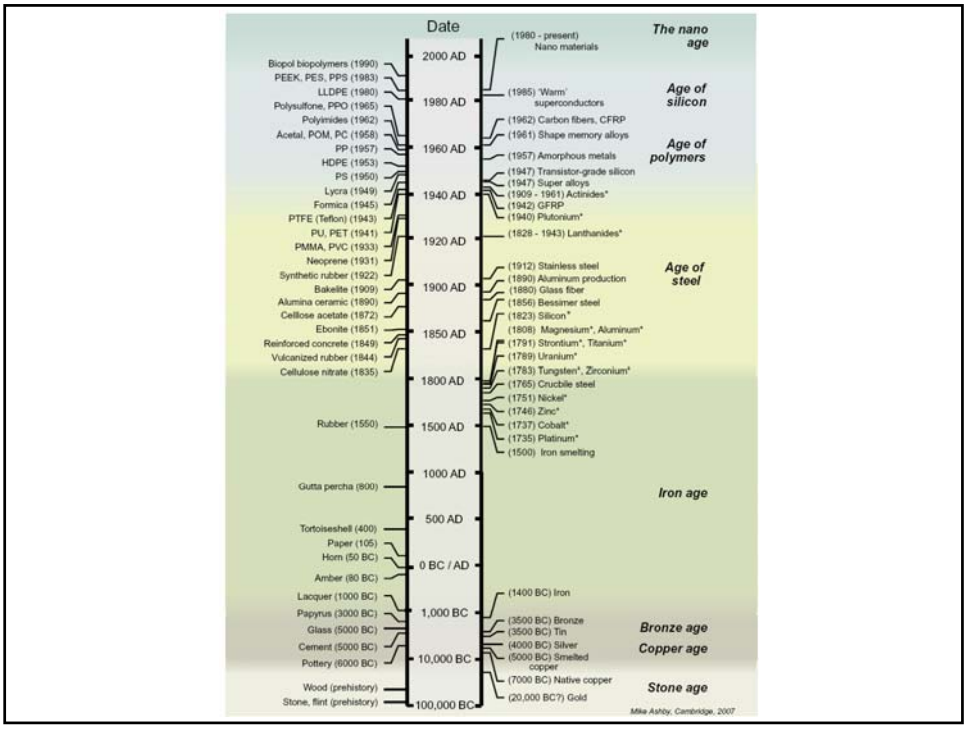
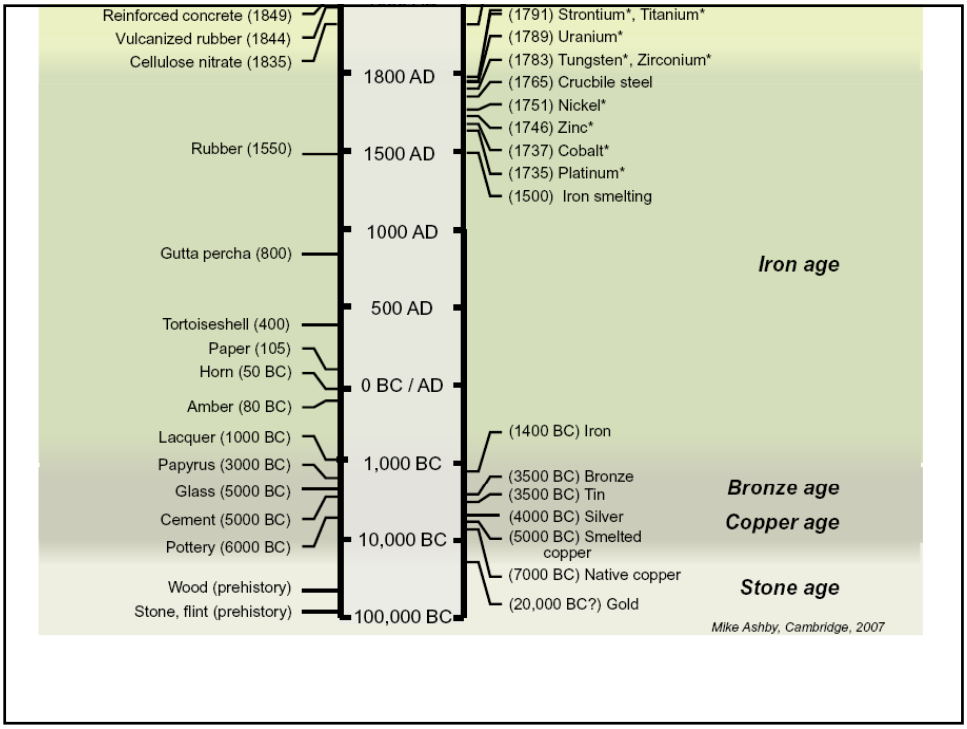
مقدمه نانو مواد

عصرهای متحول کننده زندگی بشر

- **عصر حجر**
- **عصر مفرغ**
- **عصر آهن**
- **قرون وسطی**
- **رونسانس**
- **عصر اطلاعات**
- **عصر نانو**


Date
2000 AD
1980 AD
1960 AD
1940 AD
1920 AD
1900 AD
1850 AD
1800 AD
1500 AD
1000 AD
500 AD
0 BC / AD
1,000 BC
10,000 BC
100,000 BC
Biopol biopolymers (1990)
PEEK, PES, PPS (1983)
LLDPE (1980)
Polysulfone, PPO (1965)
Polyimides (1962)
Acetal, POM, PC (1958)
PP (1957)
HDPE (1953)
PS (1950)
Lycra (1949)
Formica (1945)
PTFE (Teflon) (1943)
PU, PET (1941)
PMMA, PVC (1933)
Neoprene (1931)
Synthetic rubber (1922)
Bakelite (1909)
Alumina ceramic (1890)
Cellulose acetate (1872)
Ebonite (1851)
Reinforced concrete (1849)
Vulcanized rubber (1844)
Cellulose nitrate (1835)
Rubber (1550)
Gutta percha (800)
Tortoiseshell (400)
Paper (105)
Horn (50 BC)
Amber (80 BC)
Lacquer (1000 BC)
Papyrus (3000 BC)
Glass (5000 BC)
Cement (5000 BC)
Pottery (6000 BC)
Wood (prehistory)
Stone, flint (prehistory)
(1980 - present) Nano materials
(1985) 'Warm' superconductors
(1962) Carbon fibers, CFRP
(1961) Shape memory alloys
(1957) Amorphous metals
(1947) Transistor-grade silicon
(1947) Super alloys
(1909 - 1961) Actinides*
(1942) GFRP
(1940) Plutonium*
(1828 - 1943) Lanthanides*
(1912) Stainless steel
(1890) Aluminum production
(1880) Glass fiber
(1856) Bessimer steel
(1823) Silicon*
(1808) Magnesium*, Aluminum*
(1791) Strontium*, Titanium*
(1789) Uranium*
(1783) Tungsten*, Zirconium*
(1765) Crucbile steel
(1751) Nickel*
(1746) Zinc*
(1737) Cobalt*
(1735) Platinum*
(1500) Iron smelting
(1400 BC) Iron
(3500 BC) Bronze
(3500 BC) Tin
(4000 BC) Silver
(5000 BC) Smelted copper
(7000 BC) Native copper
(20,000 BC?) Gold
The nano age
Age of silicon
Age of polymers
Age of steel
Iron age
Bronze age
Copper age
Stone age
Mike Ashby, Cambridge, 2007


Reinforced concrete (1849)
Vulcanized rubber (1844)
Cellulose nitrate (1835)
1800 AD
Rubber (1550)
1500 AD
1000 AD
Gutta percha (800)
500 AD
Tortoiseshell (400)
Paper (105)
Horn (50 BC)
0 BC / AD
Amber (80 BC)
Lacquer (1000 BC)
Papyrus (3000 BC)
1,000 BC
Glass (5000 BC)
Cement (5000 BC)
Pottery (6000 BC)
10,000 BC
Wood (prehistory)
Stone, flint (prehistory)
100,000 BC
(1791) Strontium*, Titanium*
(1789) Uranium*
(1783) Tungsten*, Zirconium*
(1765) Crucbile steel
(1751) Nickel*
(1746) Zinc*
(1737) Cobalt*
(1735) Platinum*
(1500) Iron smelting
(1400 BC) Iron
(3500 BC) Bronze
(3500 BC) Tin
(4000 BC) Silver
(5000 BC) Smelted copper
(7000 BC) Native copper
(20,000 BC?) Gold
Iron age
Bronze age
Copper age
Stone age
Mike Ashby, Cambridge, 2007

در باره نانو فناوری

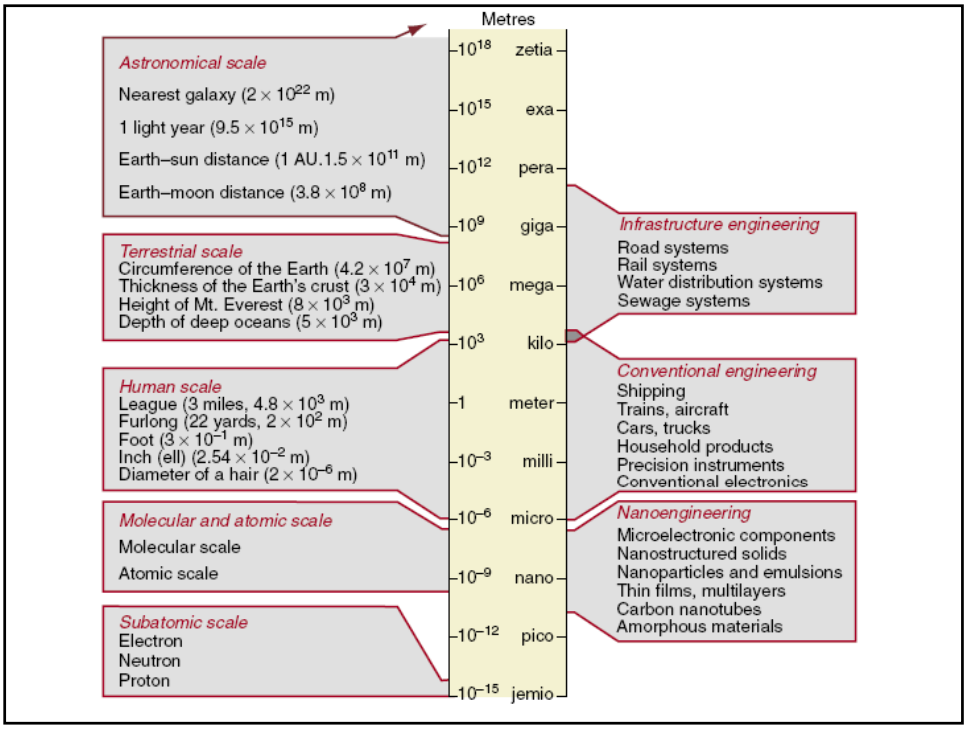
فناوری نانو واژه‌ای است کلی که به تمام فناوری‌های پیشرفته در عرصه کار در مقیاس نانو اطلاق می‌شود. معمولاً منظور از مقیاس نانو ابعادی در حدود ۱ تا ۱۰۰ نانومتر می‌باشد.

یک نانومتر یک میلیارد بار کوچکتر از یک متر است

- یک نانومتر به اندازه چیدن ۵ تا ۱۰ اتم درکنار یگدیگر است

نانو تکنولوژی به معنی انجام مهندسی مواد در ابعاد اتمی – ملکولی و در نتیجه ساخت موادی با خواص کاملا متفاوت در ابعاد نانو است.

نانوذرات، نانوالیاف، نانوکامپوزیتها، نانوکپسولها، نانوبلورها، نانوپوششها و ...

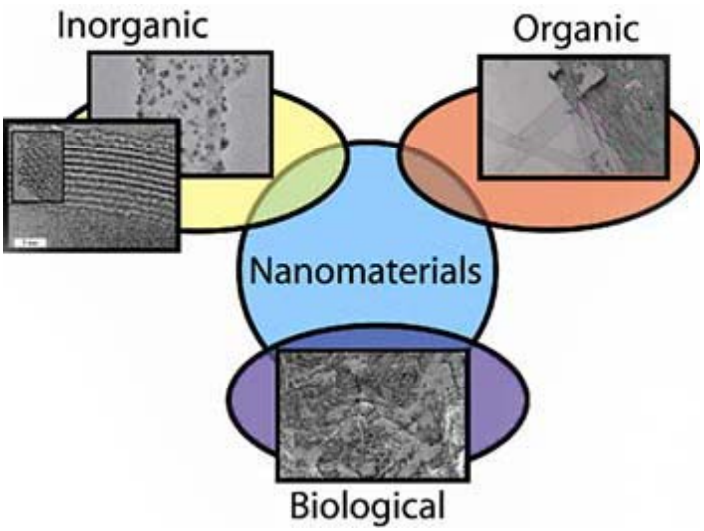


ویژگیهای جالب فن آوری نانو چیست؟

1- فوق العاده فراگیر و بین رشته ای است: فیزیک، شیمی، مهندسی مواد، مکانیک و برق و الکترونیک زیست شناسی و داروسازی.

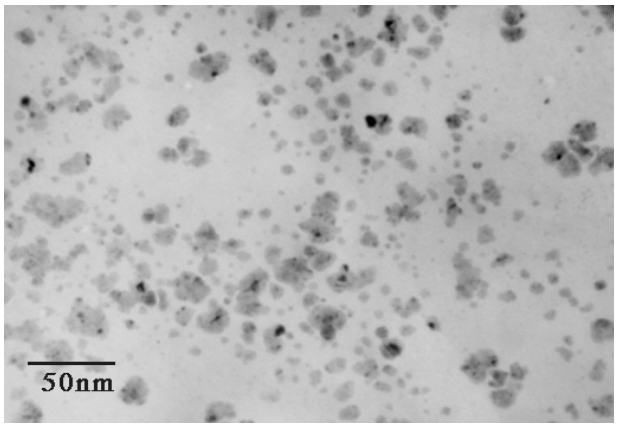
2- مرزی است بین دنیای اتمهاو مولکولها از یک طرف با دنیای ماکرو. در فناوری نانو، ویژگیها با اصول رفتاری اتمها کنترل می شوند.

3- بزرگترین چالش بشر است که در آن کنترل مواد در مقیاس اتمی امکان پذیر است.

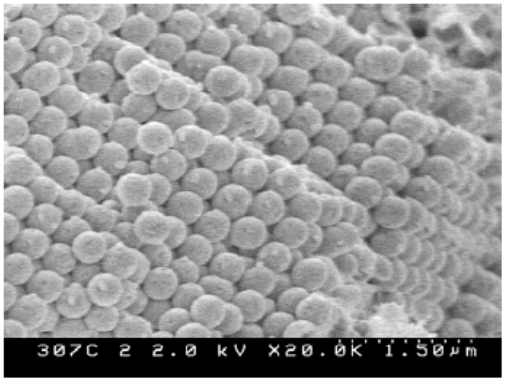


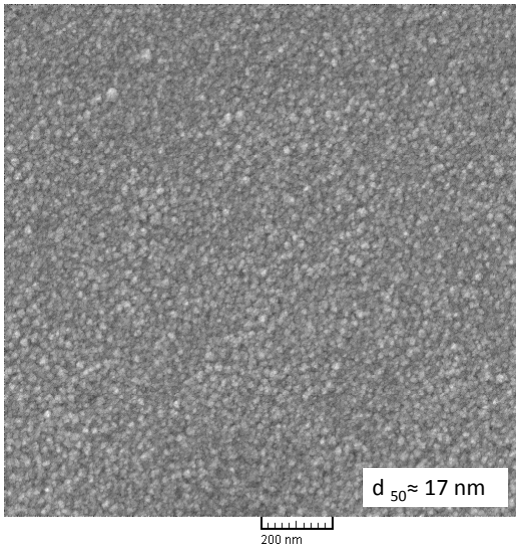
تقسیم بندی مواد نانو: از نظر شکل

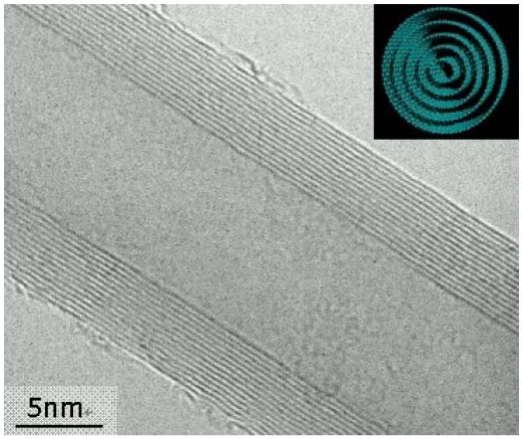
- نانوذرات
- نانو سیم ها
- نانو لوله ها
- نانو کپسول ها
- نانو لایه ها و نانو پوشش ها
- آلیاژهای نانو ساختار
- پلیمرهای نانو ساختار
- مواد متخلخل نانوساختار nanoporous
- نانو کامپوزیت ها



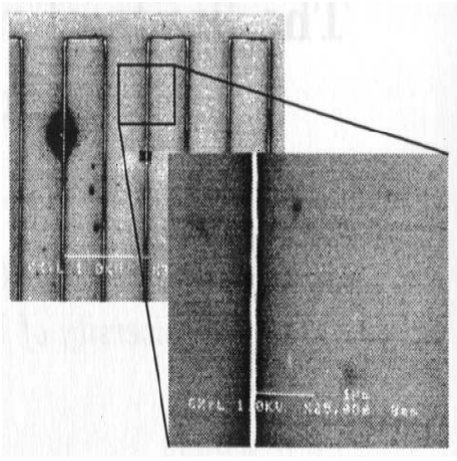
عکس TEM از نانو ذرات مس


307C 2 2.0 kV X20.0K 1.50µm


d 50≈ 17 nm
200 nm



Multi-walled carbon nanotube (MWCNT)

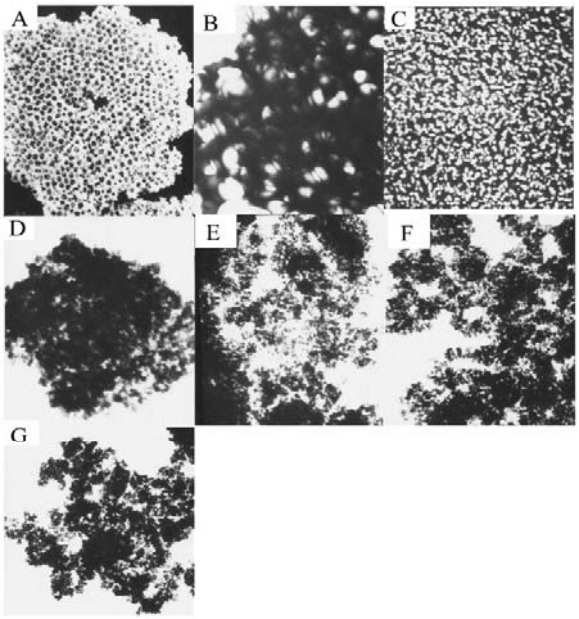


90 nm wide line created in PMMA with X-ray litography at a gap of 40 microns

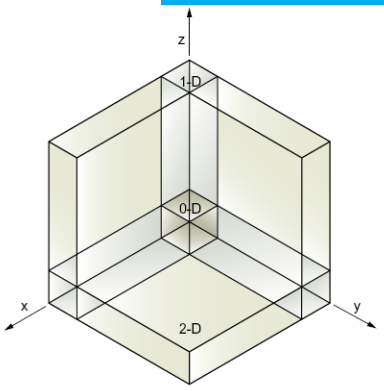
Microporous
<2 nm

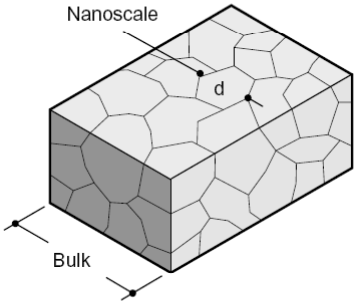
Mesoporous
2-50 nm

Macroporous
>50 nm



تقسیم بندی مواد نانو: از نظر ابعاد و محدودیت کوانتومی





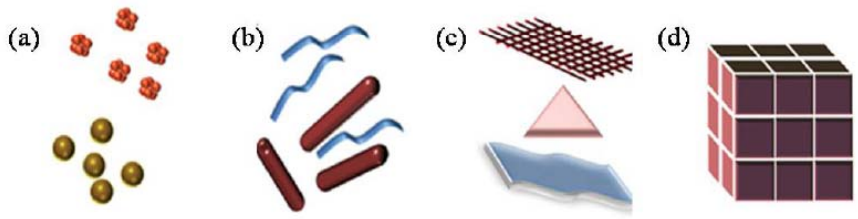
0-D: All dimensions at the nanoscale

1-D: Two dimensions at the nanoscale, one dimension at the macroscale

2-D: One dimension at the nanoscale, two dimensions at the macroscale

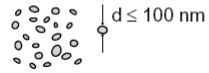
3-D: No dimensions at the nanoscale, all dimensions at the macroscale

Quantum confinement: the confinement of electrons in the nanoscale dimensions result in quantization of energy and momentum, and reduced dimensionality of electronic states.

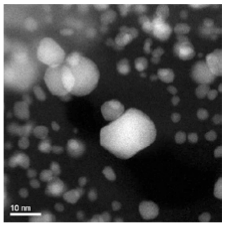


(a) 0D spheres and clusters,
(b) 1D nanofibers, wires, and rods,
(c) 2D films, plates, and networks,
(d) 3D nanomaterials: nanocrystlline and nanocomposites

0-D
All dimensions (*x,y,z*) at nanoscale

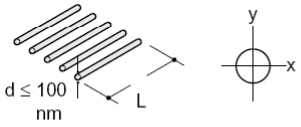


Nanoparticles

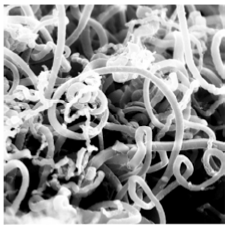


Quantum dots
نقاط کوانتمی

1-D
Two dimensions (*x,y*) at nanoscale, other dimension (*L*) is not



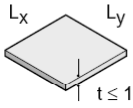
Nanowires, nanorods, and nanotubes



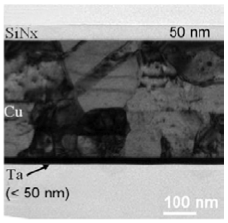
Quantum wires
سیمهای کوانتمی

2-D

One dimension (t) at nanoscale, other two dimensions- (L_x, L_y) are not



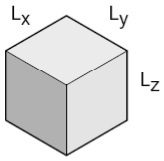
Nanocoatings and nanofilms



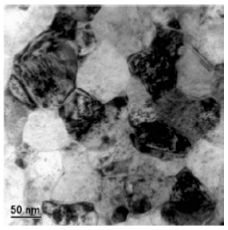
Quantum wells
(چاه) دره های کوانتمی

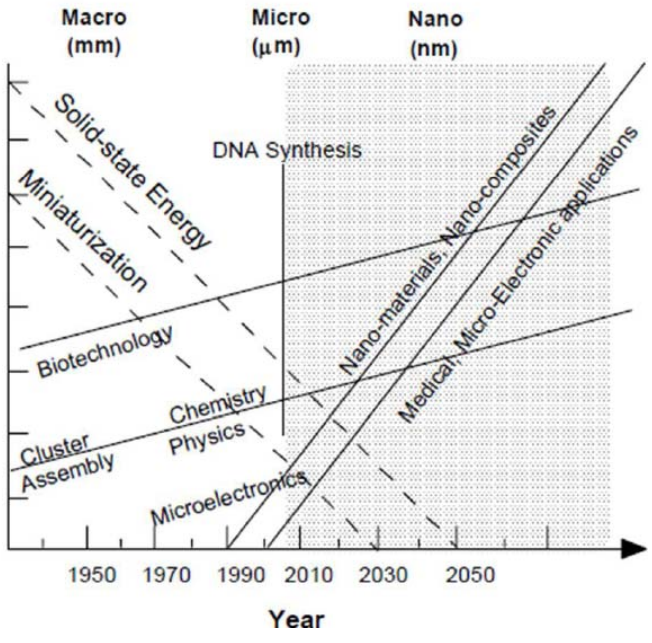
3-D

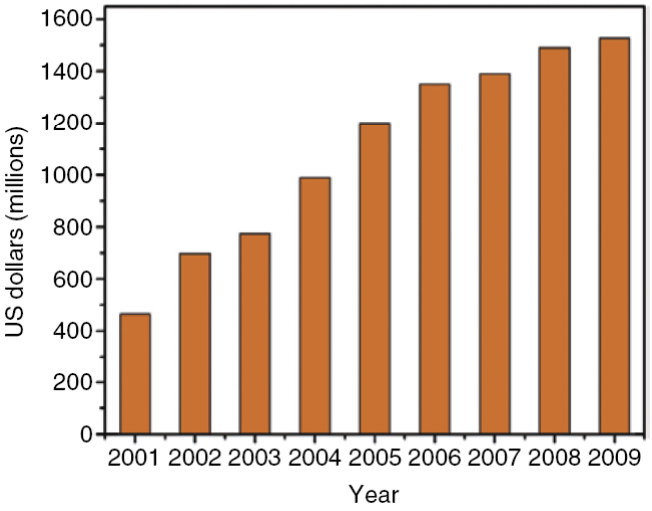
No bulk dimension at nanoscale

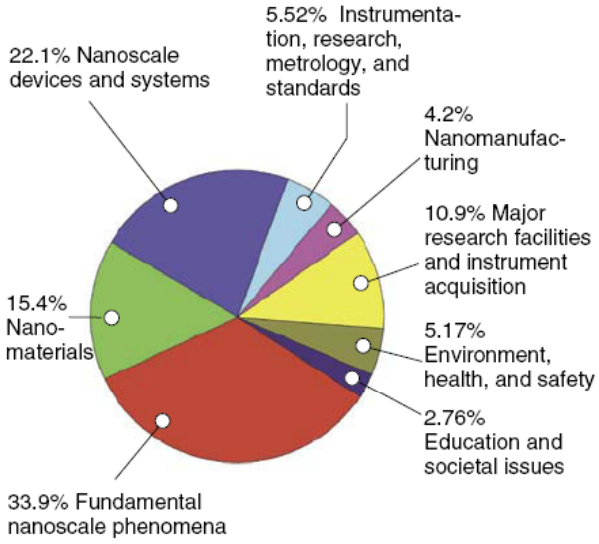


Nanocrystalline and nanocomposite materials





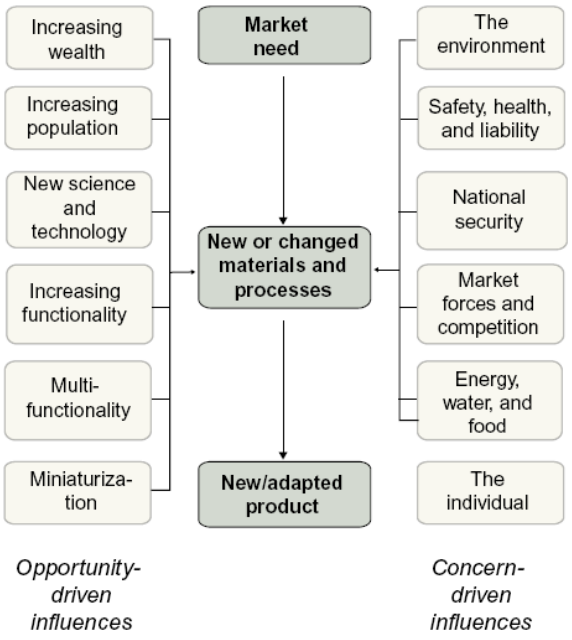

1600
1400
1200
1000
800
600
400
200
0
US dollars (millions)
2001 2002 2003 2004 2005 2006 2007 2008 2009
Year

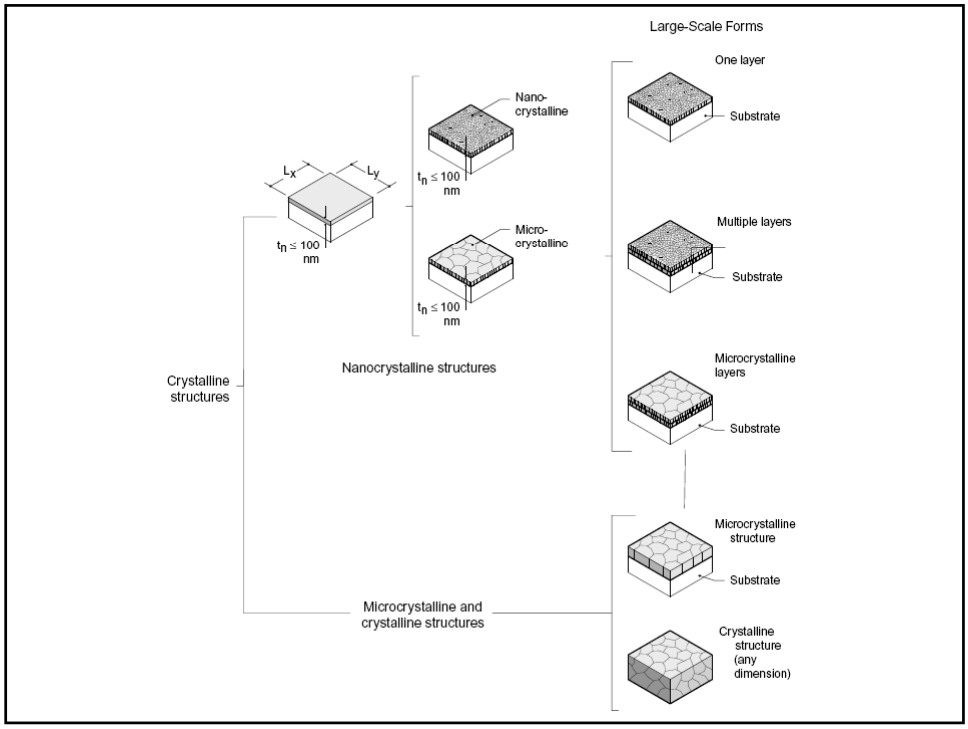

22.1% Nanoscale devices and systems
5.52% Instrumentation, research, metrology, and standards
4.2% Nanomanufacturing
10.9% Major research facilities and instrument acquisition
5.17% Environment, health, and safety
2.76% Education and societal issues
33.9% Fundamental nanoscale phenomena
15.4% Nanomaterials

سرمایه گذاری های جهانی در زمینه توسعه فناوری نانو (سال ۲۰۱۲)

کشور	بودجه (میلیون دلار)	سهم (درصد)
امریکا	۱۸۰۰	۱۲
ژاپن	۱۰۰۰	۶/۷
بقیه کشورهای جهان	۱۲۲۰۰	۸۱/۳
ایران	۲۰	۰/۱

کل سرمایه گذاری جهانی:
۱۵ میلیارد دلار





کامپوزیت ها و نانو کامپوزیت ها

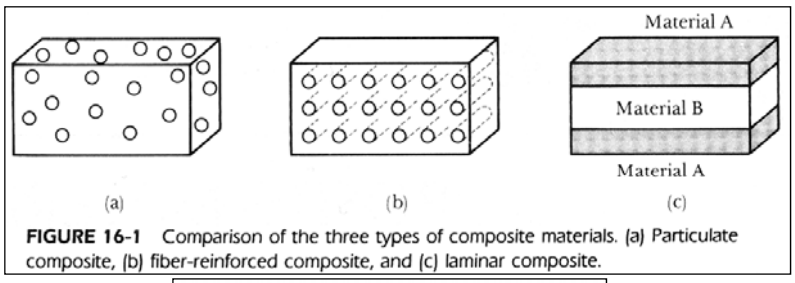


FIGURE 16-1 Comparison of the three types of composite materials. (a) Particulate composite, (b) fiber-reinforced composite, and (c) laminar composite.

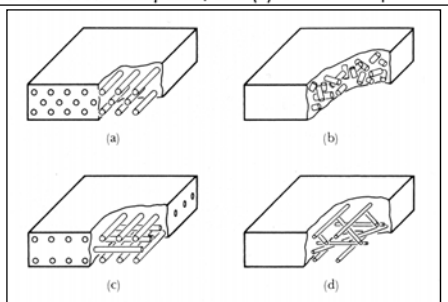
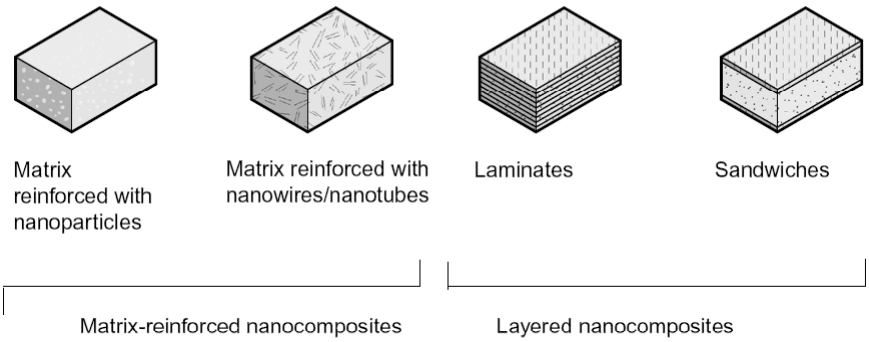
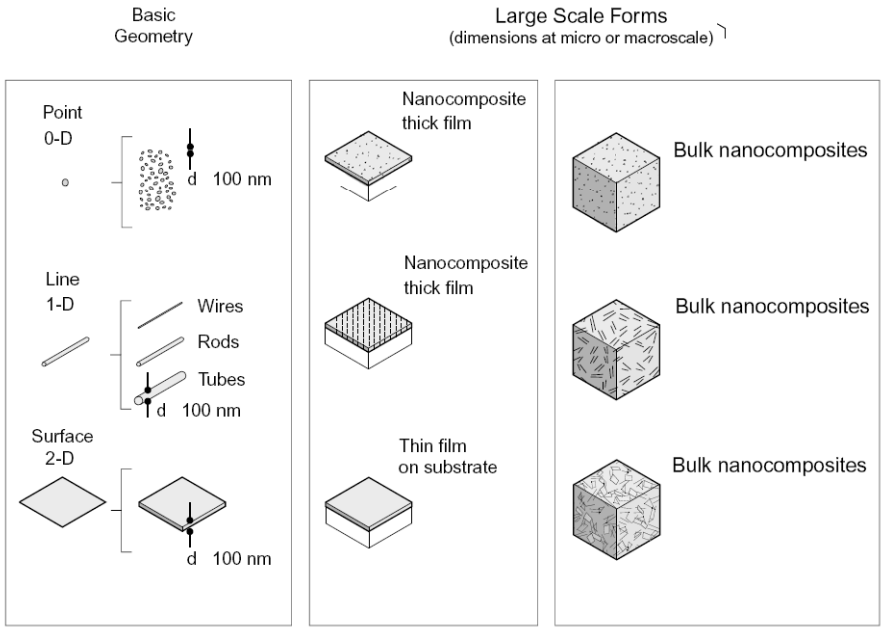
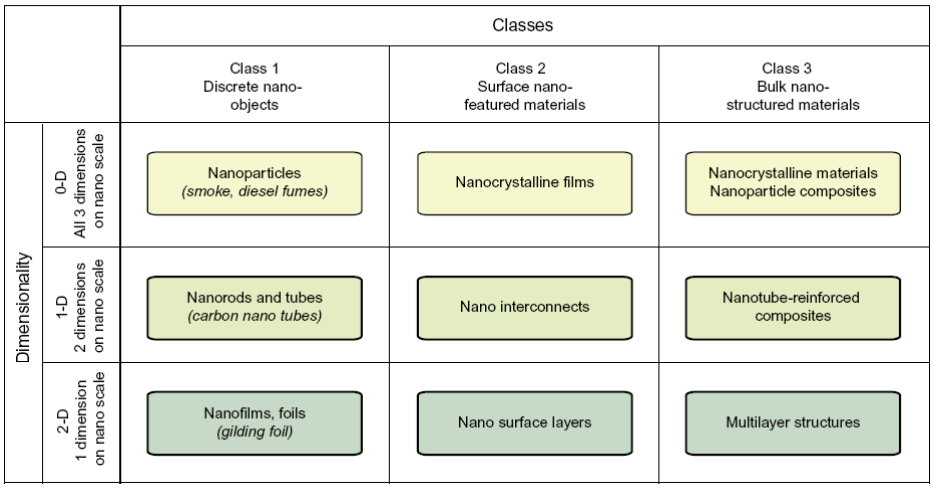


FIGURE 16-10 Various morphologies of fiber-reinforced composites. (a) Continuous unidirectional fibers, (b) randomly oriented discontinuous fibers, (c) orthogonal fibers, and (d) multiple-ply fibers.

نانو کامپوزیت ها







Tab. 1.1. Examples of nanomaterials.

	Size (approx.)	*Materials*
Nanocrystals and clusters (quantum dots)	diam. 1–10 nm	Metals, semiconductors, magnetic materials
Other nanoparticles	diam. 1–100 nm	Ceramic oxides
Nanowires	diam. 1–100 nm	Metals, semiconductors, oxides, sulfides, nitrides
Nanotubes	diam. 1–100 nm	Carbon, layered metal chalcogenides
Nanoporous solids	pore diam. 0.5–10 nm	Zeolites, phosphates etc.
2-Dimensional arrays (of nano particles)	several nm2–μm2	Metals, semiconductors, magnetic materials
Surfaces and thin films	thickness 1–1000 nm	A variety of materials
3-Dimensional structures (superlattices)	Several nm in the three dimensions	Metals, semiconductors, magnetic materials

کره:

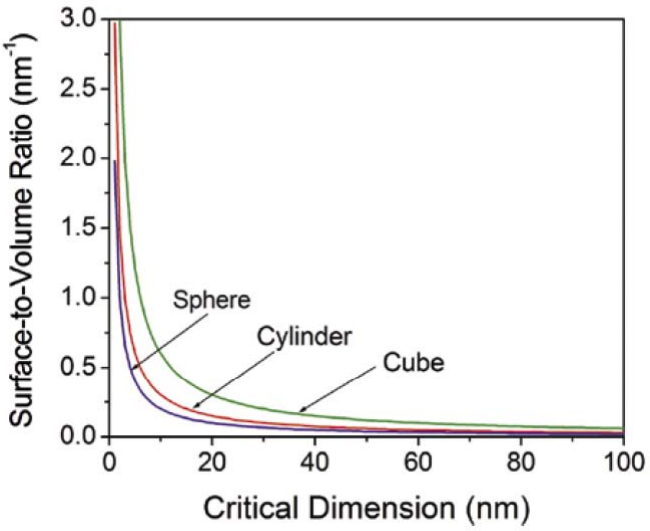
$$\frac{A}{V}=\frac{4\pi r^2}{\frac{4\pi r^3}{3}}=\frac{3}{r}$$

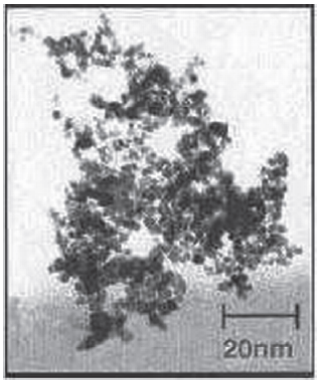
استوانه:

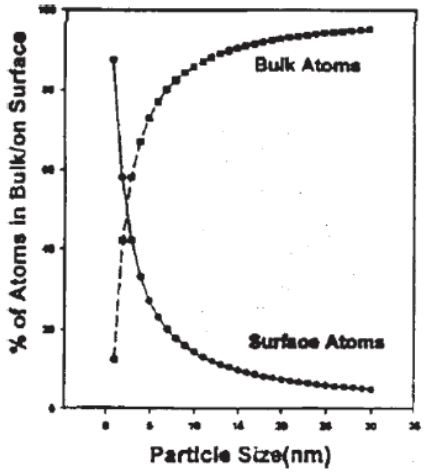
$$\frac{A}{V}=\frac{\pi r^2 H}{2\pi r H}=\frac{2}{r}$$

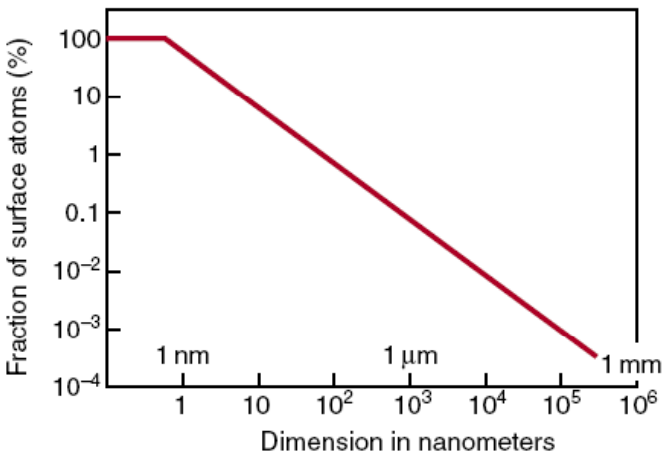
مکعب:

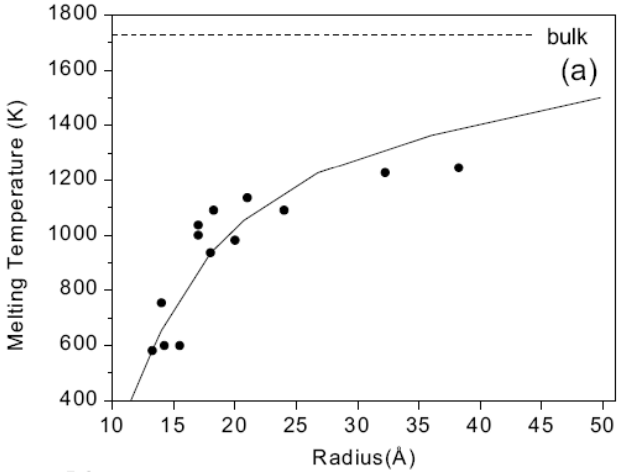
$$\frac{A}{V}=\frac{6L^2}{L^3}=\frac{6}{L}$$




20nm


% of Atoms in Bulk/on Surface
Bulk Atoms
Surface Atoms
Particle Size(nm)


Fraction of surface atoms (%)
100
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
1 nm
1 µm
1 mm
1
10
10^2
10^3
10^4
10^5
10^6
Dimension in nanometers



Size dependence of the melting temperature