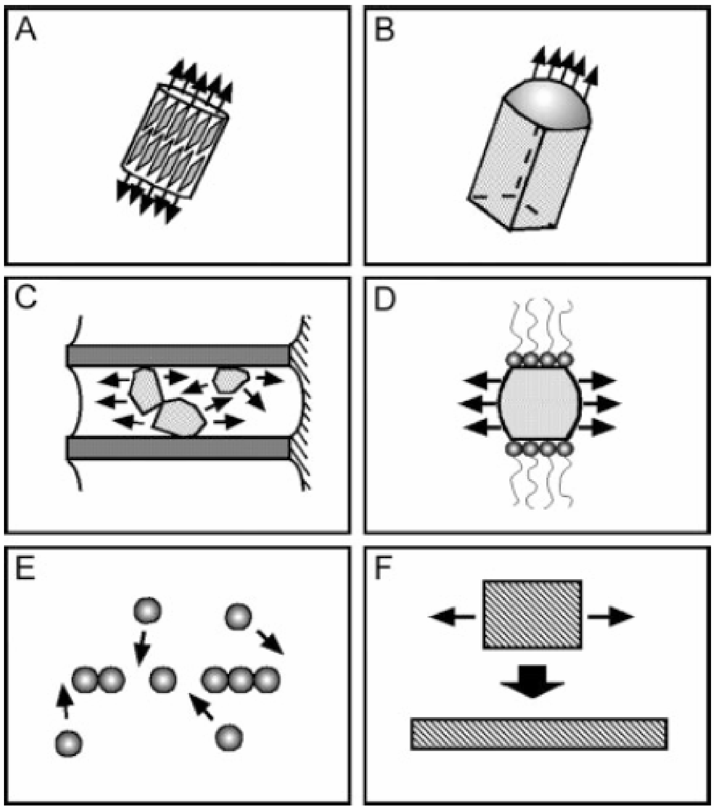
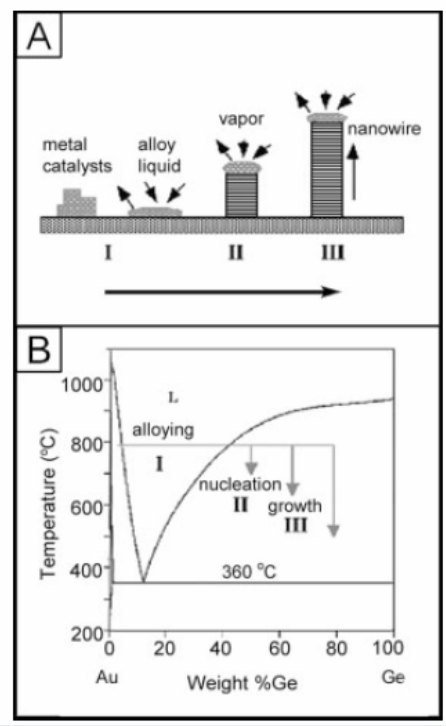



Fig. 1. Schematic illustrations of six different strategies that have been demonstrated for achieving 1D growth: a) dictation by the anisotropic crystallographic structure of a solid; B) confinement by a liquid droplet as in the vapor–liquid–solid process; C) direction through the use of a template; D) kinetic control provided by a capping reagent; E) self-assembly of 0D nanostructures; and F) size reduction of a 1D microstructure.

# Phase Segregation





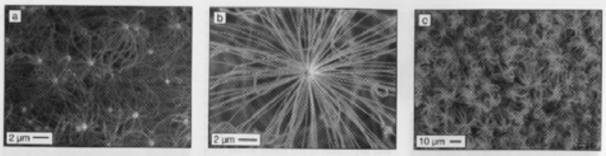
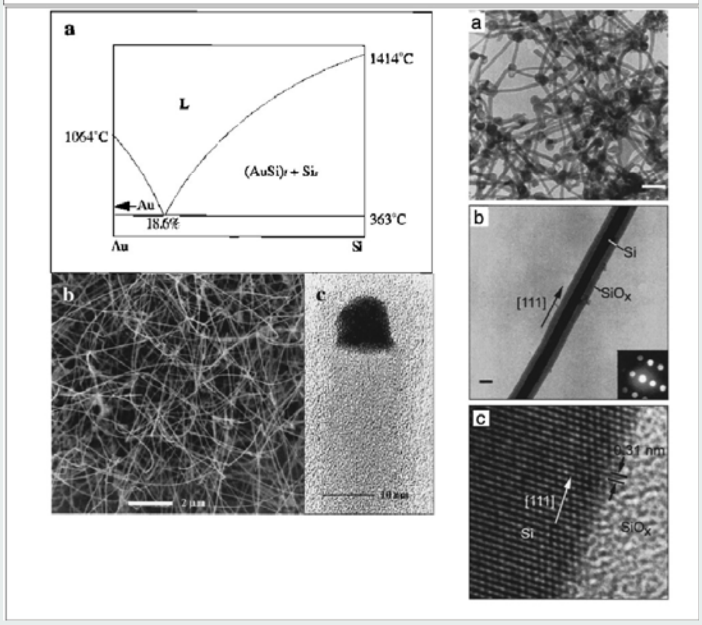




Figure 11. Scanning-electron-microscopy images of (a) a surface covered by flower-like silica nanostructures generated by heating SiC + Co at 1500°C for 30 min under an Ar-CO atmosphere, (b) a typical three-dimensional feature radiating from a central spherical Co-rich particle, and (c) a uniform "nanoflower" film obtained from heating SiC + Co at 1500°C in a pure CO atmosphere.






# Surface Structures as Templates

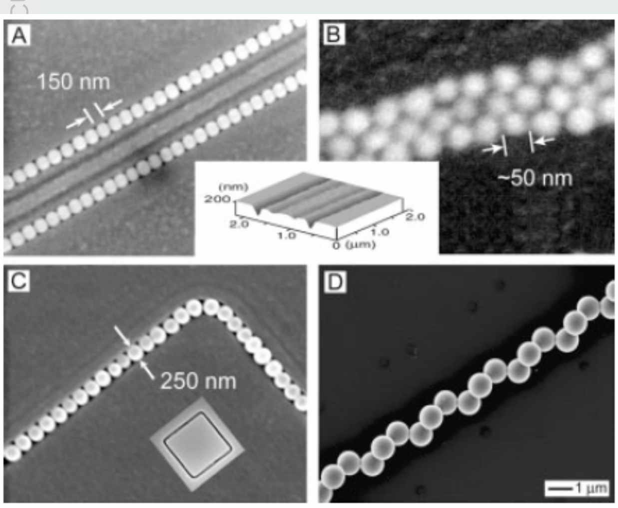



Fig. 21. A,B) Structures that were assembled from 150 nm polystyrene beads (A), and 50 nm Au colloids (B), by templating against 120 nm-wide channels patterned in a thin photoresist film (see the inset) [161a]. C) An L-shaped chain of Au@$SiO_2$ spheres assembled against a template (see the inset) patterned in a thin photoresist film [161c]. D) A spiral chain of polystyrene beads that were assembled by templating against a V-groove etched in the surface of a Si(100) wafer [161d].

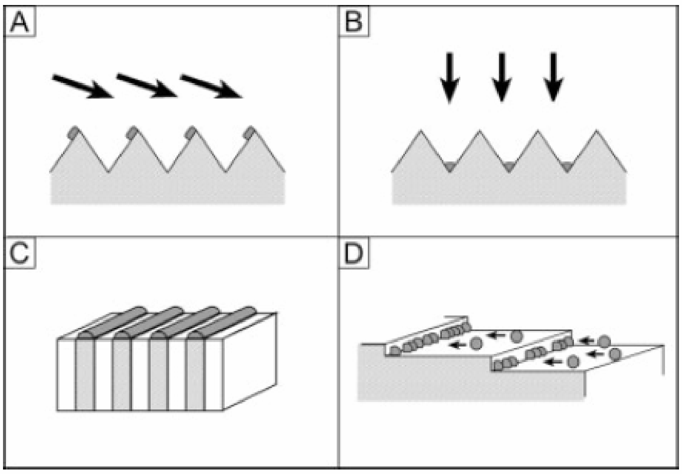
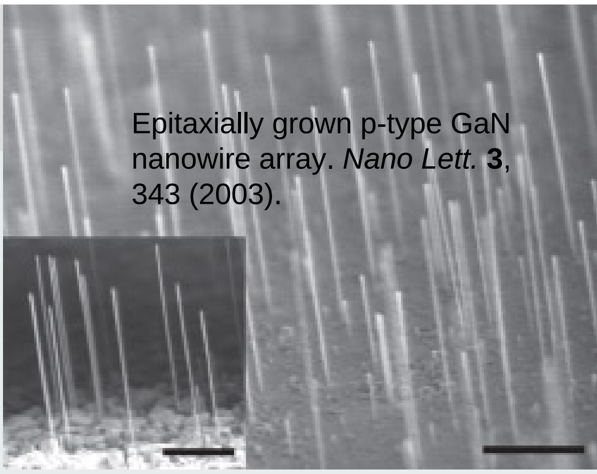


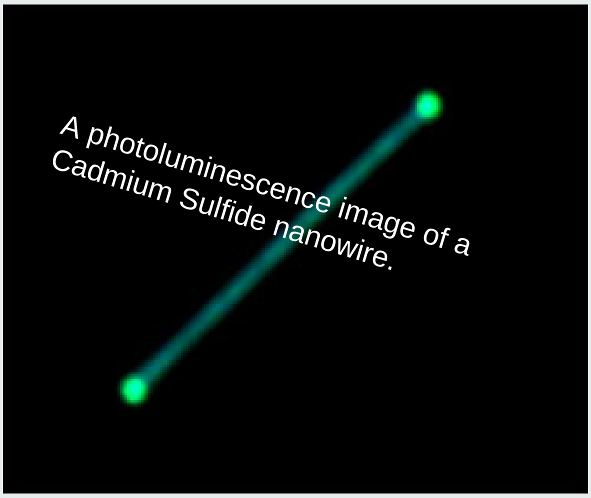

Fig. 6. Schematic illustrations of procedures that generated 1D nanostructures by A) shadow evaporation [58]; B) reconstruction at the bottom of V-grooves [60]; C) cleaved-edge overgrowth on the cross-section of a multilayer film [64]; and D) templating against step edges on the surface of a solid substrate [68].

# Semiconductors





Epitaxially grown p-type GaN nanowire array. *Nano Lett.* **3**, 343 (2003).






# Photoluminescence

R. NESPER ETH ZÜRICH & COLLEGIUM HELVETICUM

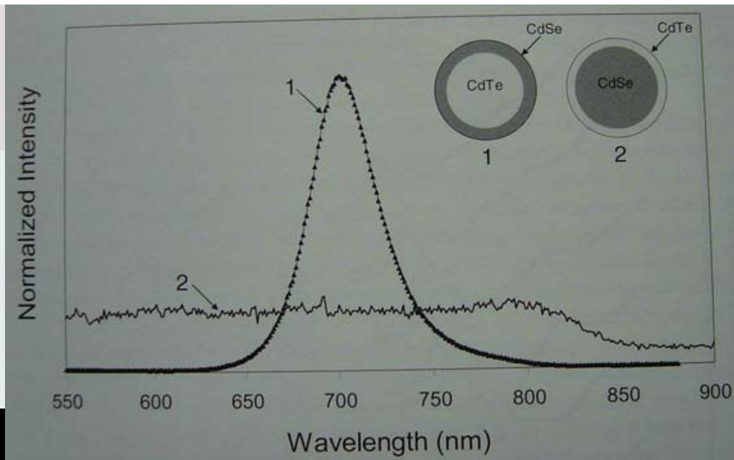
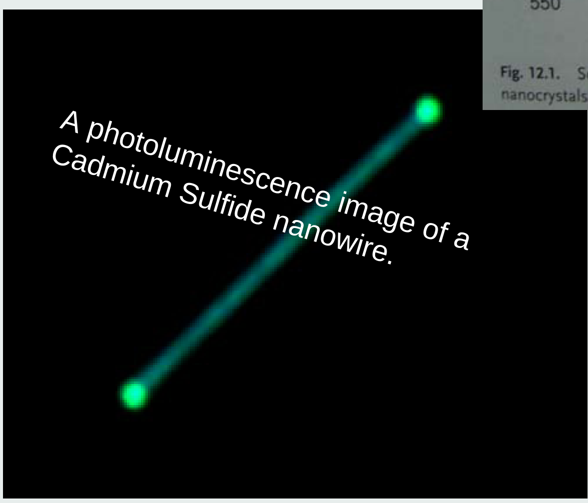


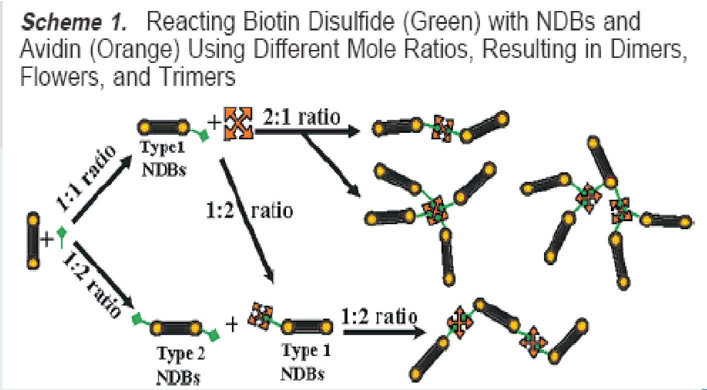

Fig. 12.1. Schematic structures of core–shell semiconductor nanocrystals and corresponding photoluminescence spectra.

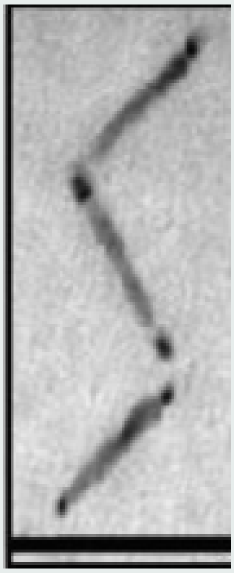


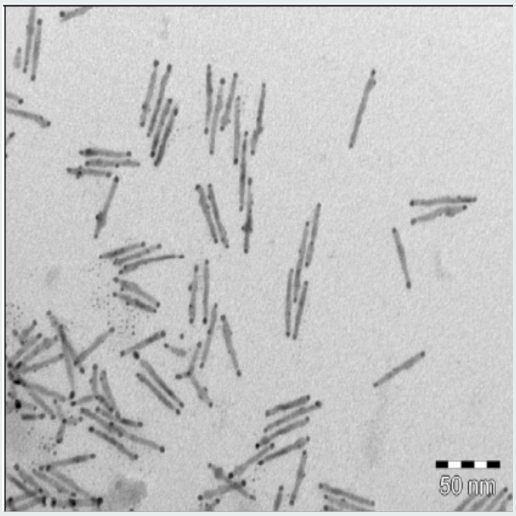
# gold-tipped CdSe nanorods



**Directed self-assembly of gold-tipped CdSe nanorods**
Asaf Salant, Ella Amitay-Sadovsky, Uri Banin
**J. AM. CHEM. SOC. 2006**, 128, 10006-10007



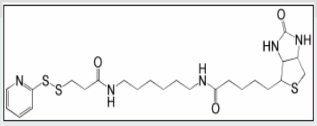



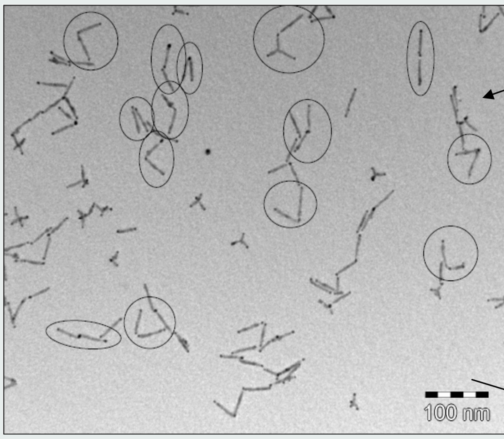


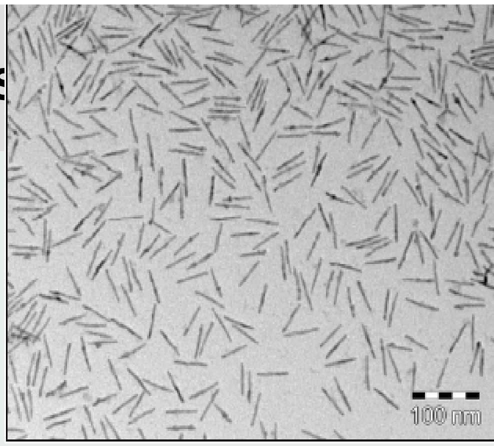


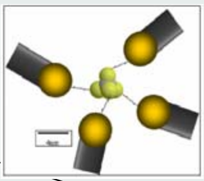

# Gold-tipped CdSe nanorods

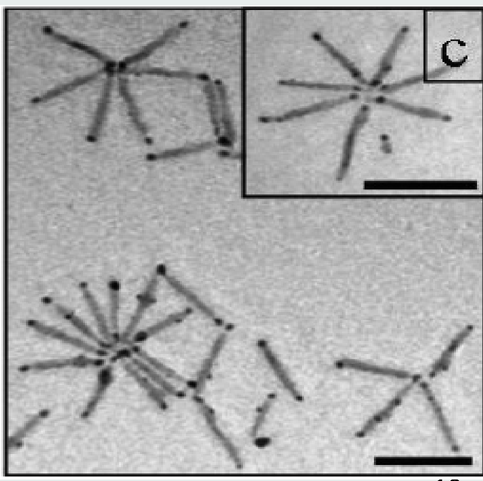






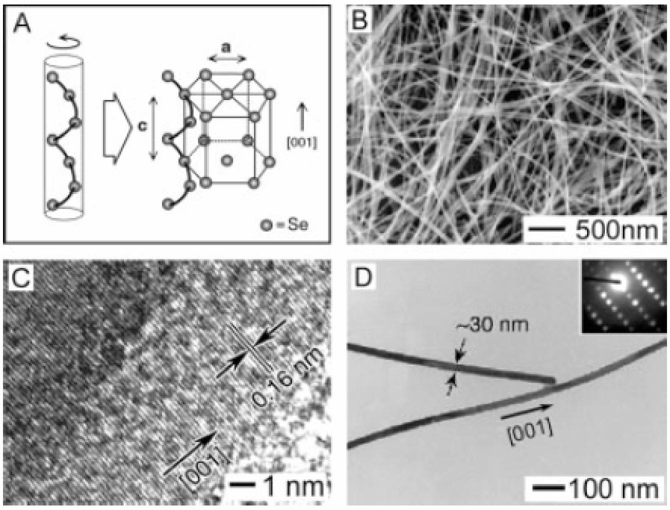


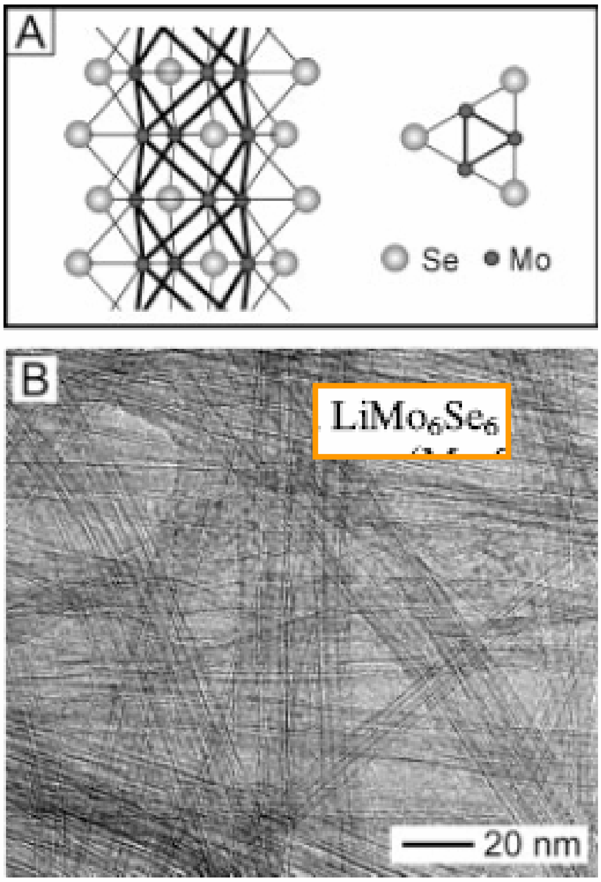

CdSe nanorods were reacted as the dimer scheme, show mostly of side-to-side interactions.

# Nanofibers by Crystal Structure



***Selenium***





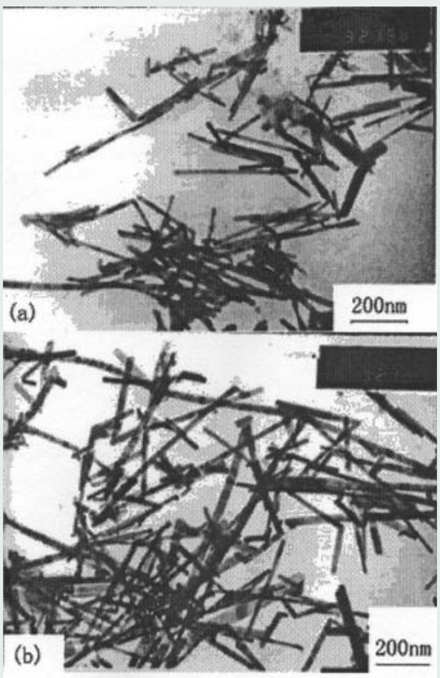

# $SnO_2$ NRs – Growth Mechanism

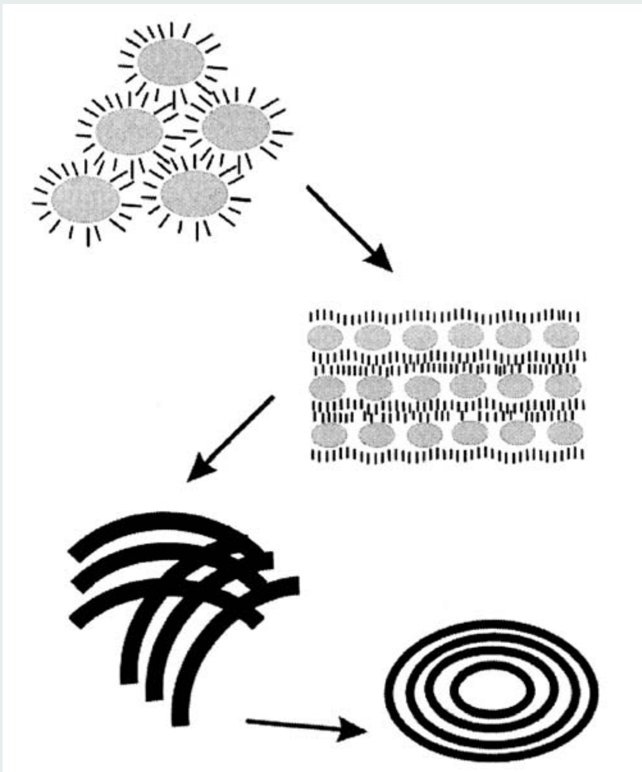


**Synthesis and Characterization of Rutile $SnO_2$ Nanorods****

By *Yingkai Liu,* Changlin Zheng, Wenzhong Wang, Chunrong Yin*, and *Guanghou Wang*

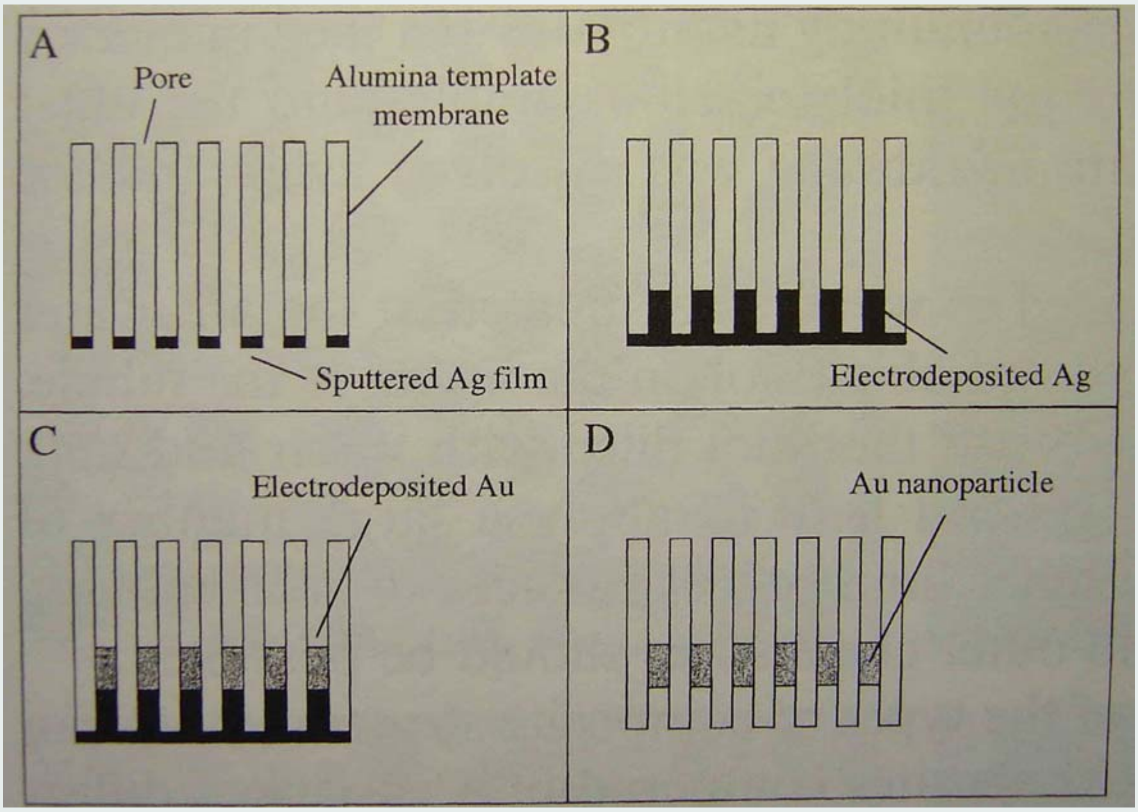
*Adv. Mater.* **2001**, *13*, No. 24, December 17



# Alumina Membranes as Outer Templates

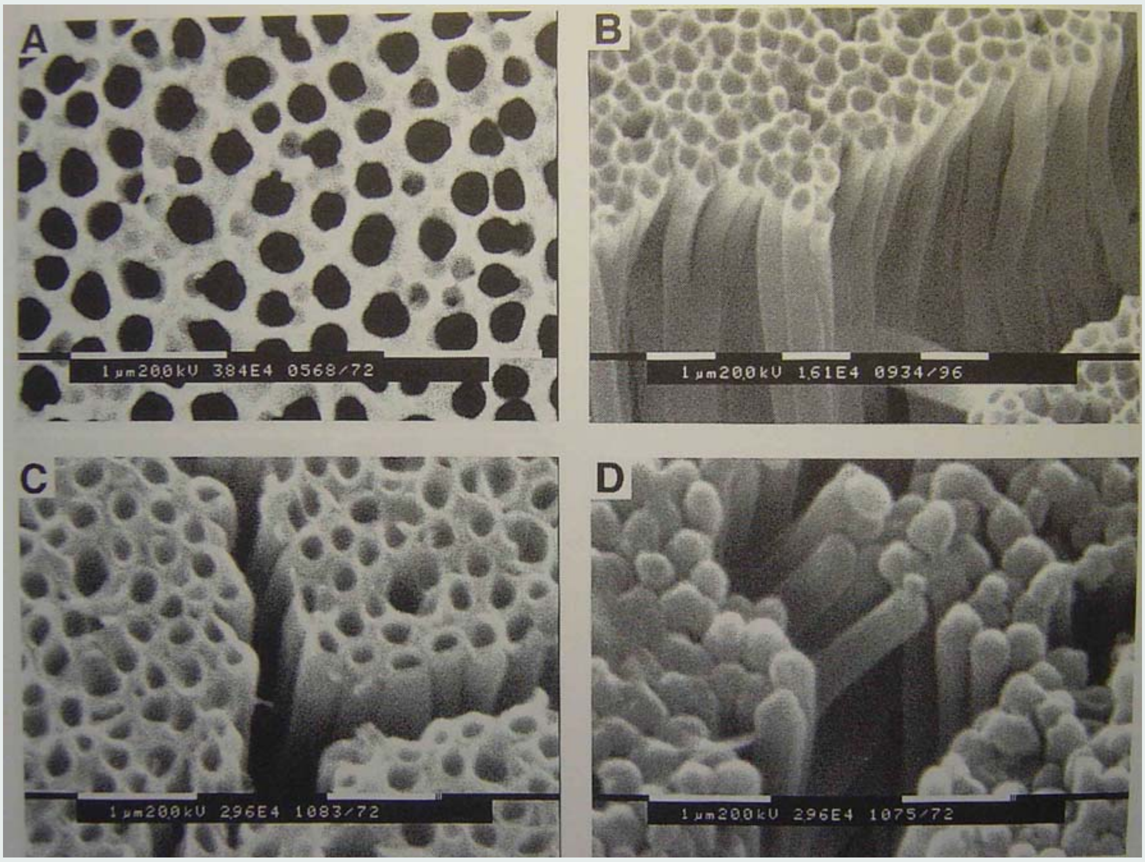







# Alumina Membranes as Outer Templates





# Hetero-Structured Nano Wires



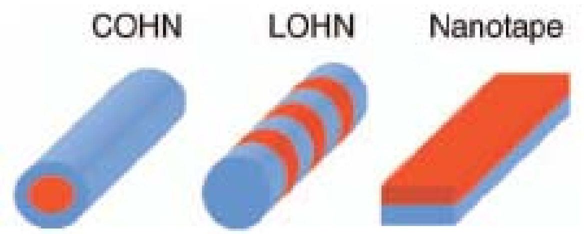



*Figure 3. Three different types of heterostructured nanowires: a coaxial heterostructured nanowire (COHN), a longitudinal heterostructured nanowire (LOHN), and a nanotape.*

**Detailed models of phonon heat conduction in semiconducting nanowires that consider modified dispersion relations and all-important scattering processes predict a large decrease (90%) in the lattice thermal conductivity of wires tens of nanometers in diameter.**

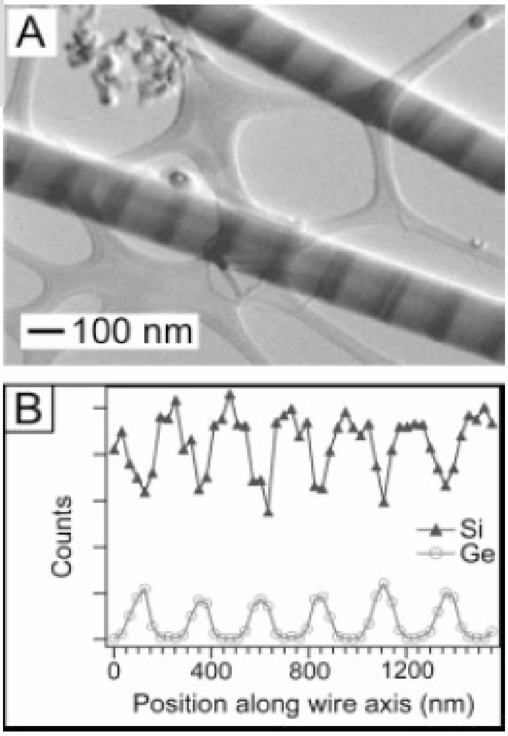



Fig. 23. A) A TEM image of two typical Si/SiGe superlattice nanowires. B) Compositional profiles showing the spatial modulation in Si and Ge contents along the longitudinal axis of a nanowire [186].

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