

# **STIINTA SI INGINERIA MATERIALELOR**

---

**Prof.Dr.Ing. Catalin POPA**

# BIBLIOGRAFIE

<http://www.sim.utcluj.ro/wp/>

→ Download cursuri: Popa Catalin; password = PopaCatalin

- H. Colan, V. C. Cândeа, s.a. - Știința materialelor Vol. 1, U.T. Press 2013;
- V. Cândeа, C. Popa, T. Marcu - Atlas, structuri metalografice, U.T.Press 2012;
- V.Candea, C.Popa, N.Sechel, V.Buharu – Clasificarea si simbolizarea aliajelor feroase si neferoase, UTPress, 2010;
- C. Popa, V. Cândeа, V. Șimon, D. Lucaciу, O. Rotaru - Știința biomaterialelor. Biomateriale metalice, U.T.Press 2008;
- V.A.Serban, A.Raduta, Stiinta si ingineria materialelor, Timisoara, Ed. Politehnica 2012;
- H.Colan, s.a. – Studiul Metalelor, Bucuresti, EDP 1983;
- D.Askeland – Introduction to Materials Science, J.Wiley & Sons, 1993
- C. Paul – Materials Science and Engineering, ASM 1991
- W. D. Callister, D. G. Rethwisch - Fundamentals of materials science and engineering, John Wiley and Sons 2013;
- W. F. Hosford, Elementary materials science , ASM International 2013;
- D.L. Chung - Composite materials: science and applications : functional materials for modern technologies, Springer 2003;

# INTRODUCERE IN STIINTA MATERIALELOR

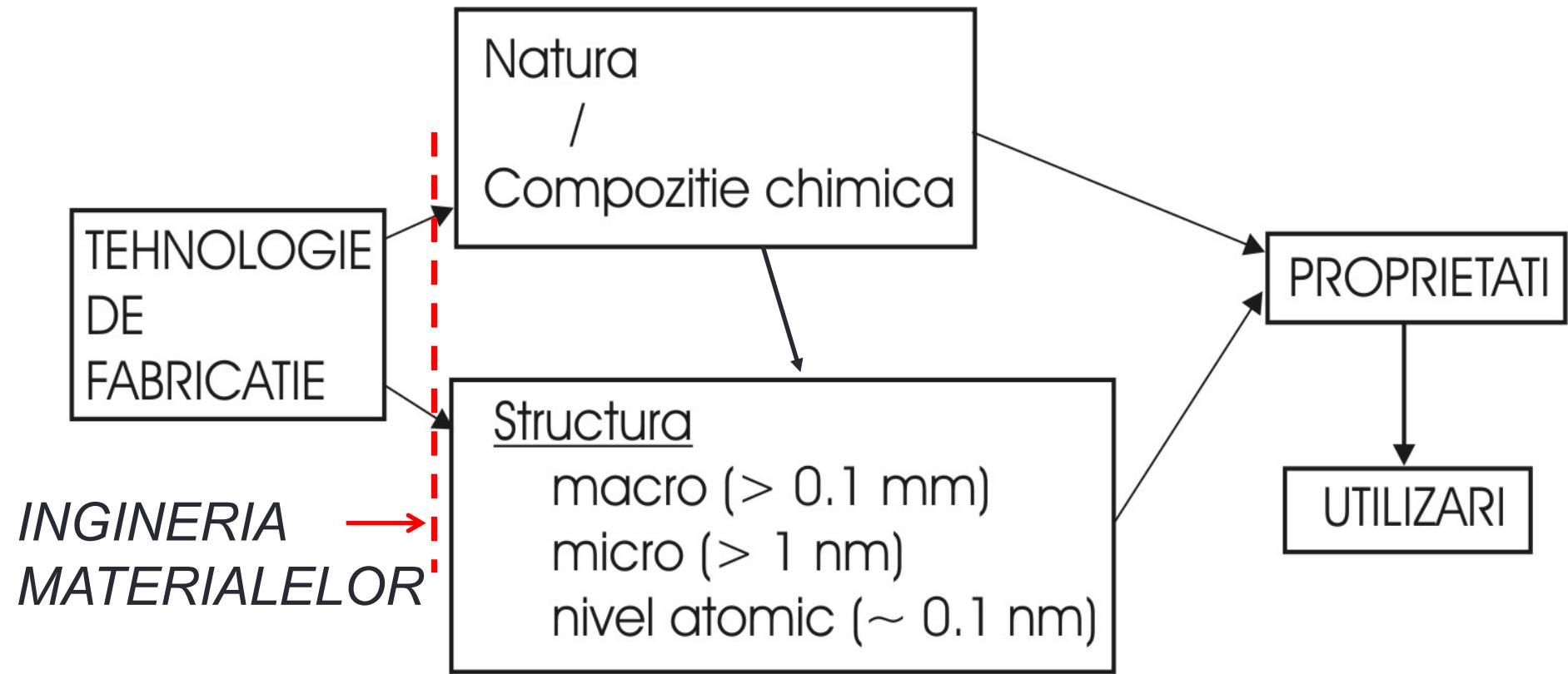
**Stiinta materialelor :** Ramura a stiintelor tehnice care studiaza raportul dintre

- compozitia chimica
- structura
- proprietati



pentru materialele de uz ingineresc

- **Vechime :** ca stiinta, dupa 1840 (microscopul optic)



**Inginerul proiectant** - selectia materialelor si a starii lor in functie de proprietati, consecinta a structurii (pe toate nivelurile) si compozitiei chimice;

**Inginerul tehnolog** - tehnologii de fabricatie pentru obtinerea eficienta a pieselor de calitate avand caracteristicile prescrise de proiectant;

# Continutul cursului

- Introducere in Stiinta Materialelor. Clasificarea materialelor de uz tehnic.
- Proprietatile materialelor.
- Rezistenta la coroziune. Metode de protectie anticoroziva.
- Legaturile interatomice. Structura cristalina și amorfă.
- Cristalizarea metalelor.
- Deformarea plastica a metalelor.
- Ecruisarea, recristalizarea. Ruperea.
- Teoria aliajelor.
- Diagrama Fe-C. Oțelurile nealiate. Fonte de turnatorie.
- Tratamente termice.
- Oteluri aliate
- Aliaje neferoase: aliaje cu baza Al, Cu;
- Polimeri
- Materiale ceramice
- Materiale compozite

**Cod de culori:**  
**Rosu – esential**  
**Albastru – foarte important**  
**Negru – importanta normala**

# Proprietatile materialelor

- **Fizice**
- **Mecanice**
- **Chimice**
- **Tehnologice**

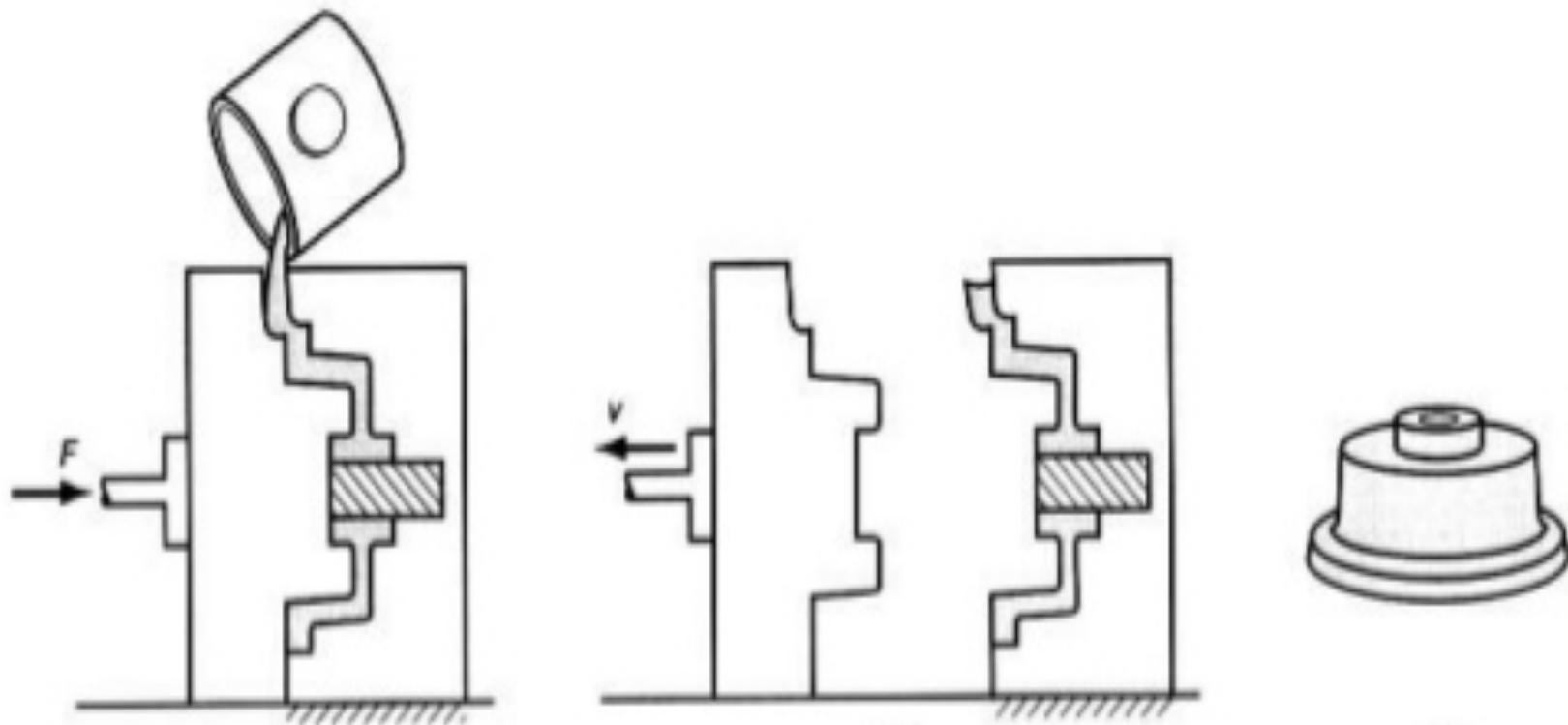
→ proprietati functionale

SUDABILITATE  
ASCHIABILITATE  
TURNABILITATE  
[DEFORMABILITATE]

.....

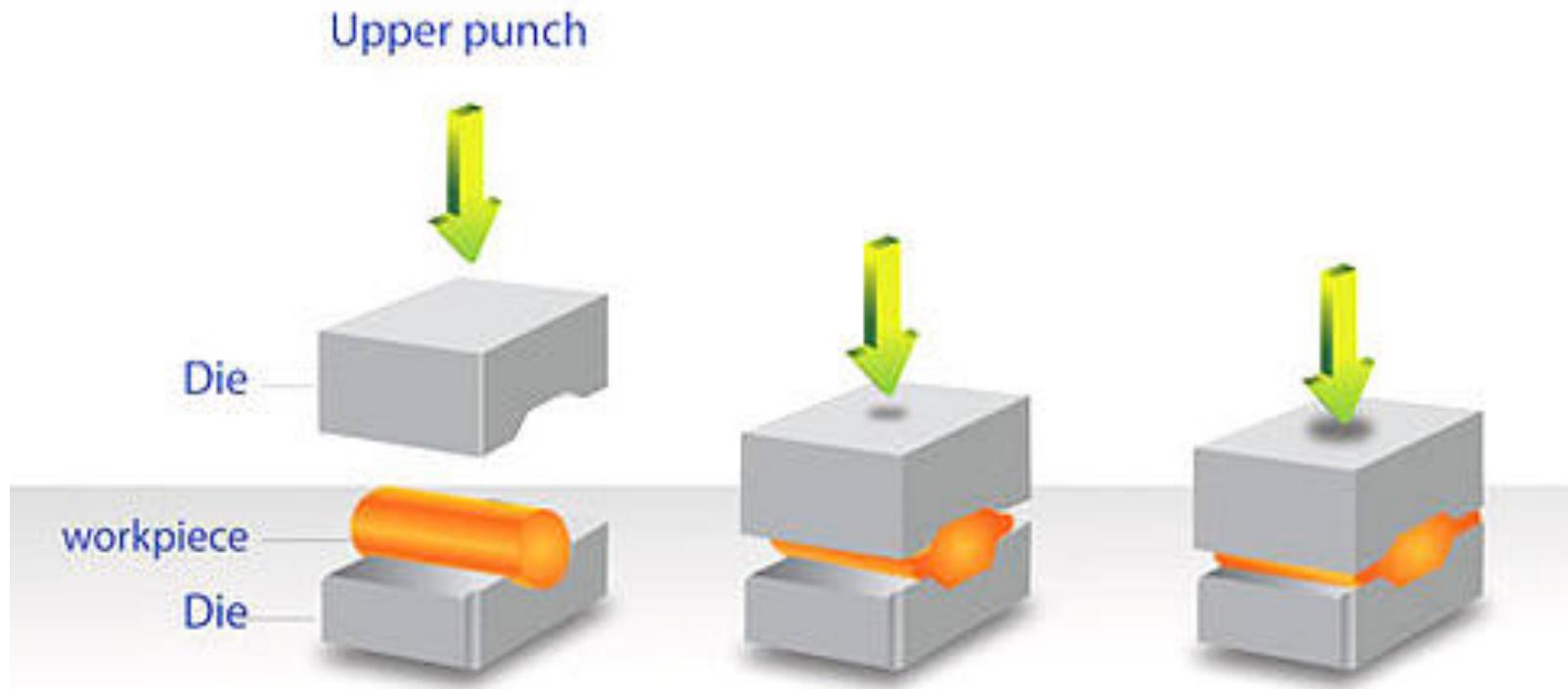
# Metode de procesare a materialelor

## - Turnarea -



# Metode de procesare a materialelor

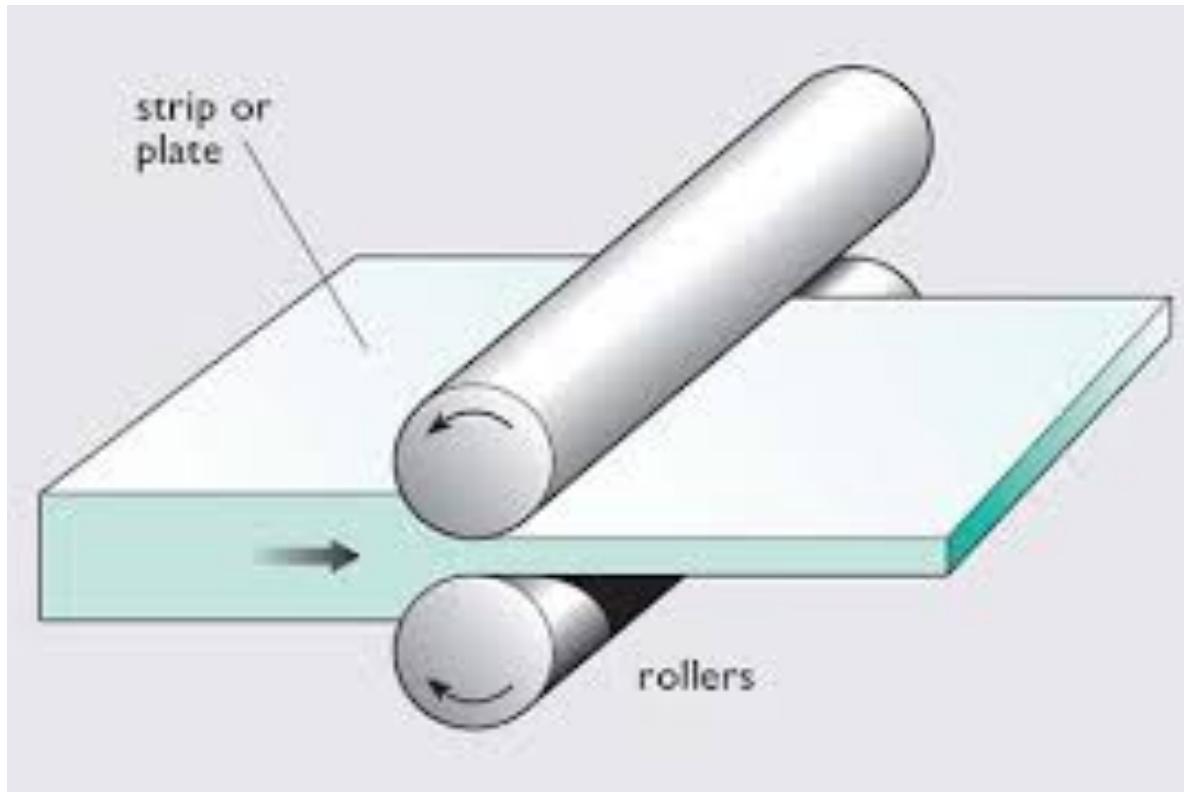
## - Deformarea plastica -



Forjarea (la cald)

# Metode de procesare a materialelor

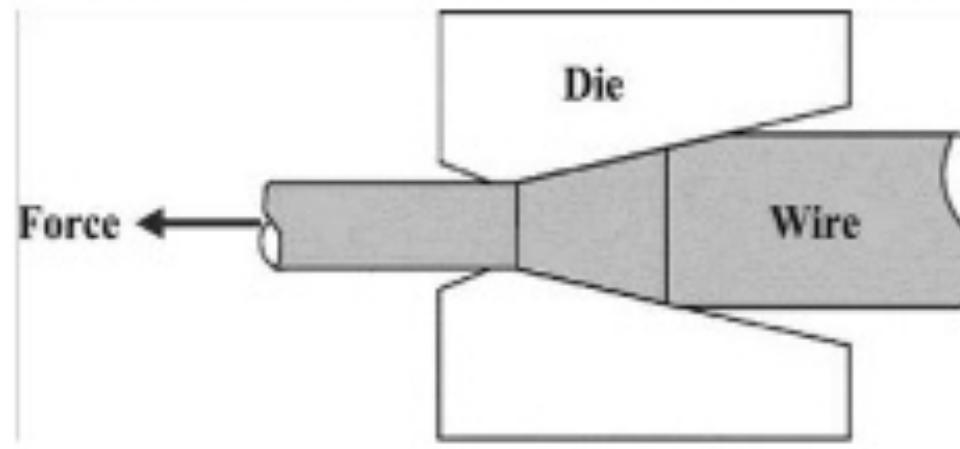
## - Deformarea plastica -



Laminarea (la cald)

# Metode de procesare a materialelor

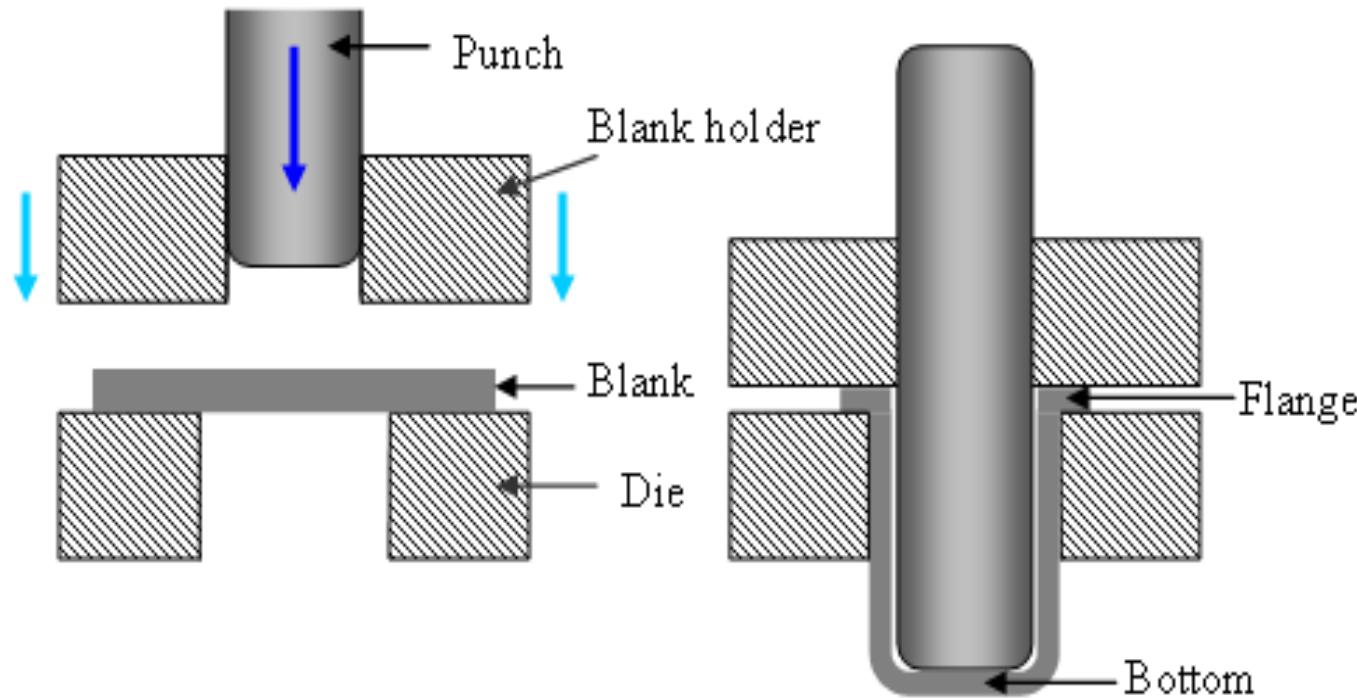
## - Deformarea plastica -



Trefilarea

# Metode de procesare a materialelor

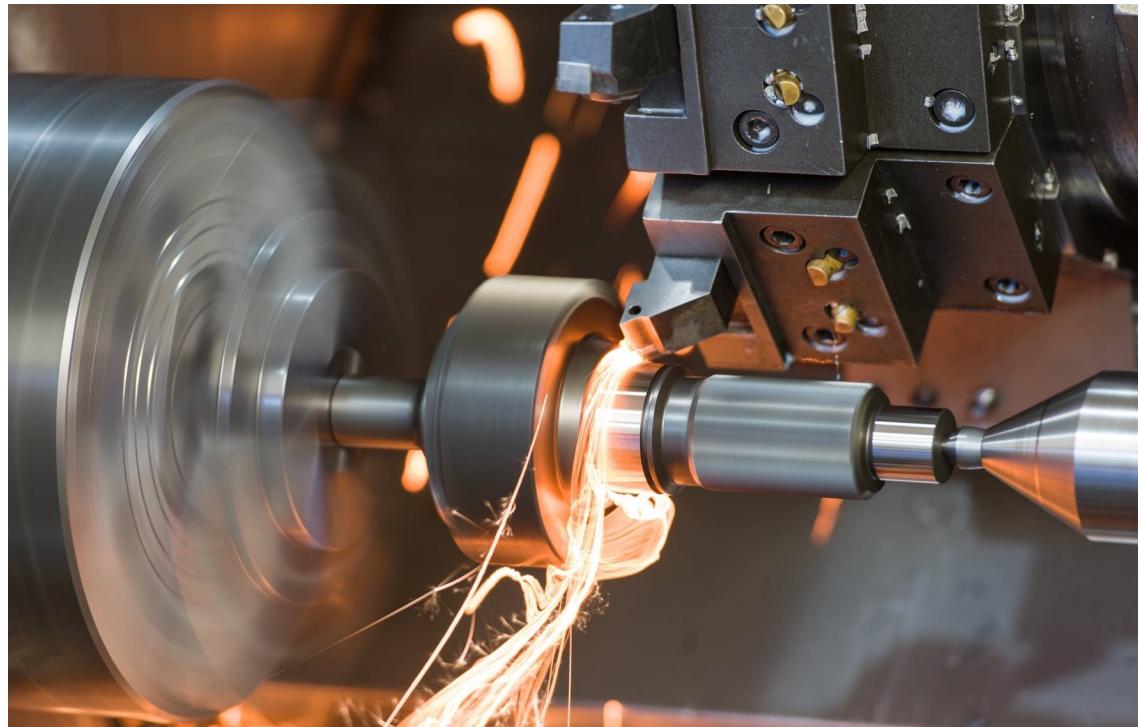
## - Deformarea plastica -



Ambutisarea

# Metode de procesare a materialelor

## - Aschierea -



Strunjirea

# Metode de procesare a materialelor

## - Sudarea -



Sudarea cu arc electric

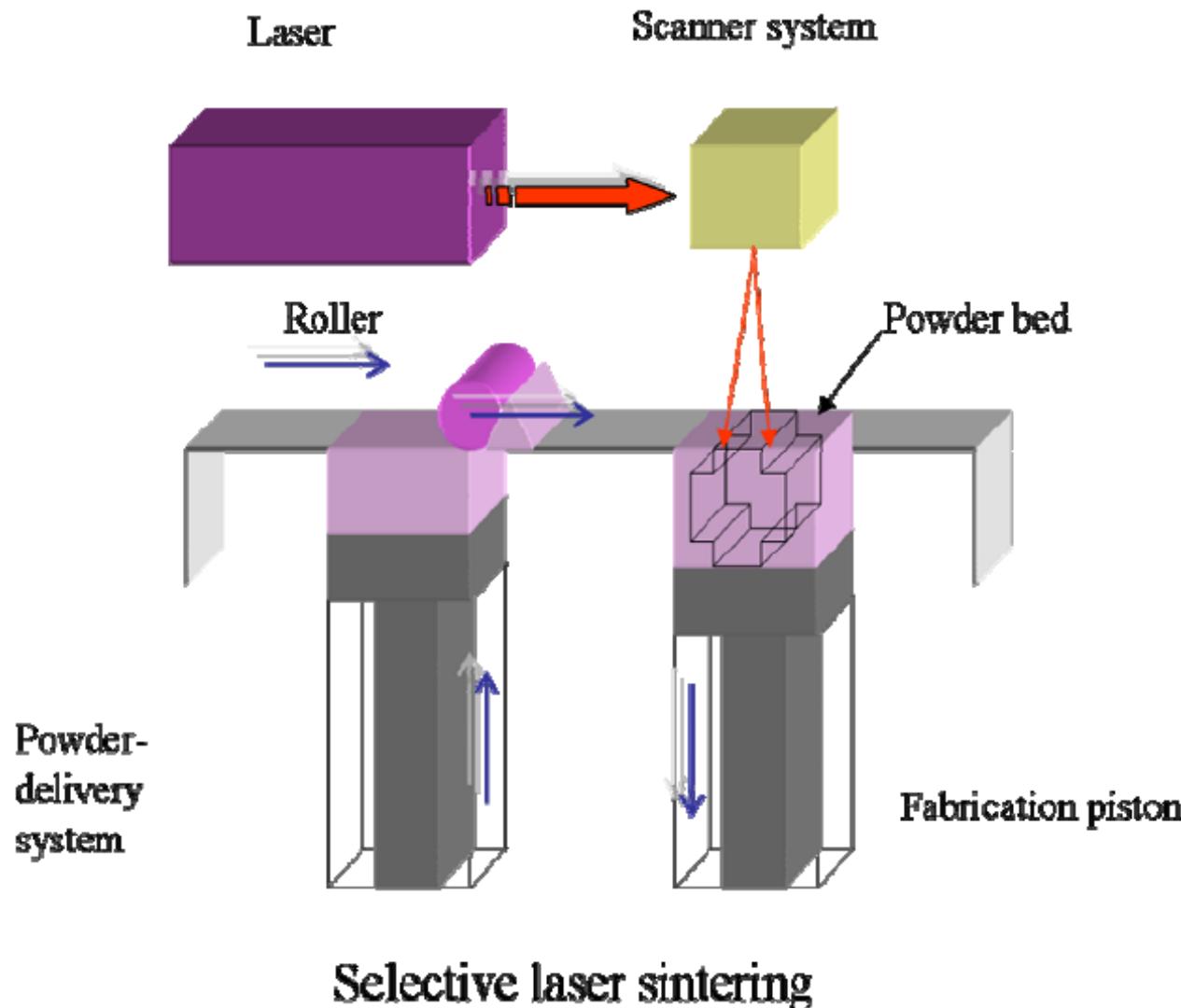
# Metode de procesare a materialelor

## - Agregarea de pulberi -



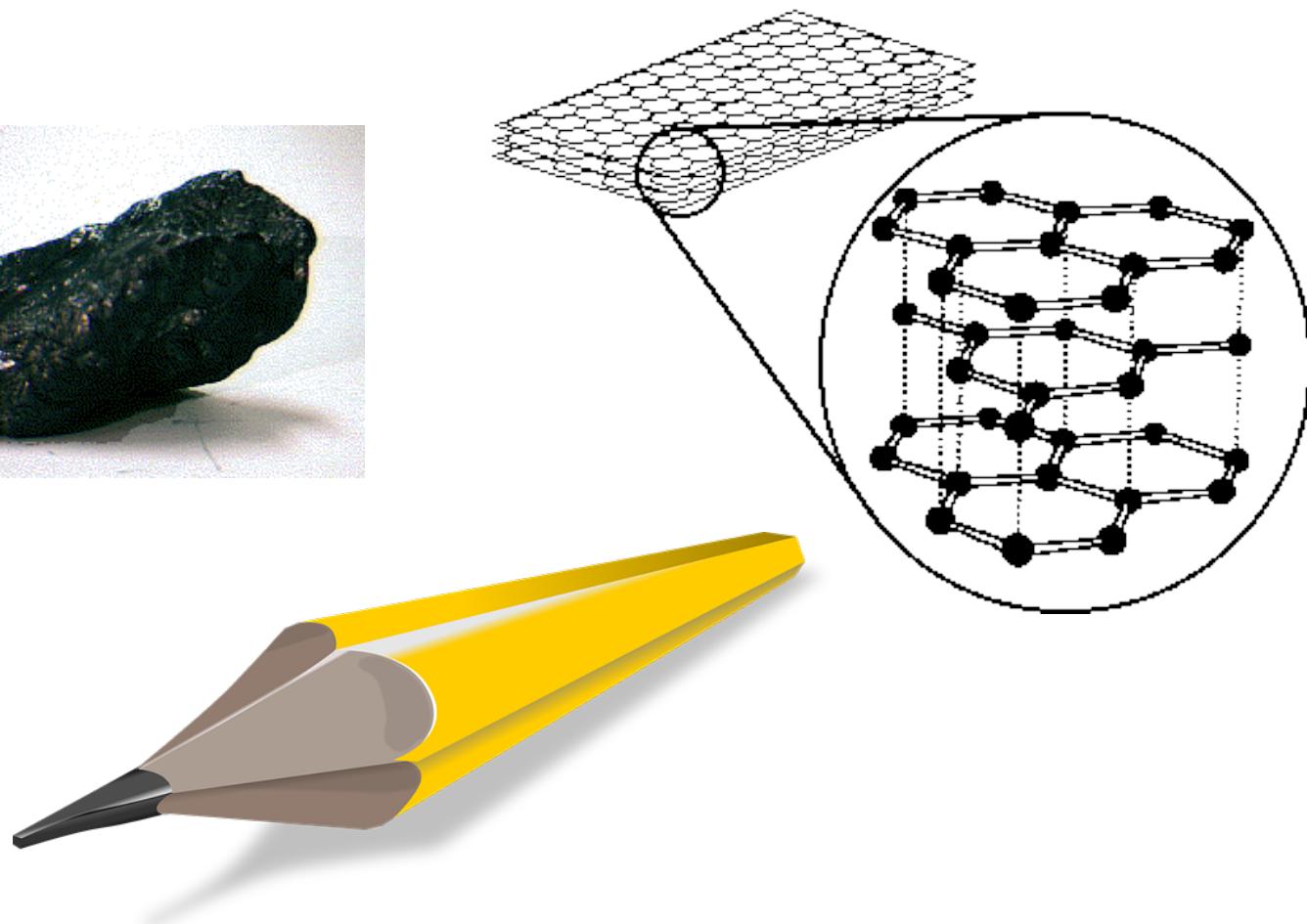
# Metode de procesare a materialelor

## - Fabricatia aditiva -



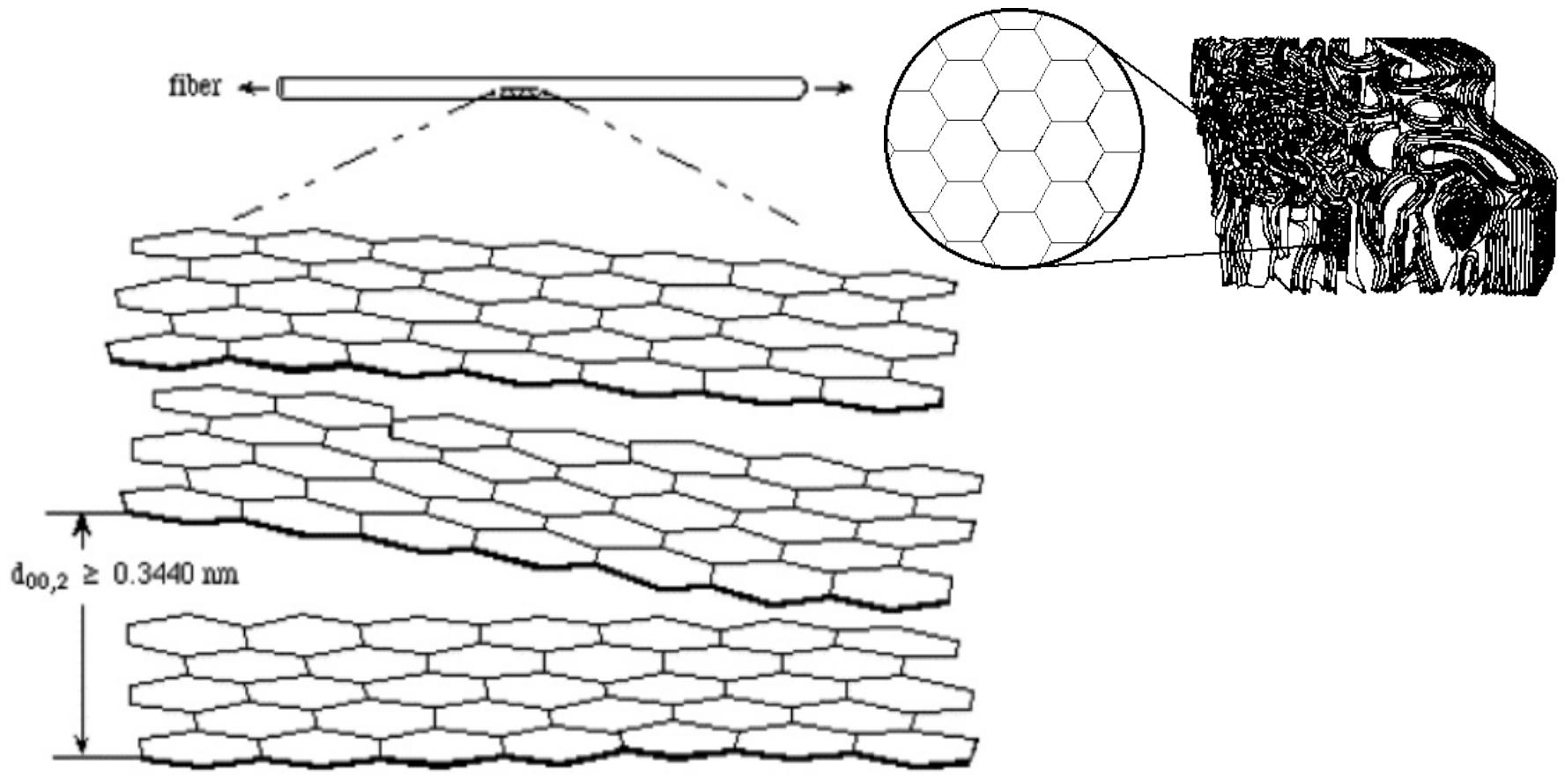
# Efectul structurii asupra proprietatilor

## Ex.: grafitul



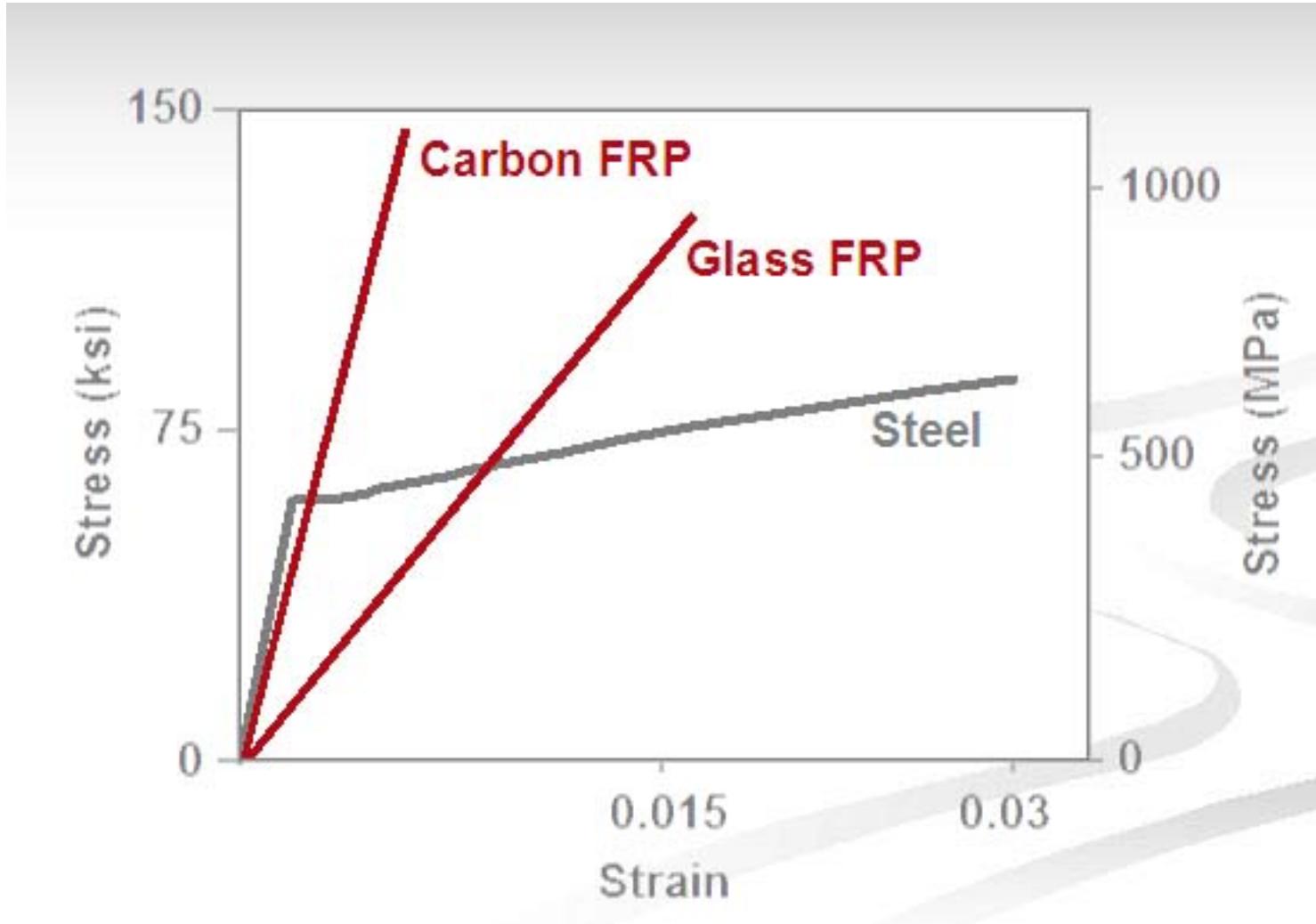
# Efectul structurii asupra proprietatilor

## Ex.: fibrele de grafit



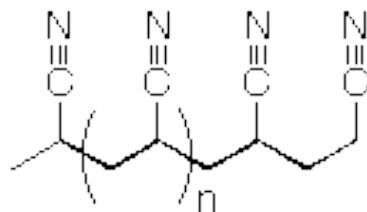
# Efectul structurii asupra proprietatilor

## Ex.: fibrele de grafit

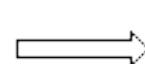


# Efectul structurii asupra proprietatilor

## Ex.: fibrele de grafit



poly(acrylonitrile)  
organic polymer



stretched

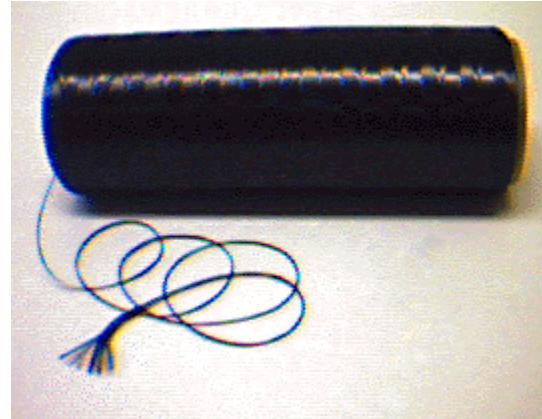


oxidized at  
200-300 °C



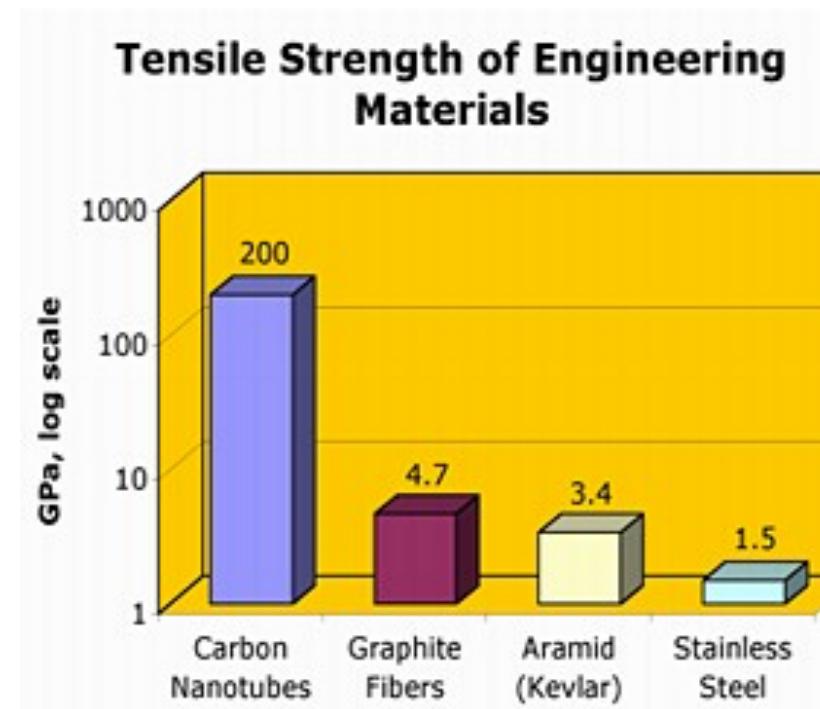
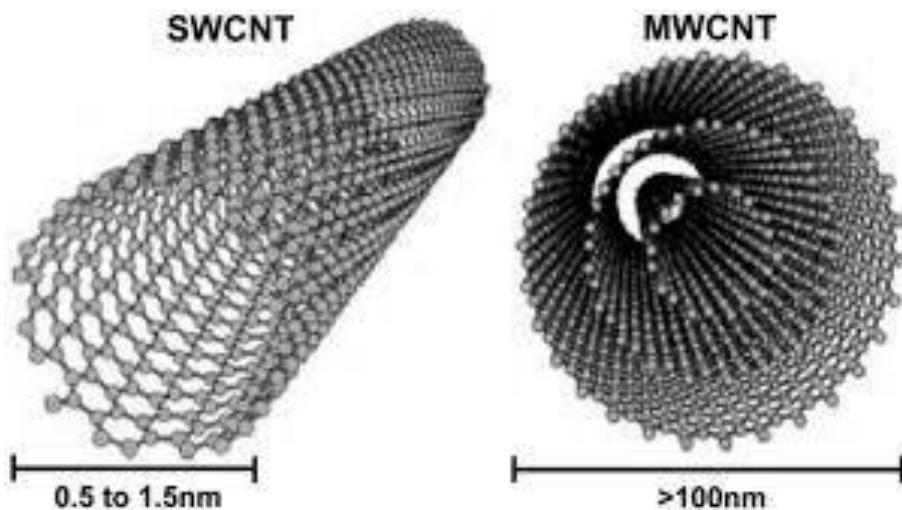
heated at  
1000-2000 °C

carbon fiber



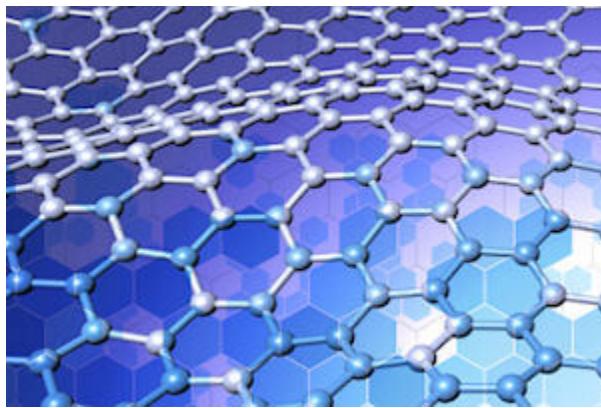
# Efectul structurii asupra proprietatilor

## Ex.: nanotuburile de grafit



# Efectul structurii asupra proprietatilor

## Ex.: grafenul



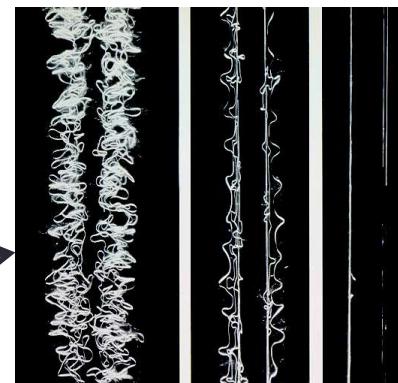
Extrem de usor: suprafata unui teren de fotbal ~1g

**Cel mai rezistent material:**

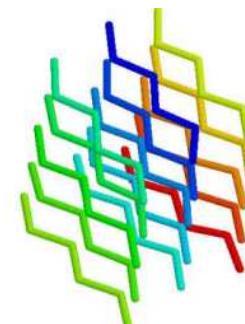
de peste 130 de ori mai rezistent decat un otel de mare rezistenta

# CLASIFICAREA MATERIALELOR

A. Dupa modul de obtinere  
naturale (os, roca, lemn, proteine, etc.)  
de sinteza



Panza de paianjen



# **CLASIFICAREA MATERIALELOR**

## **B – NATURA**

- Metale
- Ceramici
- Polimeri
- Multimateriale  
Compozite  
Materiale stratificate

## **C – UTILIZARI**

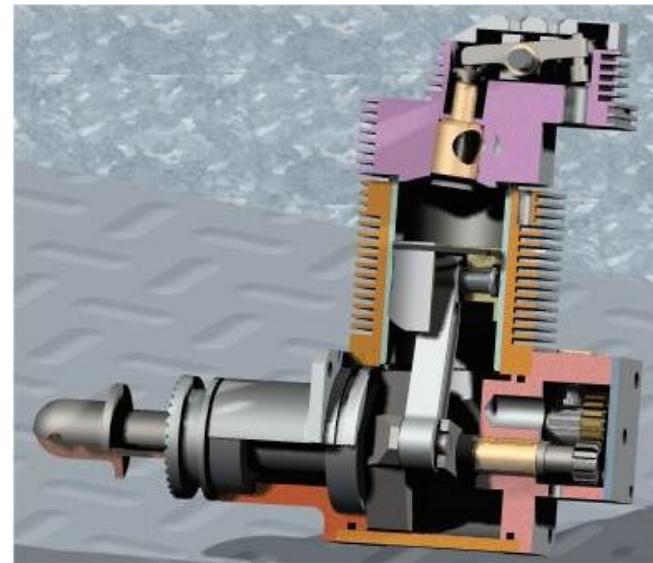
- Structurale
- Functionale
  - Material rulant
  - Aerospatiale
  - Electronica
  - Optoelectronica
  - Biomateriale
  - Stocare de energie
  - Echipament sportiv

....

# METALE

- 89 in tabelul periodic – caracter electropozitiv, niveluri energetice comune intre banda de conductie si cea de valenta
- Practic nu metale pure, ci **aliaje (termenul nu se foloseste decat in cazul metalelor!)**  
(contin si alte elemente, sunt pe baza unui metal)
- Cele mai folosite – Fe, Al, Cu, Mg, Zn, Ti, Ni, ...
- **Stare metalica:** conductori electrici, rezistivitatea creste cu temperatura; conductori termici; luciu metallic; efect termoelectric

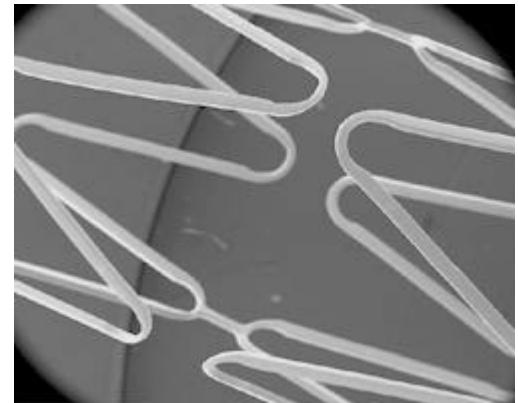
# METALE



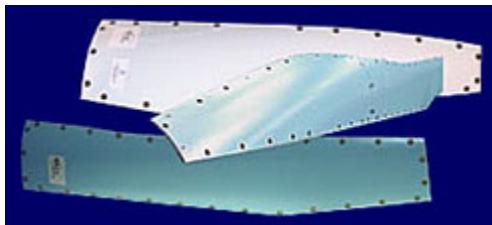
# METALE: ALIAJE AVANSATE



Aliaje superusoare



Aliaje cu memorie



Superaliale



# CERAMICI

**Definitie:** Materiale formate din compusi anorganici, fara caracter metalic.

General: contin elemente metalice combinate cu elemente puternic nemetalice (O, Cl, F, ....)

Exceptii: C, B

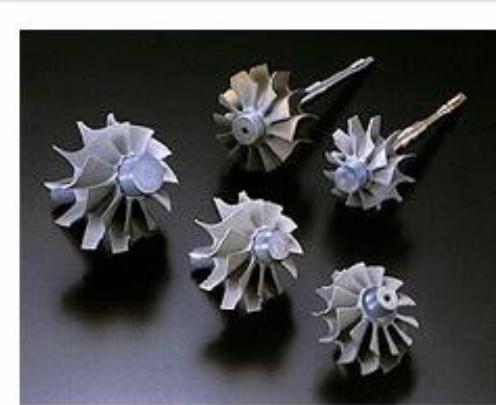
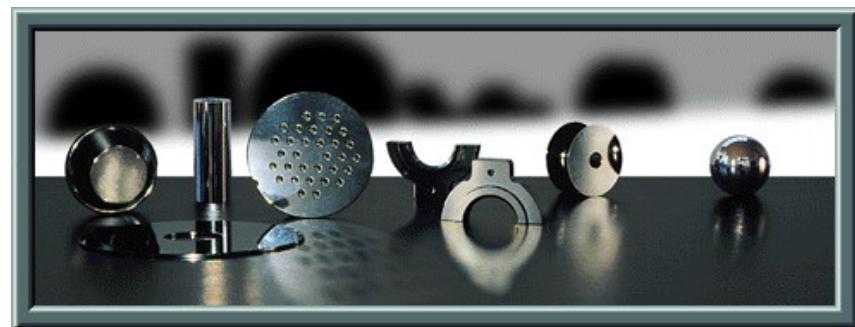
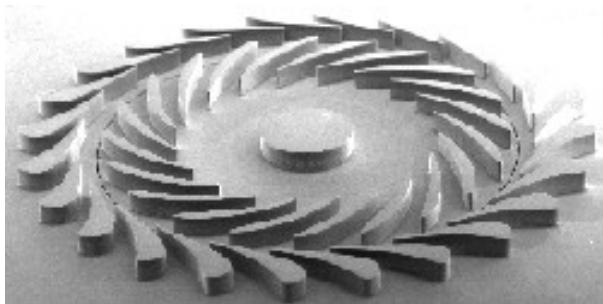
**Clasificare:** A. Clasice (portelan, faianta, lut, ....)

Tehnice (alumina, zircona, TiN,...)

B. Amorfe – sticle

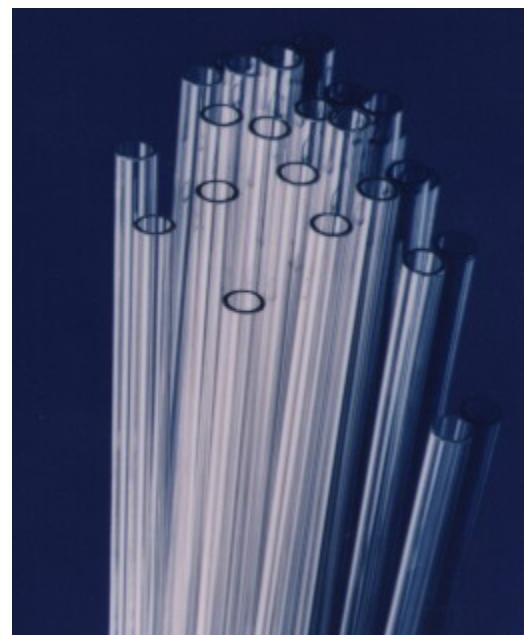
Cristaline

# CERAMICI TEHNICE CRISTALINE



Ceramic rotors under commercial production  
Materials: Sintered silicon nitride

# STICLE TEHNICE



# POLIMERI

**Definitie:** Materiale organice macromoleculare constituite din lanturi lungi de atomi

(C + H, O, N)

(M = 10<sup>4</sup> – 10<sup>6</sup> Da)

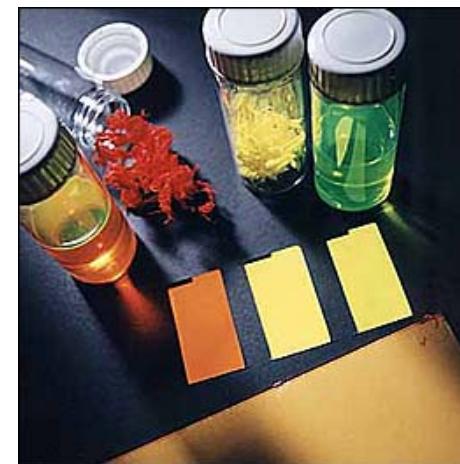
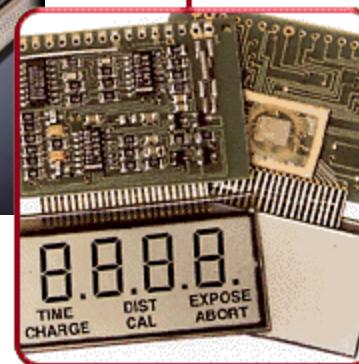
Clasificare:

- termoplasti
- termorigizi
- elastomeri

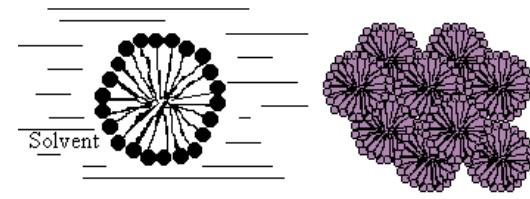
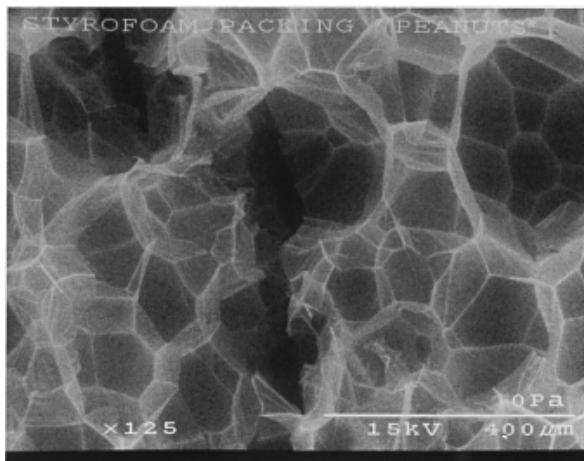
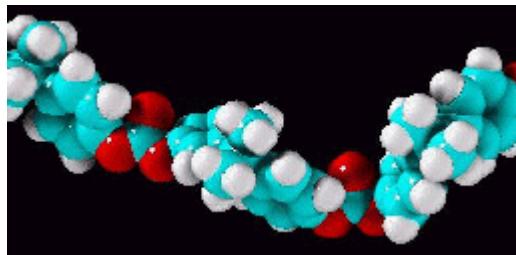
# POLIMERI



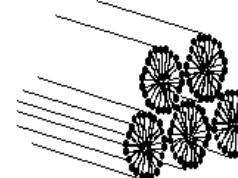
LCD & MODULES



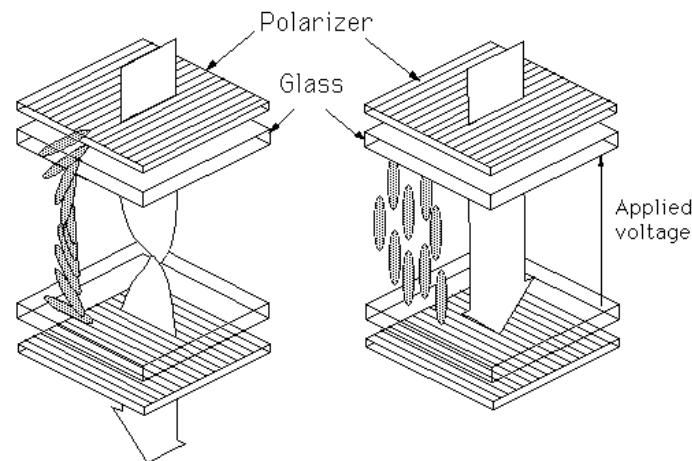
# POLIMERI



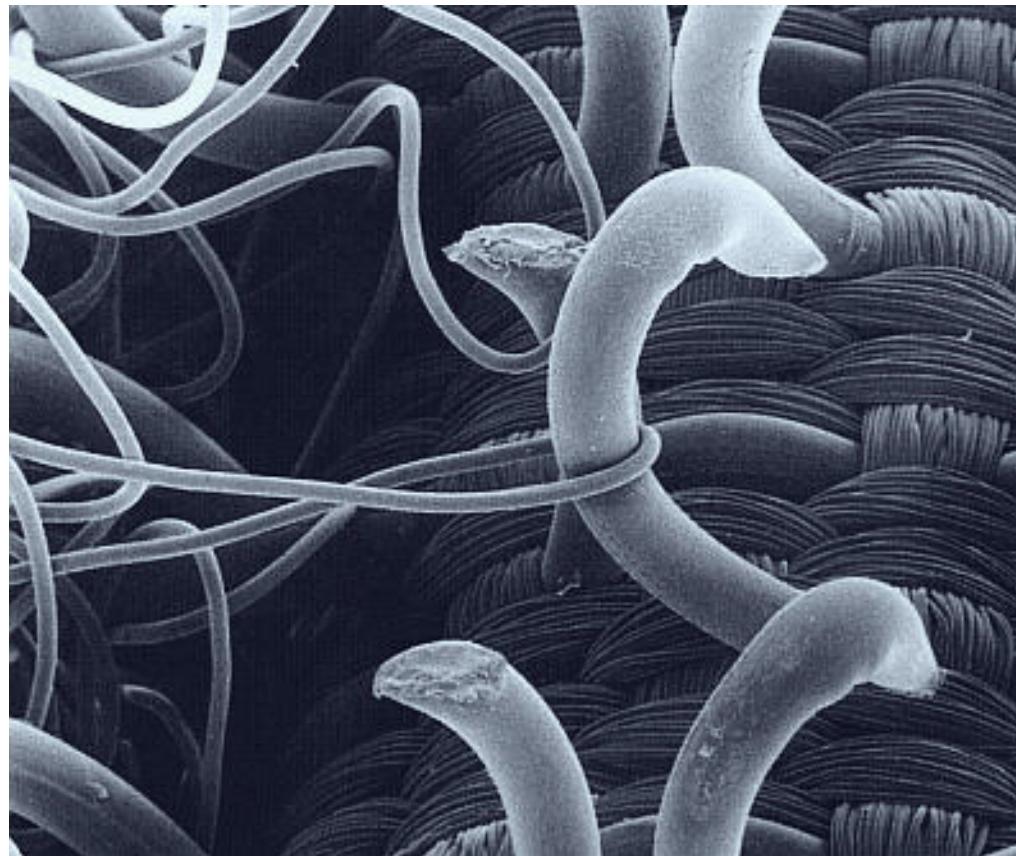
Micelles in Solution      Cubic Packed Micelles



Hexagonally Packed Micelles



# POLIMERI



# COMPOZITE

**Materiale compuse constituite din:** matrice (majoritatea volumului, menține forma piesei) + constituent de armare

**Clasificare:** A. Dupa materialul matricei **Polimerica**

Metallica

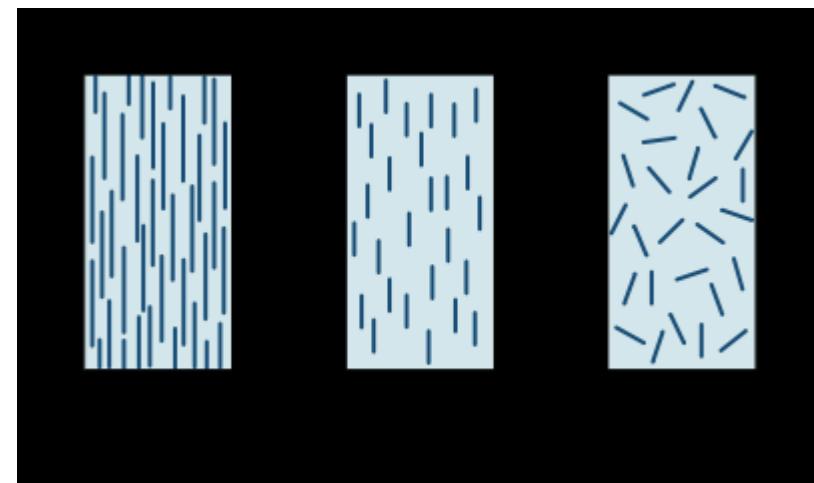
Ceramica

B. Dupa forma constituentului de armare

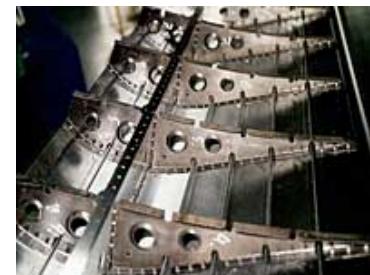
Fibre      lungi  
              scurte

Tesatura

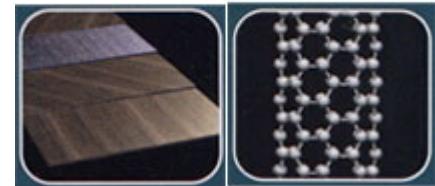
Particule



# COMPOZITE



Carbon Nanotube Technology



# COMPOZITE AVANSATE



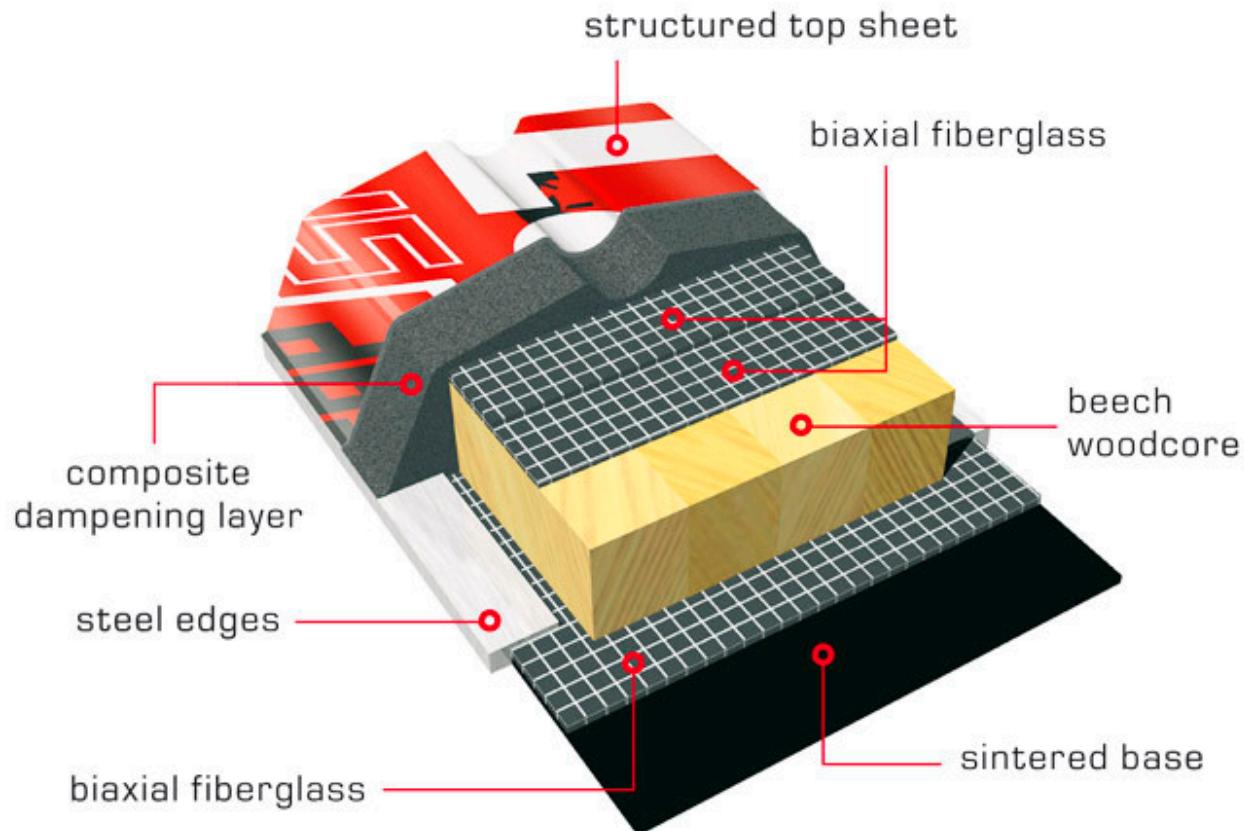
Boeing  
787



# MULTIMATERIALE STRATIFICATE

Materiale compuse alcătuite din straturi de materiale diferite imbinate solidar, care se comportă ca un material unitar

Exemplu:  
schiurile



# Materiale pentru mecanica auto – rezistente / usoare / [rezistenta la cald]

## Materiale avansate (F1)

Frane din compozite C-C  
Cilindri acoperiti ceramic  
Piese din composit polimer - ceramica



# MATERIALE PENTRU OPTOELECTRONICA

## Captatori solari



# MATERIALE PENTRU OPTOELECTRONICA

semnal fotonic



semnal electric

Captator solar  
Randament 37%

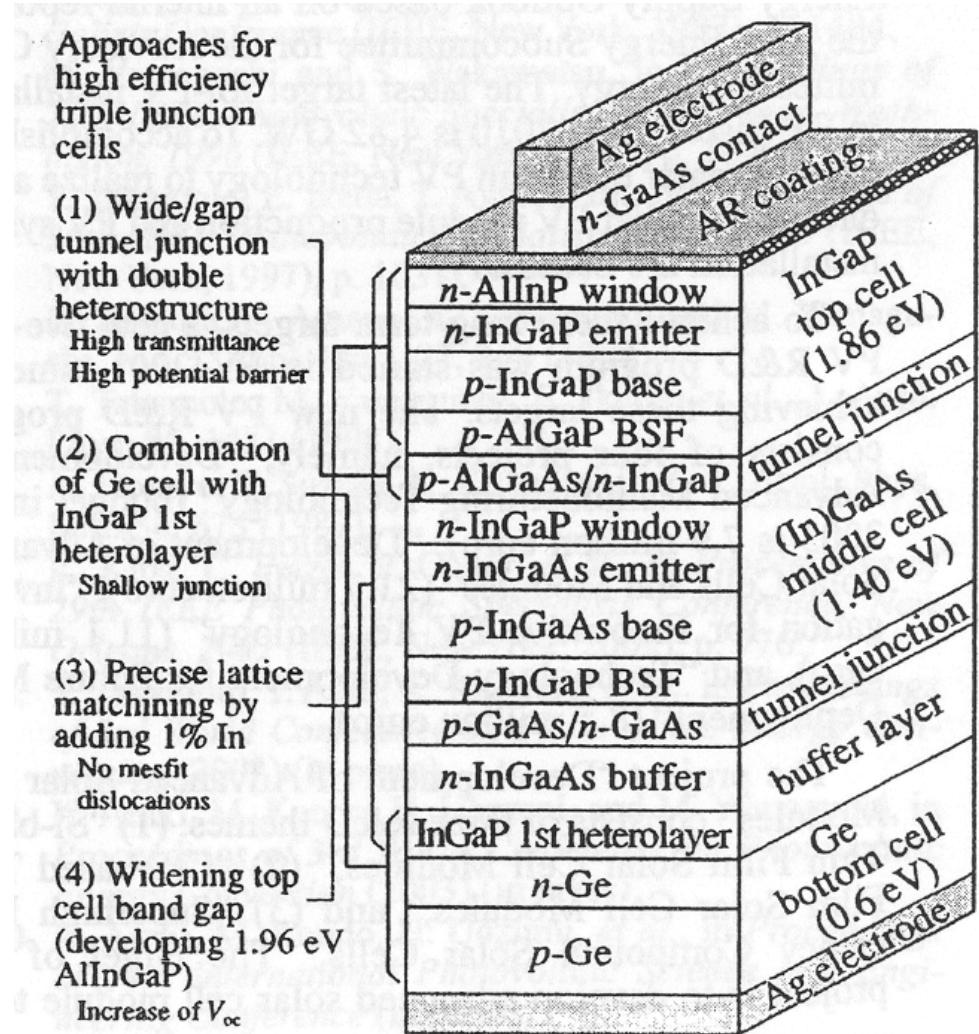
Approaches for  
high efficiency  
triple junction  
cells

(1) Wide/gap  
tunnel junction  
with double  
heterostructure  
High transmittance  
High potential barrier

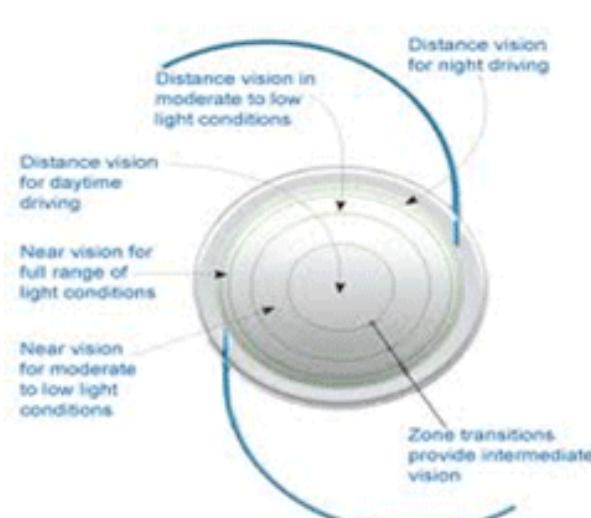
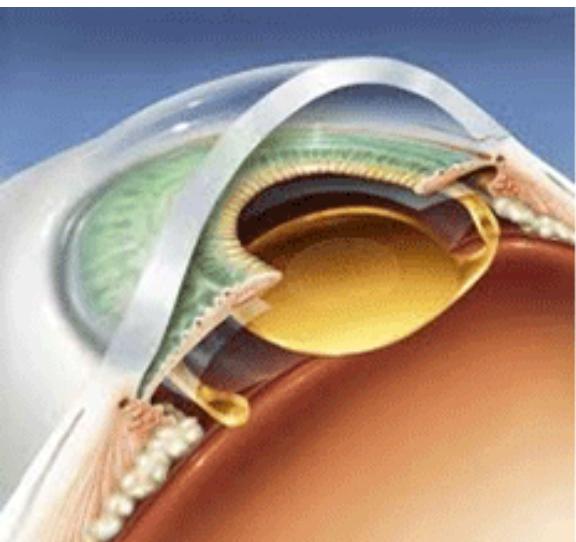
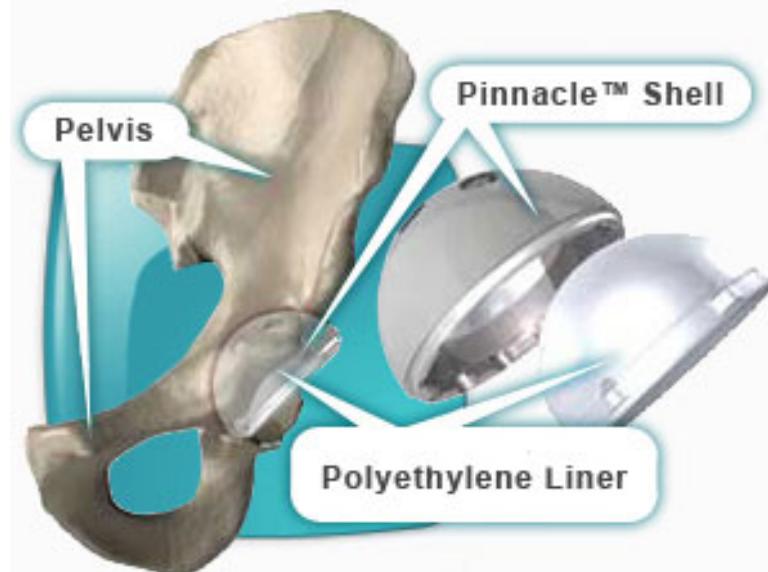
(2) Combination  
of Ge cell with  
InGaP 1st  
heterolayer  
Shallow junction

(3) Precise lattice  
matching by  
adding 1% In  
No mesfit  
dislocations

(4) Widening top  
cell band gap  
(developing 1.96 eV  
AlInGaP)  
Increase of  $V_{oc}$



# BIOMATERIALE



# **PROPRIETATILE MATERIALELOR**

# PROPRIETATI FIZICE

Densitatea  
[kg/m<sup>3</sup>]

$$\rho = m / V$$

metale: Li(0.53) ... Mg(1.74)...Al(2.7)...Fe(7.8)... Os(22.5)  
ceramici: Grafit(2.28)....WC(13-15.3)  
polimeri: 0.83 – 2.15

valori față de apă [kg/m<sup>3</sup> x 10<sup>-3</sup>]

## Conductivitatea electrică      $\sigma$

Metale: conductori

Ag – Cu – Au – Al - ... – Mn

Ceramici: izolatori (general);

exceptii: C, semiconductori, unii supraconductori

Polimeri: izolatori (general)

exceptii: polimeri conductori

## Conductivitatea termică      $\lambda$

= energia termică transferată prin material pentru a crește cu un grad temperatura la o distanță de 1 m în timp de 1 s;

În general similar cu  $\sigma$

metalele: conductori      Au – Cu – Ag – Al - ....  
ceramici, polimeri: izolatori

# PROPRIETATI FIZICE

**Coeficientul de dilatare termica**

$\alpha$

$$l = l_0 (1 + \alpha \Delta t)$$

(aproximativ)

In general: polimeri > metale > ceramici

exceptii: aliaj invar

**Proprietati magnetice**

$\chi_m$  = susceptibilitatea magnetica;  
 $\mu$  = permeabilitatea magnetica

Materiale:

diamagnetice ( $\chi_m < 0$ ) (Cu, Ag, Au, ...)

paramagnetice ( $\chi_m > 0$ , mic) (Fey, Al, Ti, ...)

feromagnetice ( $\chi_m \gg 0$ )

(Fea, Ni, Co, sub temperatura Curie)

# Intrebari de autoevaluare

1. Care sunt metodele de fabricatie in care materia prima este adusa in stare lichida?
2. Numiti procedee de deformare plastica la cald si la rece.
3. Care sunt avantajele si dezavantajele fabricatiei aditive?
4. Care e, in sistem international, densitatea fierului?
5. Se poate afirma ca metalele sunt mai grele decat polimerii? Dar decat ceramicile?
6. Exista metale care plutesc pe apa? Cum se explica plutirea pe apa a vapoarelor?
7. Cum sunt ceramicile din punctul de vedere al conductivitatii electrice? Dar termice?
8. Sunt toate metalele conductori electrici si termici?
9. Ce se intampla la incalzirea unui conductor electric izolat cu PVC?
10. Temperatura Curie a fierului este  $770^{\circ}\text{C}$ . Ce proprietati magnetice are fierul la  $800^{\circ}\text{C}$ ? Dar la  $500^{\circ}\text{C}$ ?
11. O bara de Cu este introdusa intr-un camp magnetic N-S. Se va magnetiza? Cum? Dar o bara de Co?