Nanocose : sviluppare, manipolare e utilizzare nuovi materiali in un miliardesimo di metro

Dino Leporini

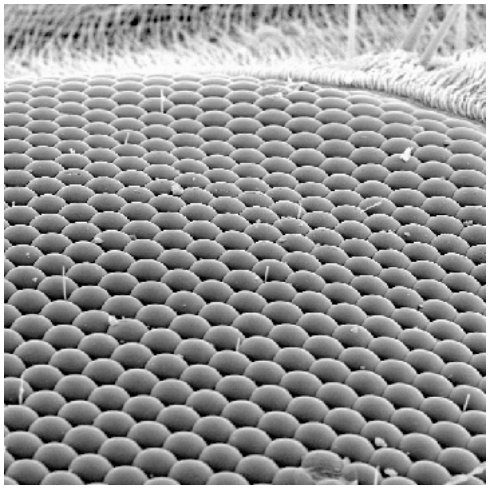
Dipartimento di Fisica “Enrico Fermi”, Universita’ di Pisa

Transistor ibrido molecolare a nanotubi
*Scan: 1.5 * 1.5 μm*

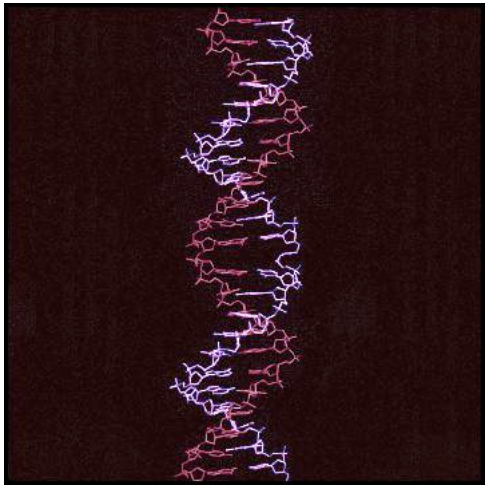
Scale di Lunghezza

10^{0} metri

10^{-2} metri

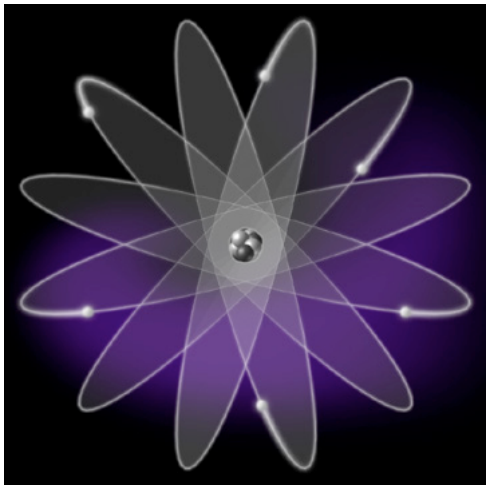


10^{-4} metri



10^{-8} metri

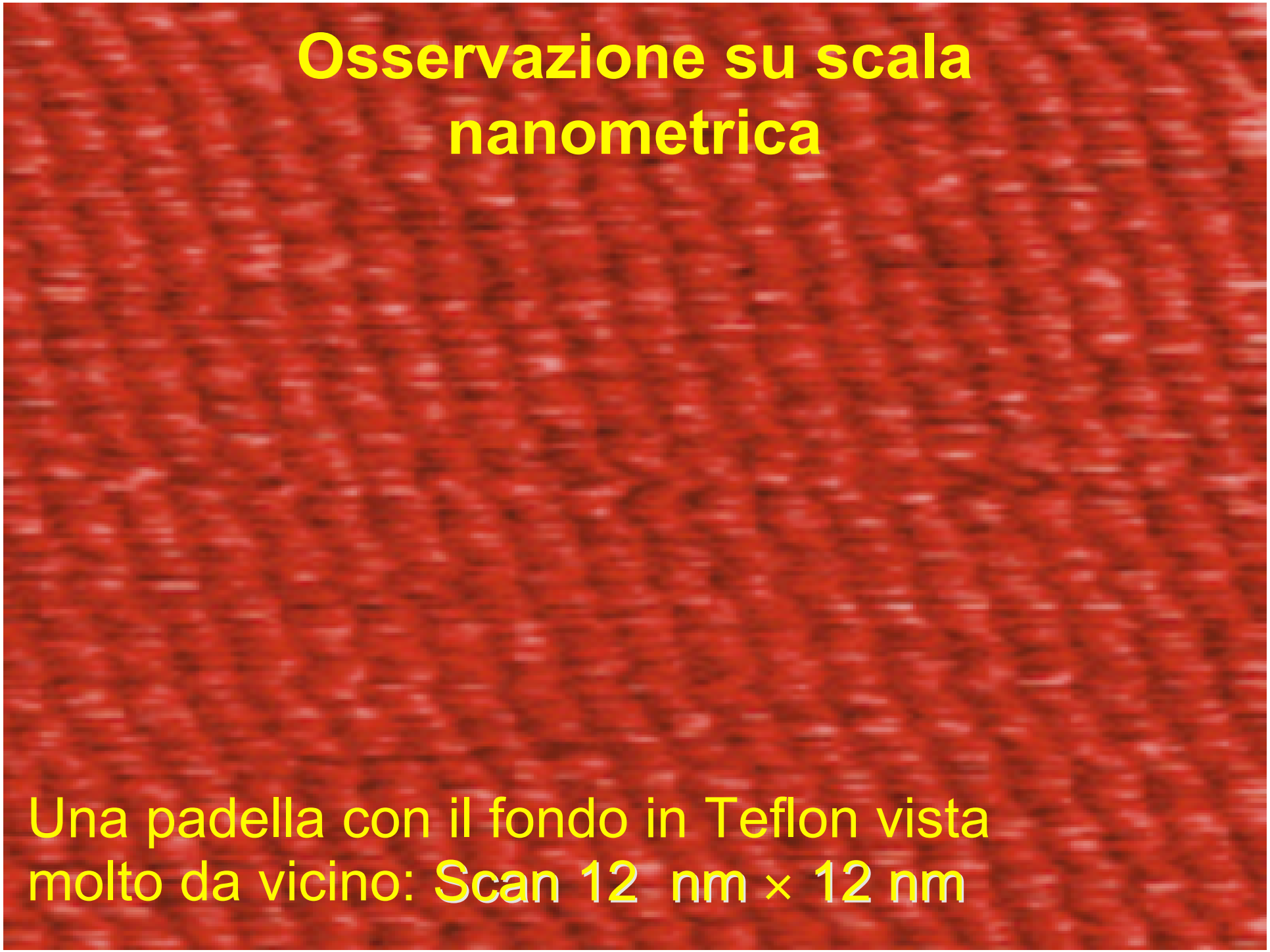
10^{-9} metri



10^{-10} metri

Osservare su scala nanometrica

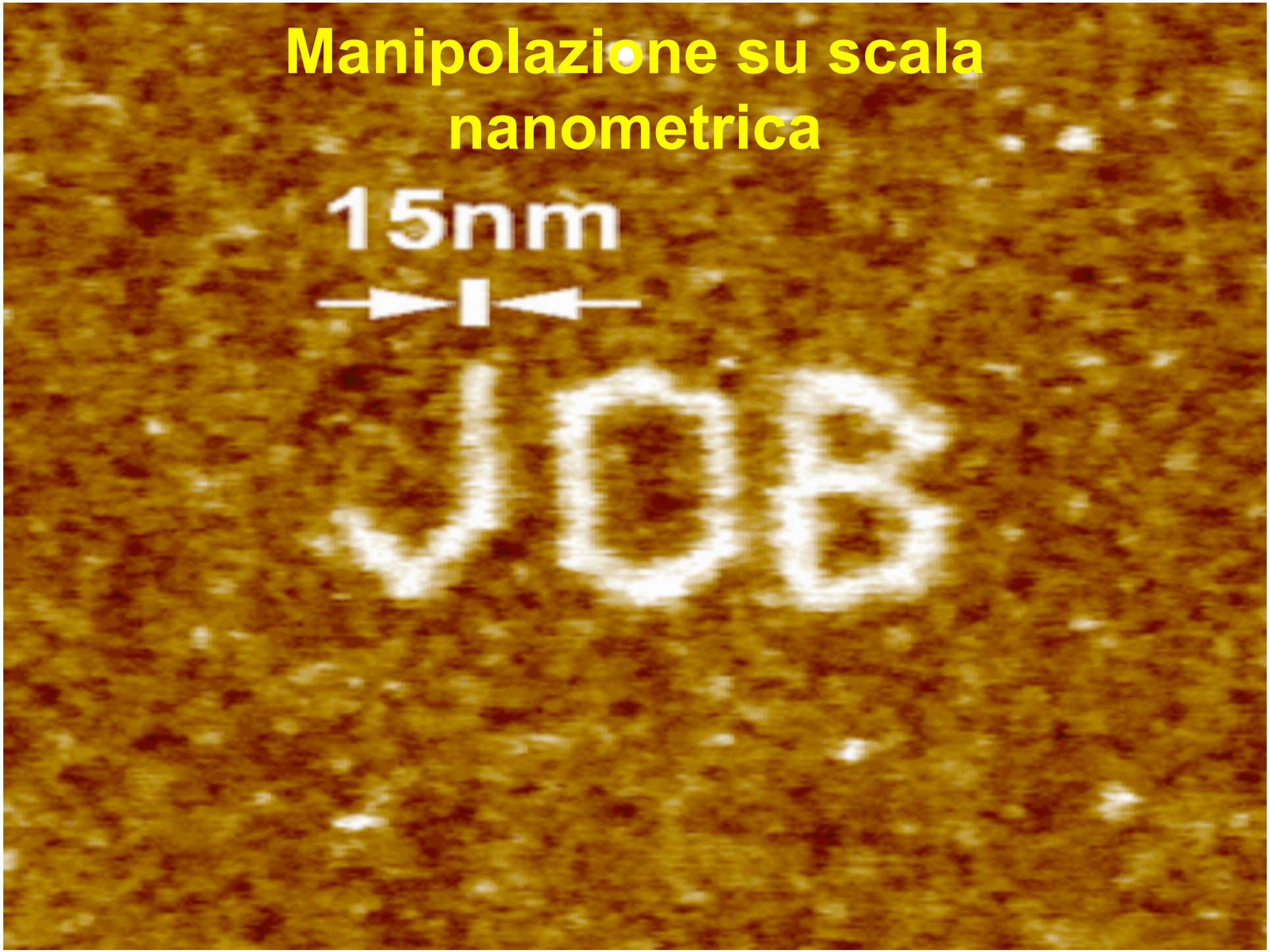
Osservazione su scala nanometrica



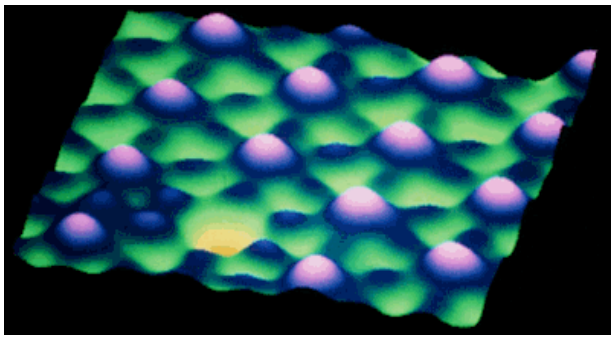
Una padella con il fondo in Teflon vista molto da vicino: Scan 12 nm × 12 nm

Manipolare su scala nanometrica

Manipolazione su scala nanometrica

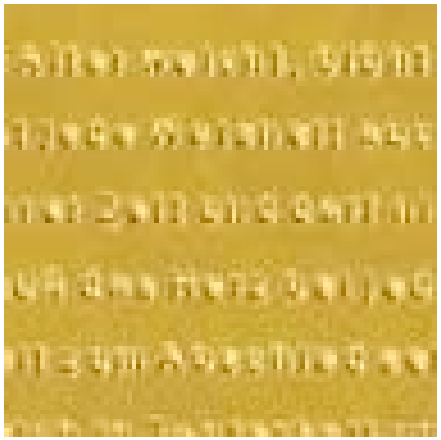


Osservazione e manipolazione su scala nanometrica (10^{-9} m)



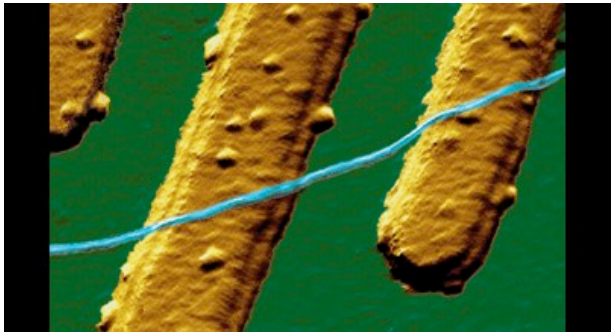
- Il piu' piccolo difetto del mondo.

Reticolo di atomi di Iodio. Si noti l'atomo mancante.
Scan 2.5 nm × 2.5 nm .



- Il piu' piccolo libro del mondo (di H.Hesse).

Strato di Perspex. Altezza lettere 26 nm
Scan 1.6 μm × 1.6 μm .



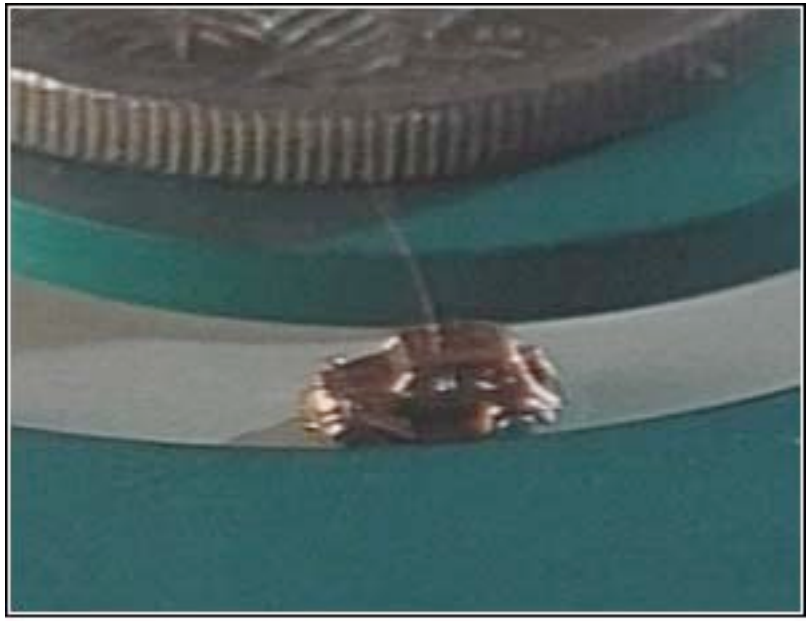
- Il piu' piccolo tubo del mondo.

Nanotubo di carbonio.
Scan 530 nm × 300 nm.

Due strategie per raggiungere la scala nanometrica:

- **Miniaturizzare**
- **Assemblare**

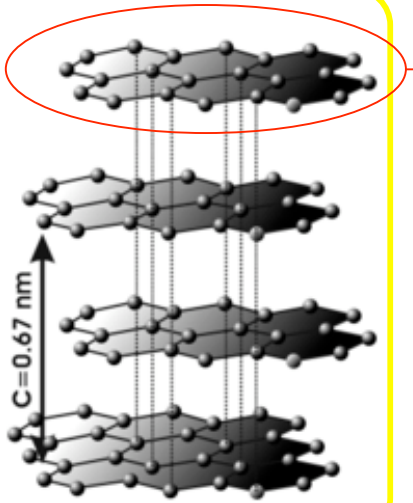
Sviluppo di nanocose :
approccio top-down (miniaturizzare)

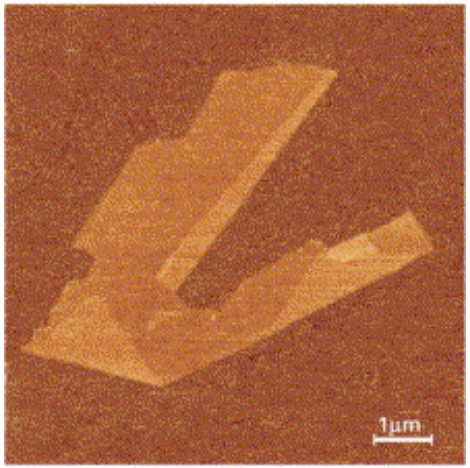


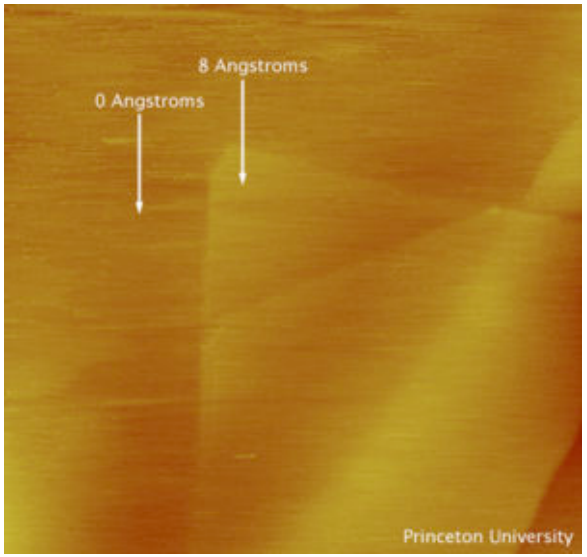
(APTV)

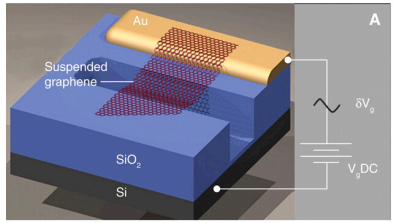
Micromacchina (1997)
Lunghezza: 5 mm,
Velocita': 0.36 Km/h

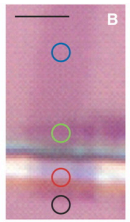
Grafene: fogli di grafite spessi 0.8 nm

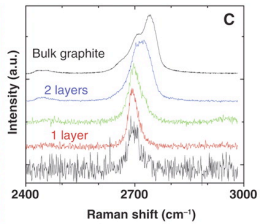


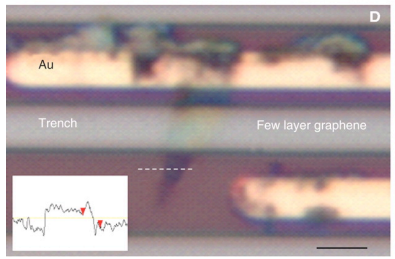


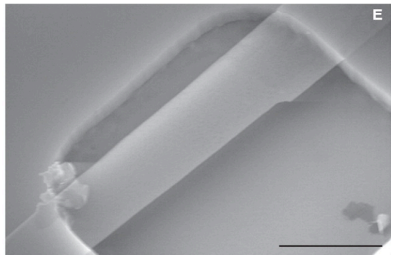










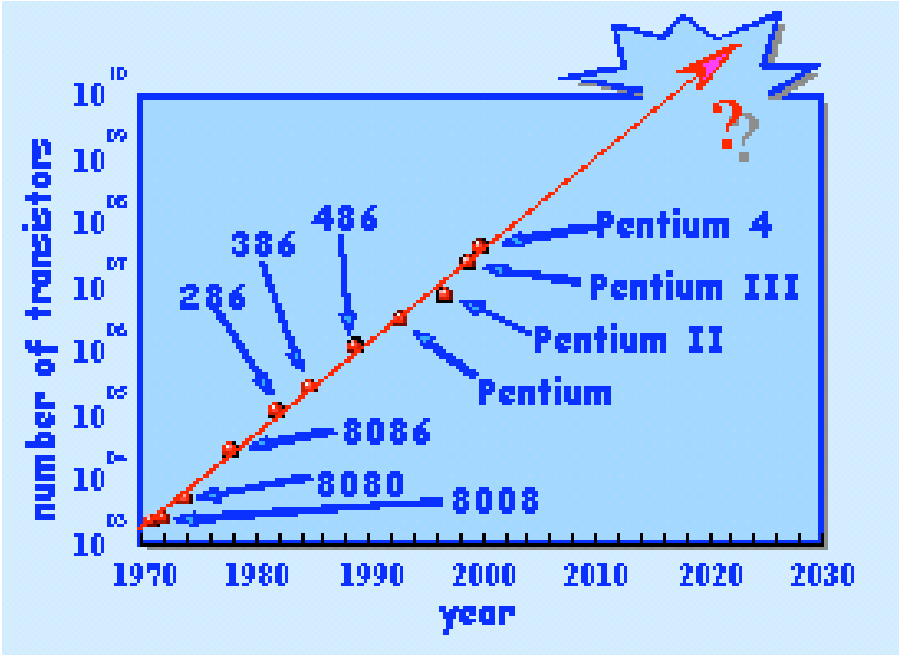


Applicazioni:

- Conducibilita’ 2D: transistor bidimensionali, chip a singola molecola,
- Dispositivi nanoelettromeccanici: convertire energia elettrica in energia meccanica su scala nanometrica.

Approccio top-down: limiti

La miniaturizzazione di un dispositivo e' in genere operazione complessa, costosa e intrinsecamente limitata.
Es.: la miniaturizzazione dei chip



Sviluppo di nanocose : approccio bottom-up (assemblare)

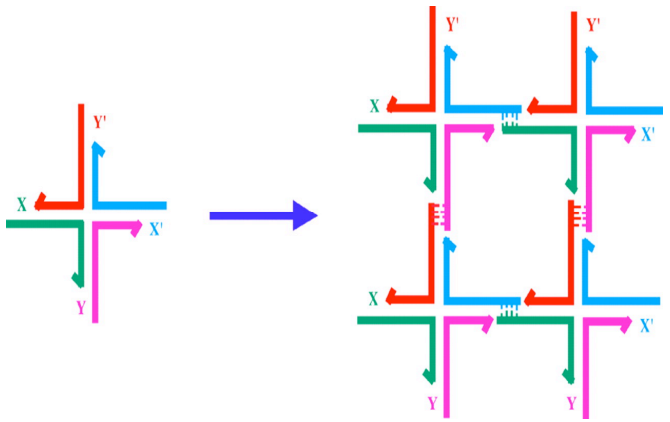
Invece di rimuovere parti, l'approccio bottom-up assembla parti.

La natura ha adottato questo schema (operando spesso su scale nanometriche) in :

- **Cellule**
- **Esseri viventi**
- **Cristalli**

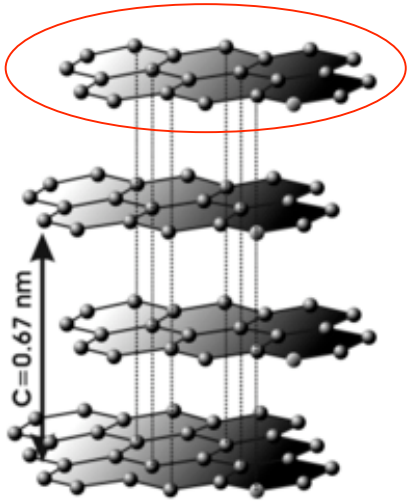
In natura l'assemblaggio e' spontaneo (self-assembly) grazie a meccanismi di riconoscimento molecolare.

Sviluppo di approcci biomimetici.

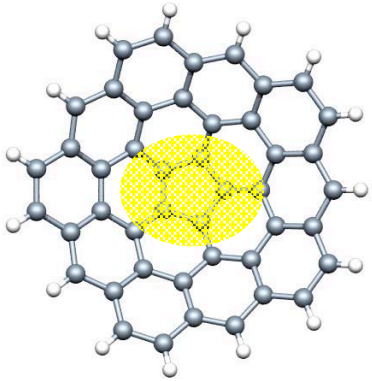


Formazione di un reticolo 2D tramite self-assembly di DNA ramificato

Bottom-up: Fullerene C_{60}

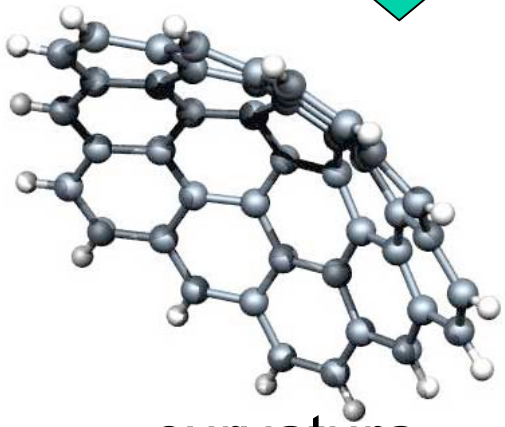


Grafite : planare

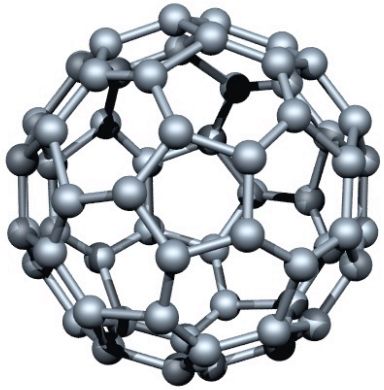


(c)2003 Chris Ewels www.ewels.info

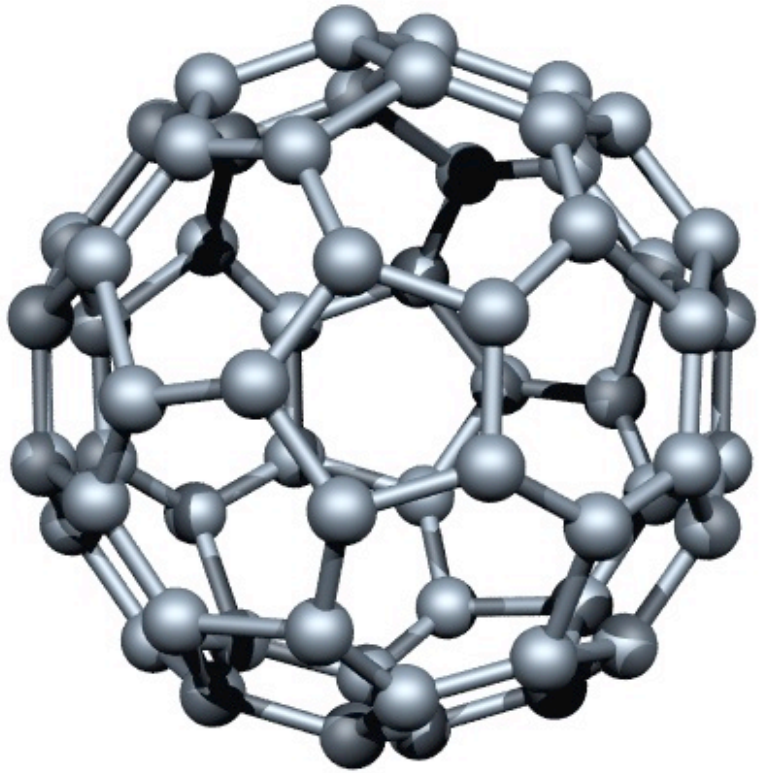
Inserimento di un pentagono nella struttura esagonale



curvatura

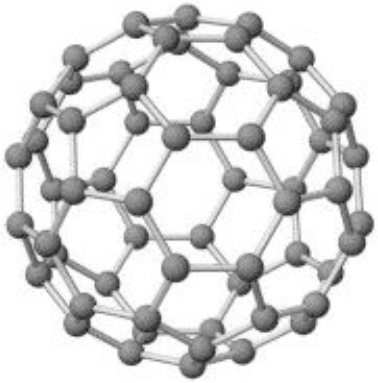


Bottom-up: Fullerene C_{60}

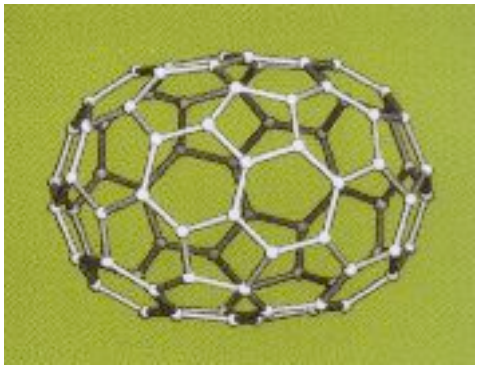


Applicazioni: calcolo quantistico, …. , giroscopi, lubrificanti

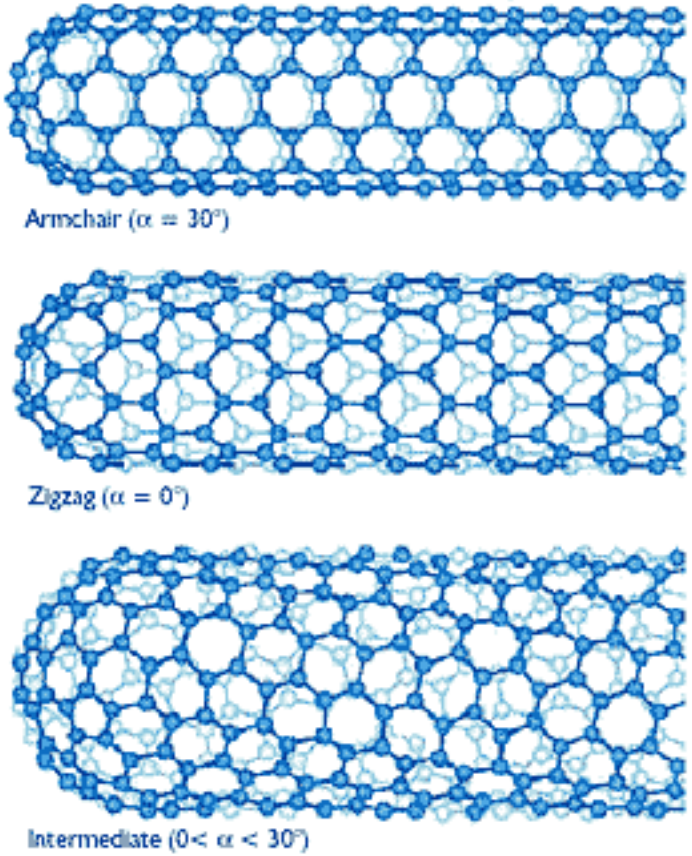
Bottom-up: nanotubi



C_{60}



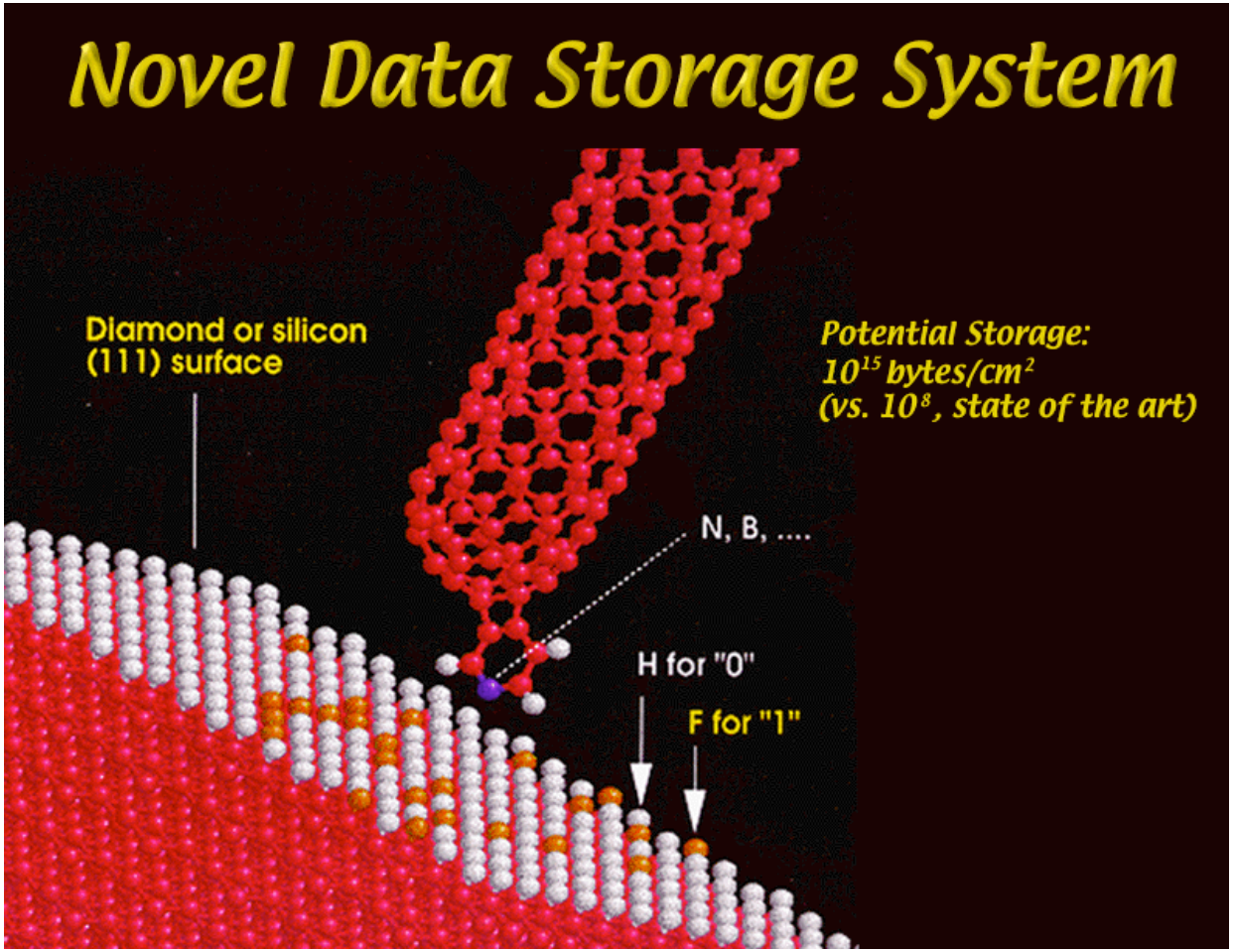
C_{84}



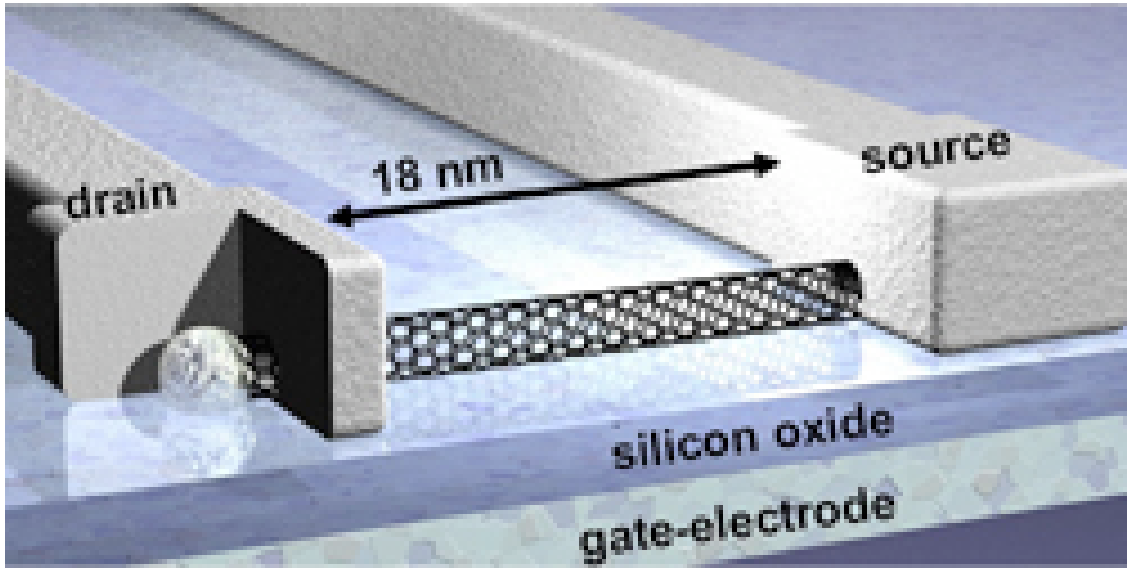
Applicazioni:

- meccaniche (100 volte + forte e 6 volte + leggero dell'acciaio) : ascensori spaziali
- elettroniche (conducibilita' simile a quella del rame): nanoelettronica
- chimico-fisiche (grande superficie + grandi volumi di intrappolamento) : Batterie ad H

Testa di lettura/scrittura di dati informatici a nanotubi

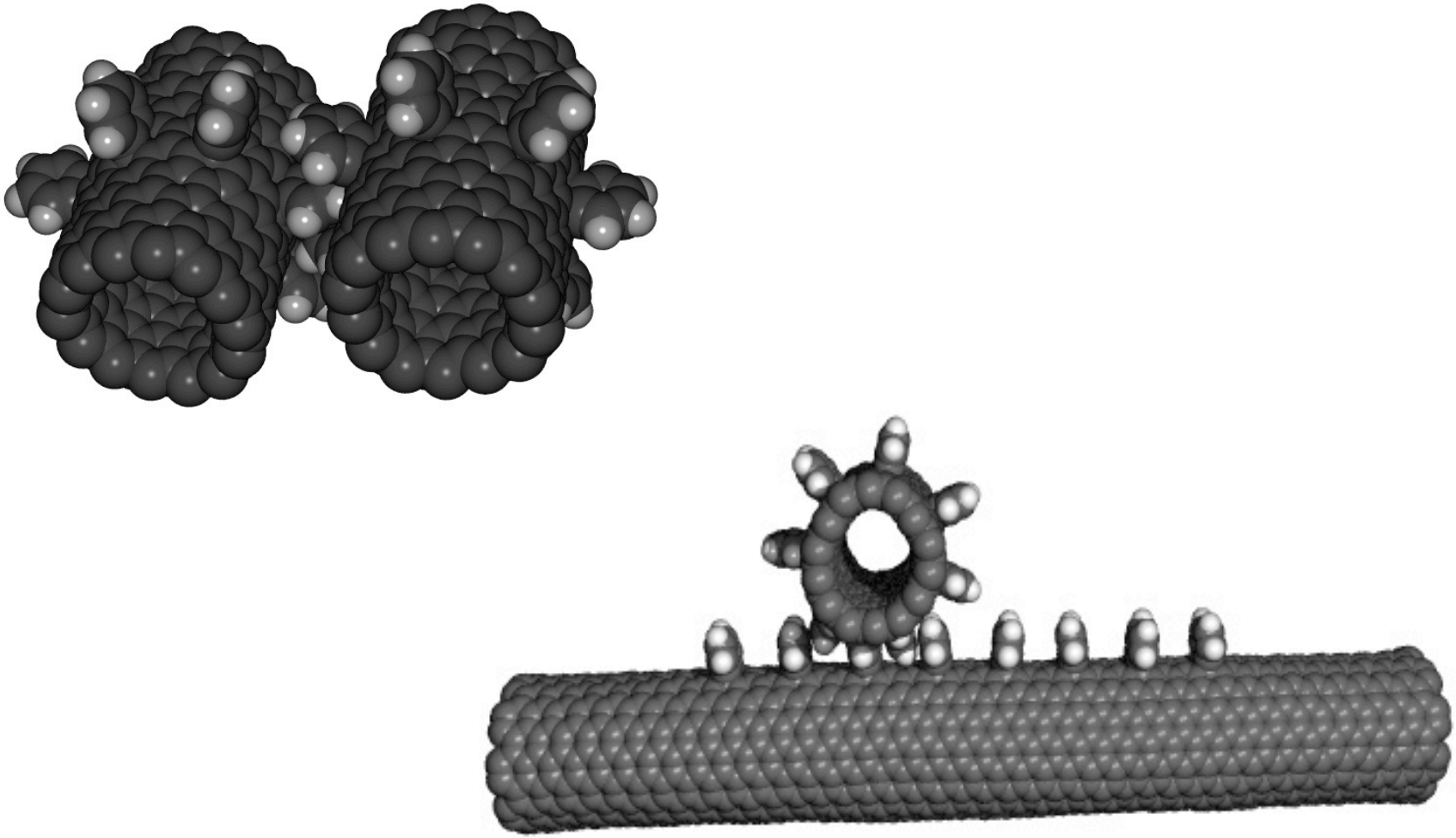


Transistor a nanotubi



- piu’ piccolo
- piu’ veloce
- meno materiale utilizzato

Bottom-up: assemblaggio di nanoingranaggi



Futuro dei processi top-down e bottom-up