

Caratterizzazione avanzata Superfici e sistemi Nanostrutturati

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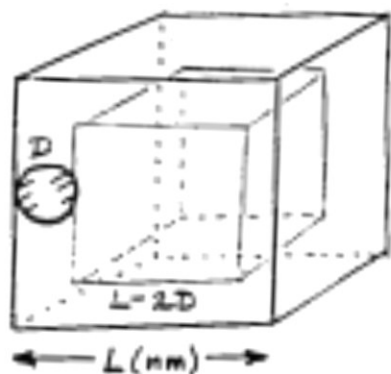
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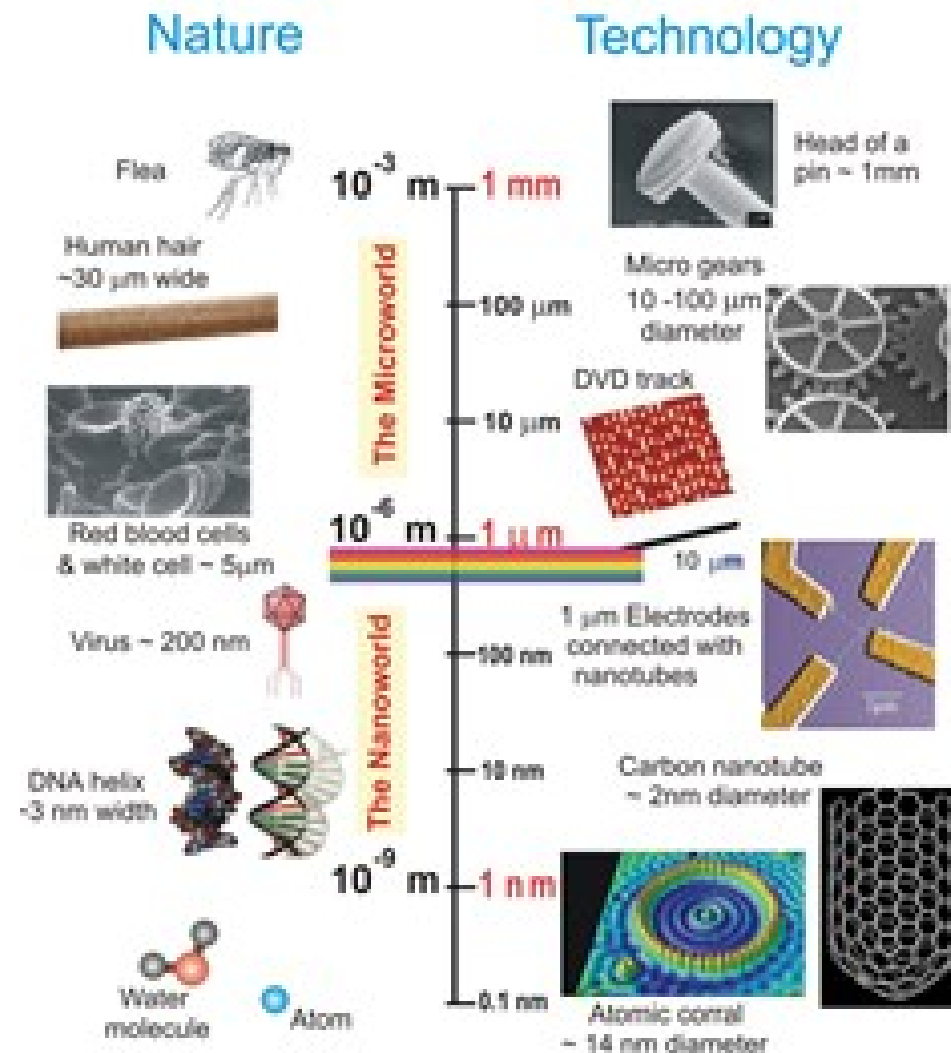
Perché studiare le superfici?

FRACTION OF ATOMS ON THE SURFACE OF A CUBE: $D = \text{ATOMIC DIAM.} = 0.2 \text{ nm} = 2 \text{ \AA}$

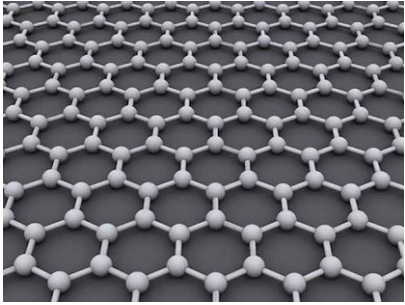


$$\text{SURFACE FRACTION} = \frac{L^3 - (L - 2D)^3}{L^3}$$

L	FRACTION
$1 \mu\text{m} = 1000 \text{ nm}$	$0.002 = 0.1\%$
$0.1 \mu\text{m} = 100 \text{ nm}$	$0.012 = 1.2\%$
$0.01 \mu\text{m} = 10 \text{ nm}$	$0.115 = 11.5\%$
$0.001 \mu\text{m} = 1 \text{ nm}$	$0.784 = 78.4\%$



Materiali 2D Monoatomici



Grafene

Silicene

Germanene

Stanene

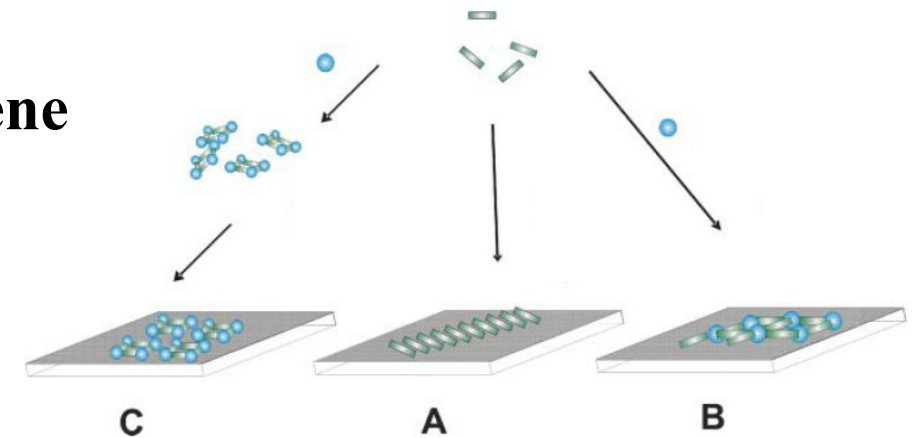
Plumbene

					helium 2 He 4.0026
		nitrogen 7 N	oxygen 8 O	fluorine 9 F	neon 10 Ne
			15.999 zolfo 16 S	18.998 cloro 17 Cl	20.180 argon 18 Ar
			32.065 selenio 34 Se	35.453 bromo 35 Br	39.948 cripton 36 Kr
			74.922 antimonio 51 Sb	78.96 tellurio 52 Te	83.80 xenone 54 Xe
			121.76 bismuto 83 Bi	127.60 polonio 84 Po	131.29 astatino 85 At
			208.98 [209]	210 [210]	222 [222]
26.982 gallio 31 Ga					
69.723 indio 49 In					
114.82 tallio 81 Tl					
204.38					

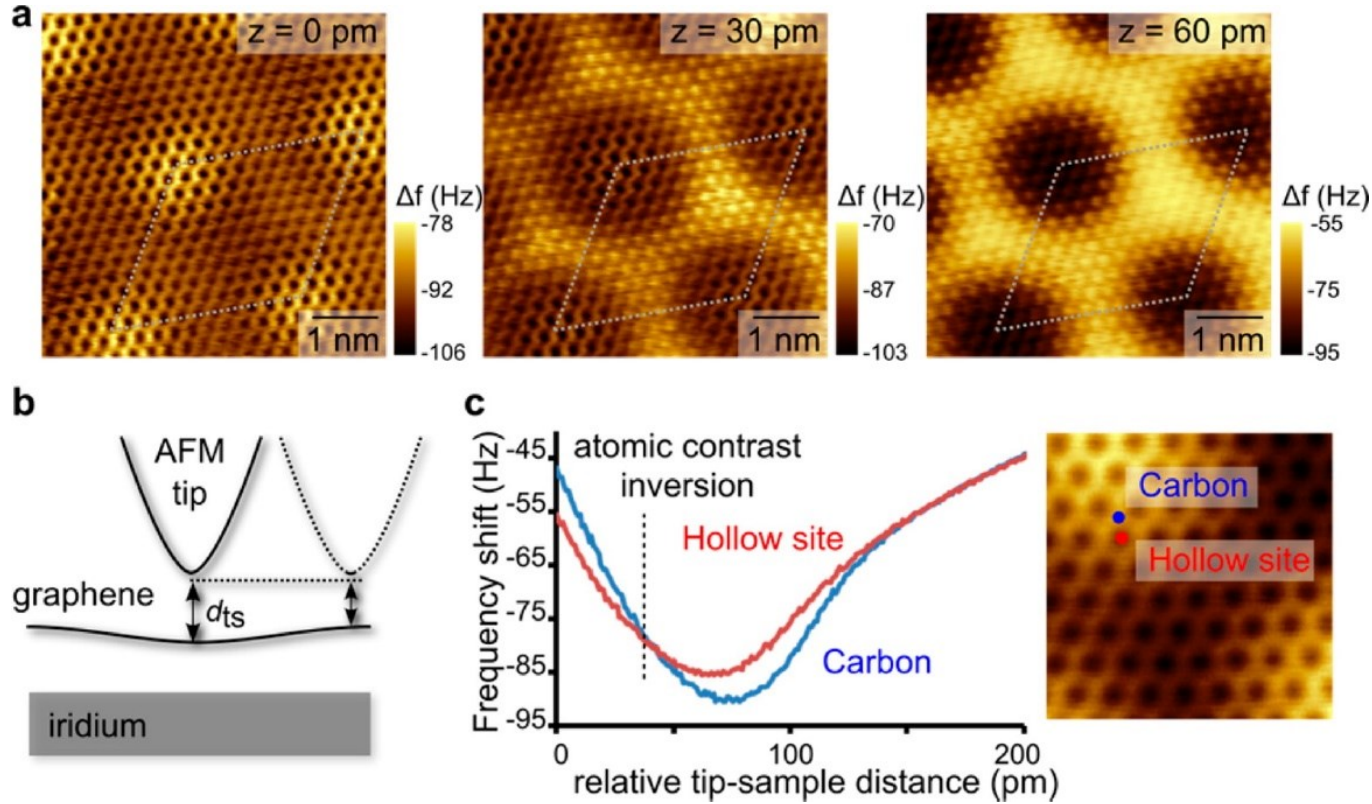
Borofene

Fosforene

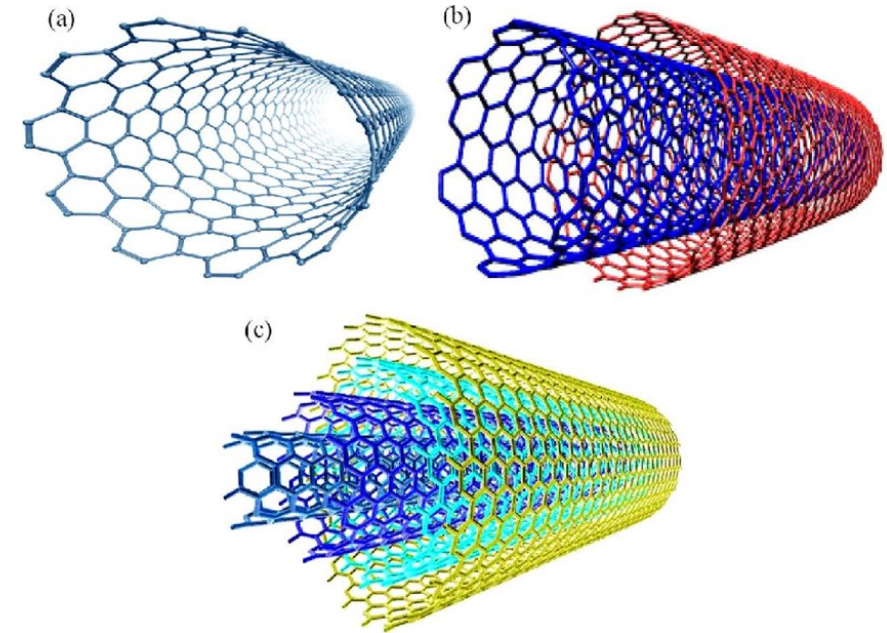
**Crescita pilotata
dalla superficie**

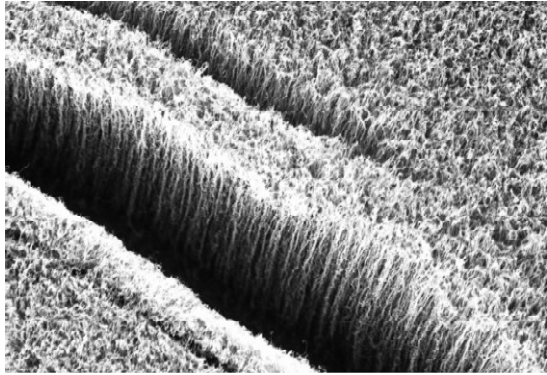


Crescita di Grafene epitassiale su Ir(111) Ultra Alto Vuoto + Alte Temperature 1500 K +AFM

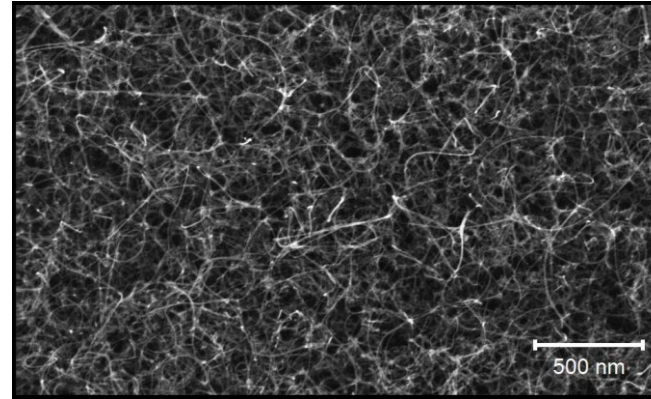


Grafene arrotolato -> nanotubo





100 nm

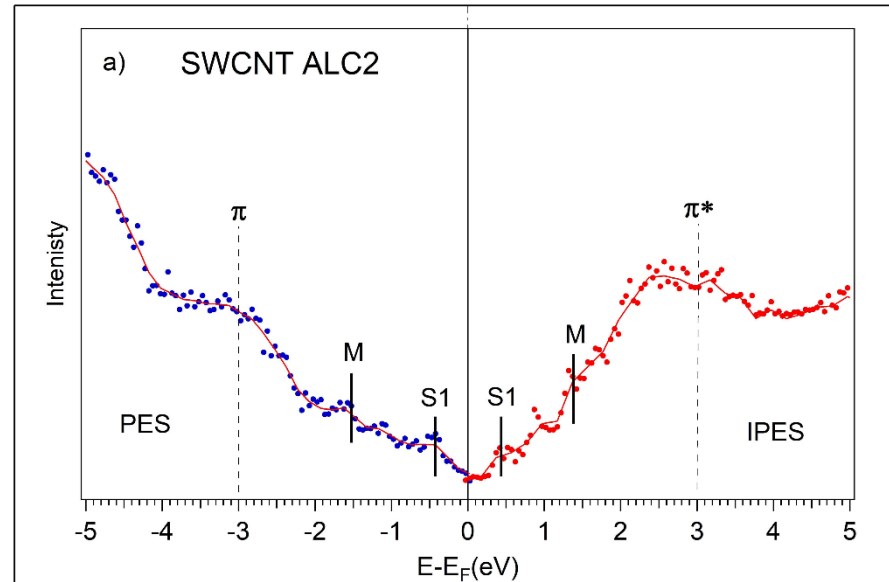
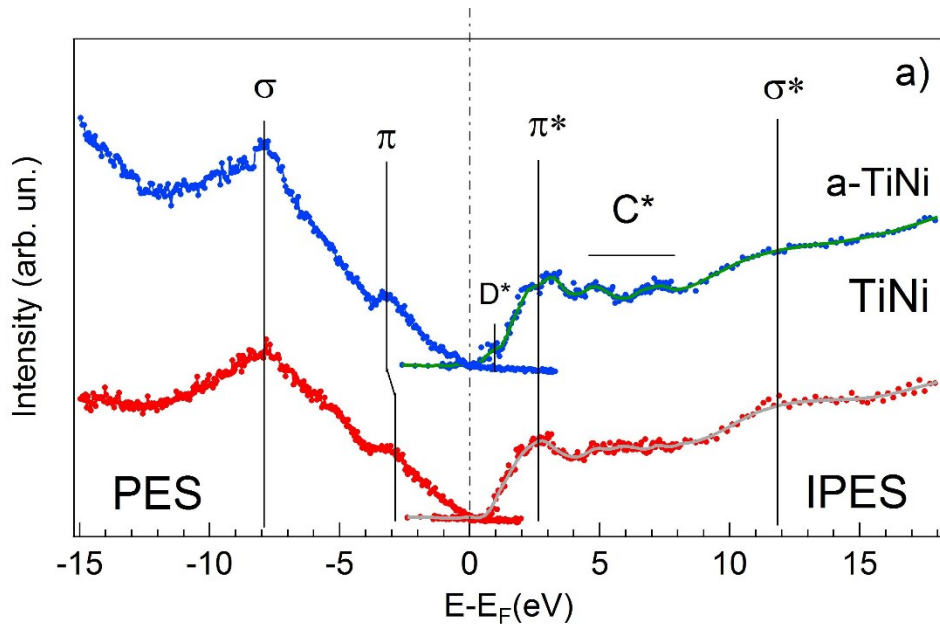


500 nm

Nanotubi di Carbonio

Applicazioni

- **Elettronica molecolare**
- **Fibre e tessuti**
- **Biomedicina**
- **Filtrazione di aria e acqua**
- **Catalisi**
- **FET**
- **Batterie alta efficienza**
- **Optoelettronica**
- **Sensori**

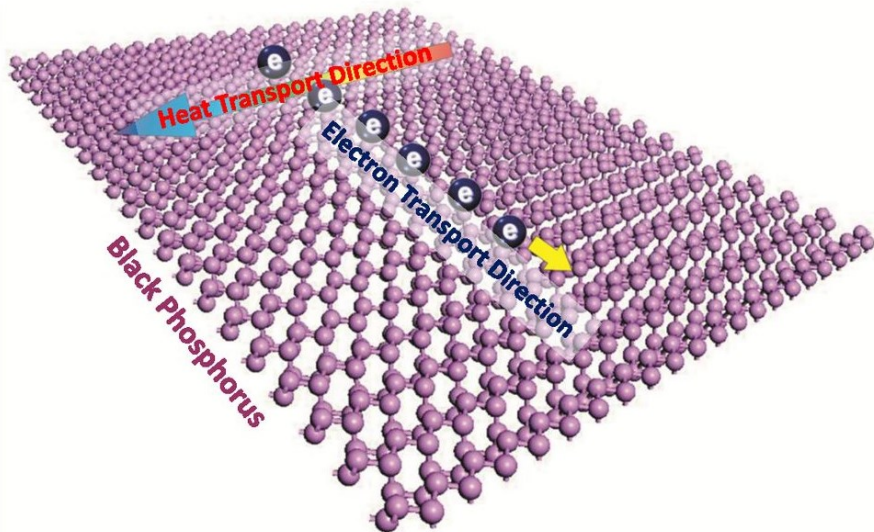


Combinazione PES-IPES

Fosforene

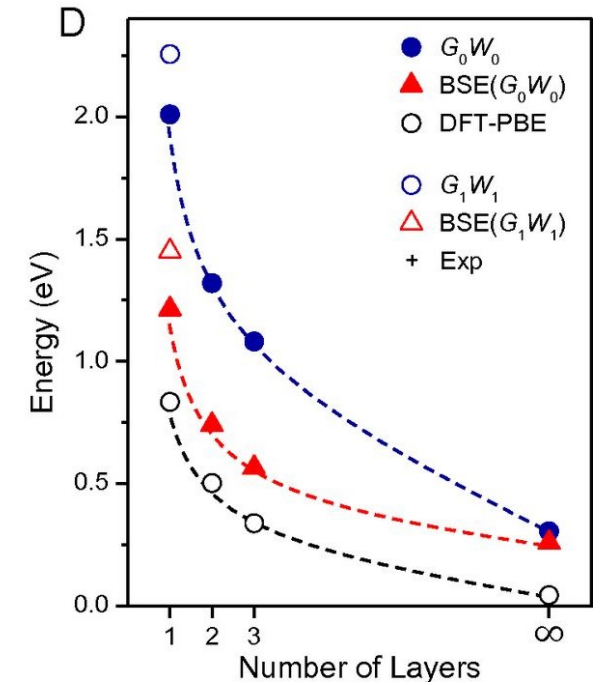
Fosforo Nero:

- Gap dipende dal numero di strati
- Anisotropia in piano delle proprietà di trasporto del calore e degli elettroni



Applicazioni

- Transistor FET
- Dispositivi Optoelettronici
- Celle Solari
- Fotocatalisi
- H₂ da Water Splitting
- Batterie a ioni di Li
- Sensori



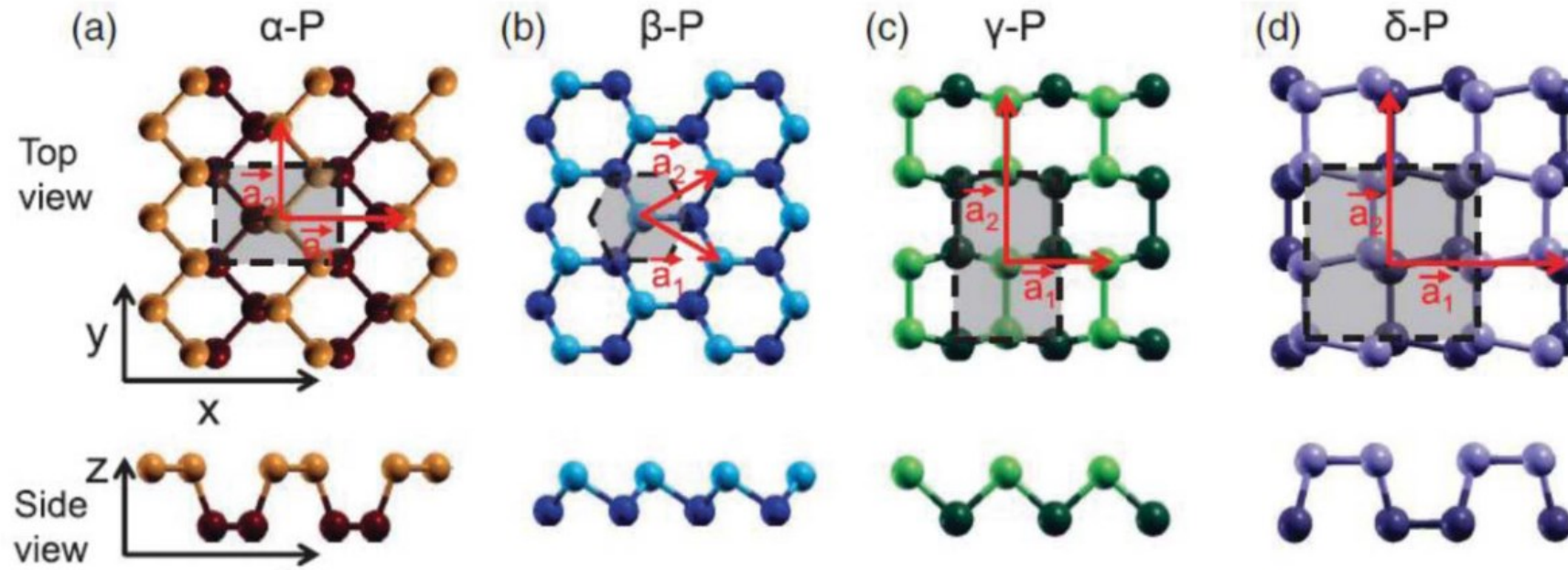
Monostrato: diverse strutture possibili

Black

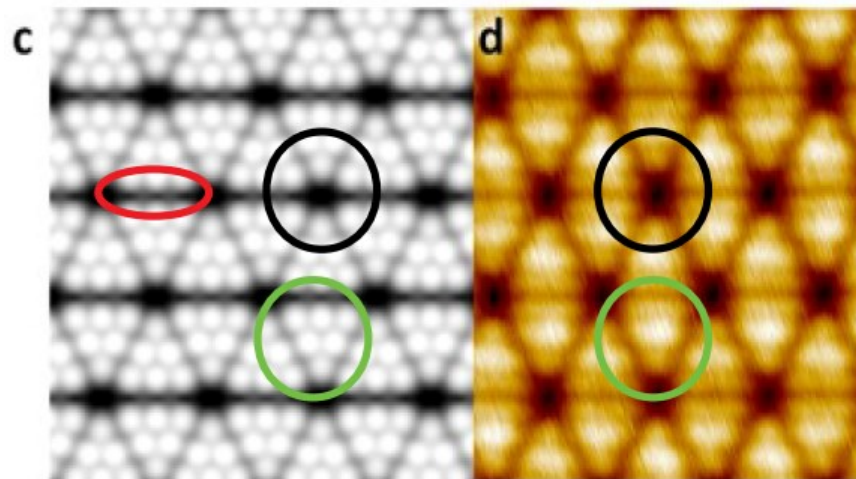
Blue

Green

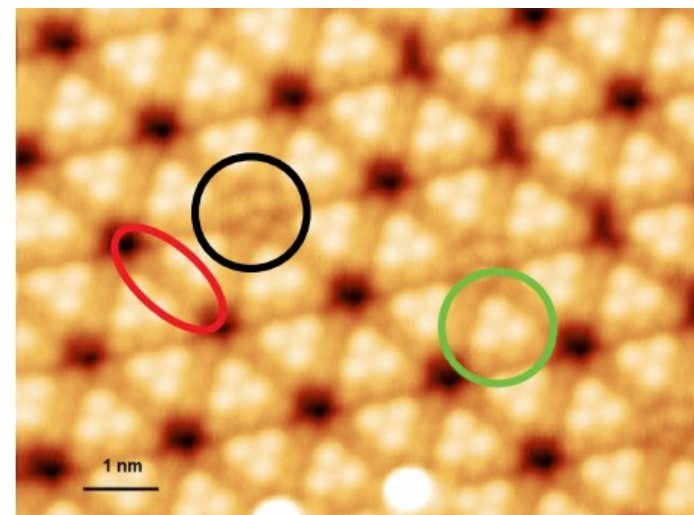
Purple



Fosforo Blu cresciuto su Au(111)

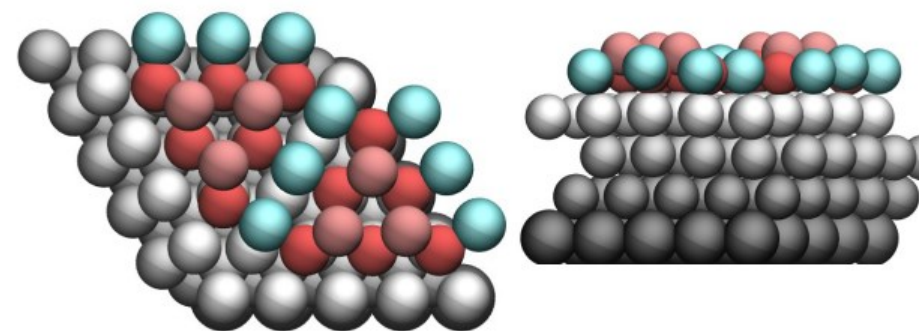
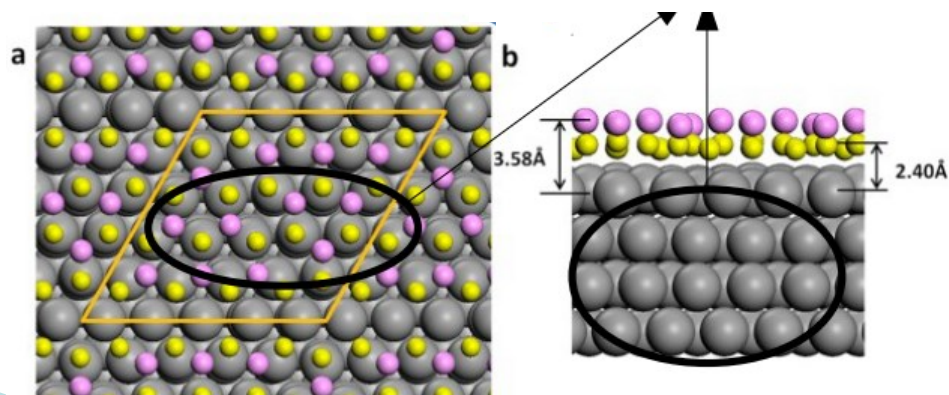


[1] J.L. Zhang et al., Epitaxial Growth of Single Layer Blue Phosphorus: A New Phase of Two-Dimensional Phosphorus, Nano Lett. 16, 4903-4908 (2016)



Our expSTM image - $P_{16} \times 2$ model

Struttura non stabile



A. Sala @ IOM TS
M. Peressi S. Dal Pupo @UniTS

Porfirina, molecola metallorganica -> semiconduttori organici

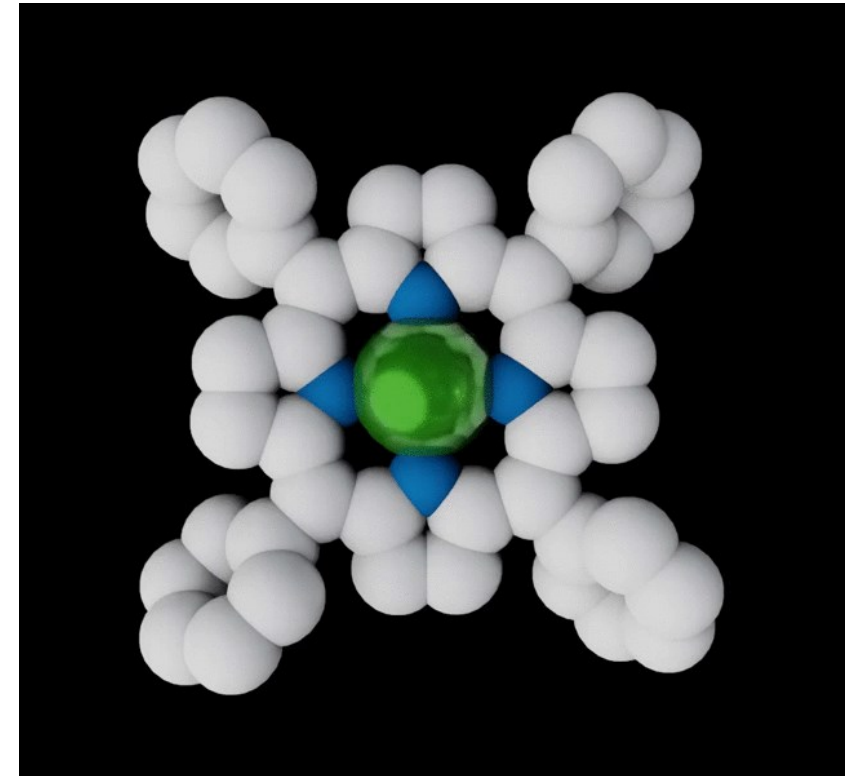
Funzionalizzabile mediante diversi ligandi

Metallo al centro: Cu, Zn, Ni, Fe, Pd,

Applicazioni:

- Celle Solari
- Dispositivi elettronici a basso consumo
- Transistor molecolari
- Spintronica
- H₂ da Water Splitting
- Sensori
- Quantum Computing
- Terapie anti tumorali

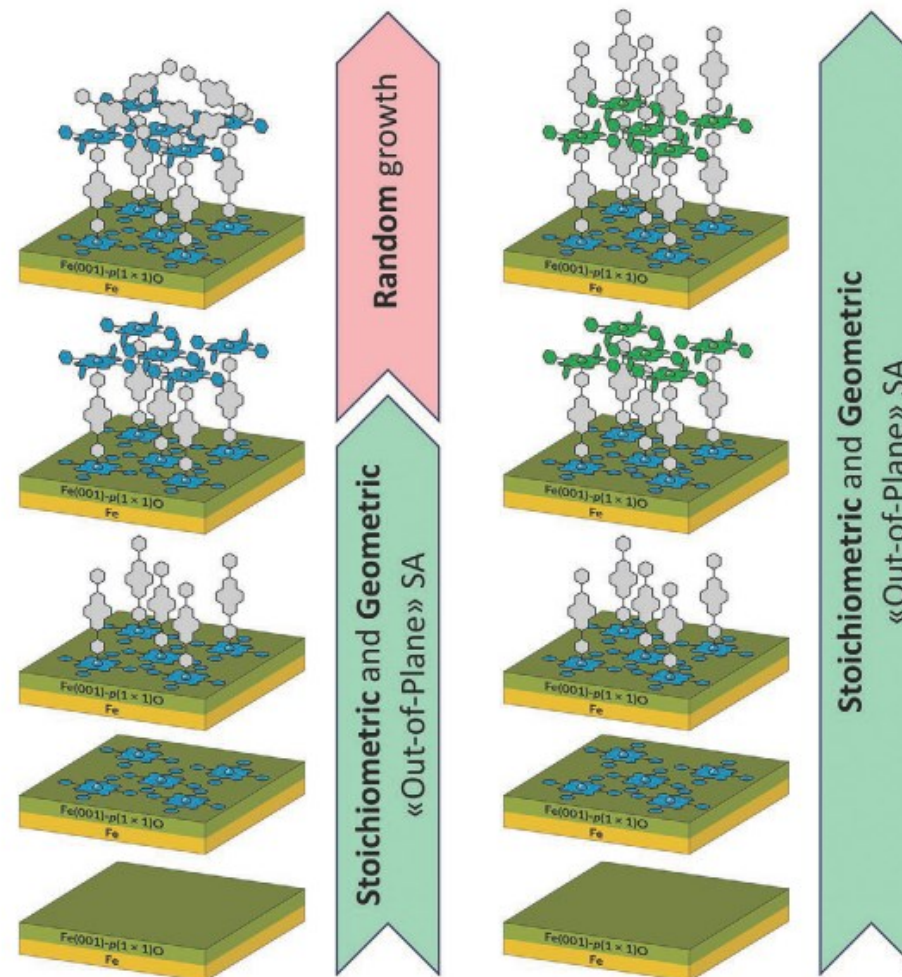
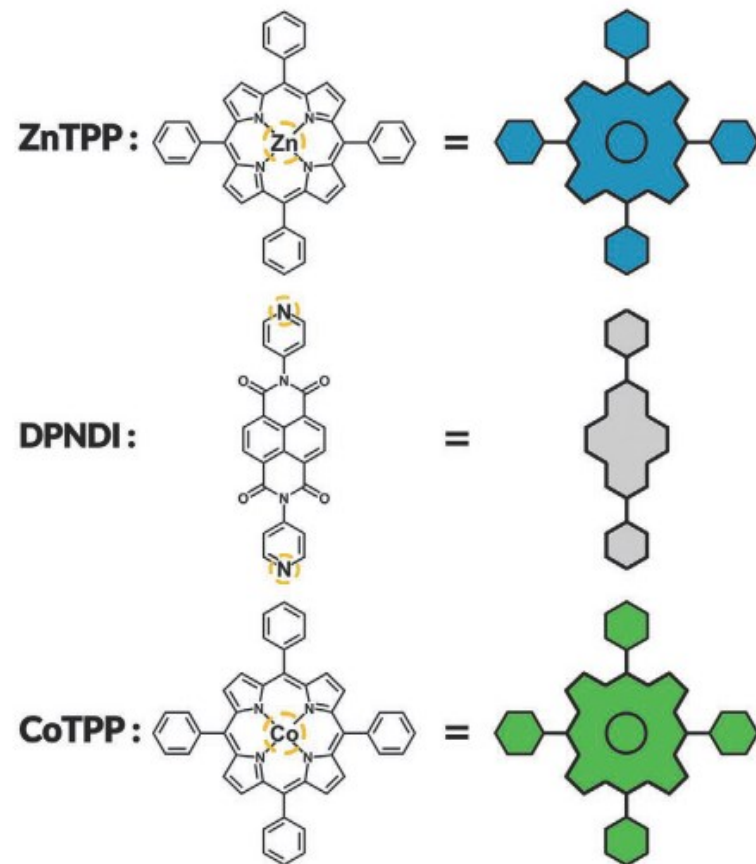
1.5 nm



Presente nei sistemi biologici fondamentali
Emoglobina, Clorofilla, F430,...

Autoassemblamento in 3D

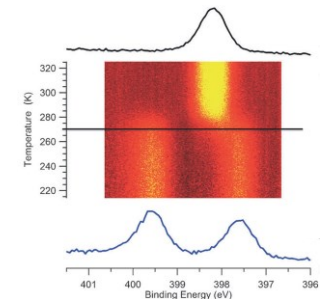
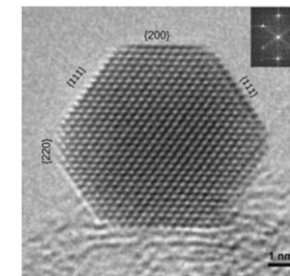
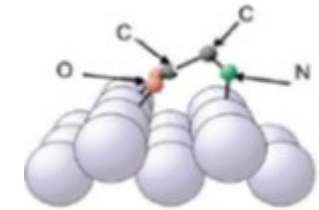
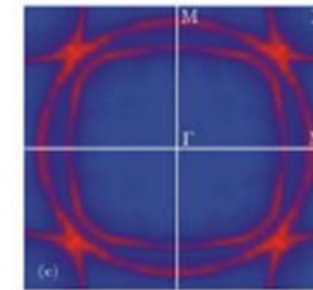
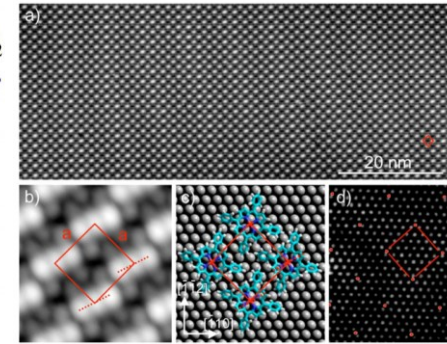
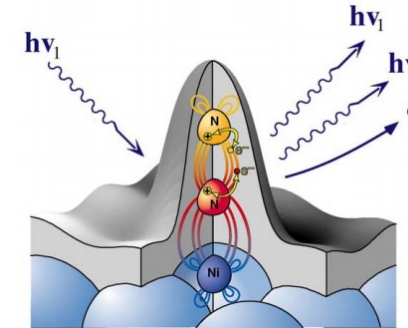
coordination site 



A. Bossi, A. Orbelli Biroli @CNR-SCITEC MI
G. Bussetti et al. @Polimi
L. Floreano, L. Schio @CNR-IOM TS
Adv. Funct. Mater. 2021, 31, 2011008

Laboratorio Congiunto Superfici e Nanostrutture CNR-IOM Dipartimento di Fisica e Geologia (dr. A. Verdini, dr.ssa M. Pedio, prof. G. Carlotti)

- Tecniche e materiali per il vuoto e l'ultra alto vuoto
- Spettroscopie elettroniche
- Microscopia con risoluzione subnanometrica
- Criogenia
- Caratterizzazione fine (subatomico/ps) con sincrotroni/FEL
- Crescita film ultrasottili (monostrato, multistrato,...)
- Nanoarchitetture
- Analisi dati/modellizzazione
- Formazione/training
- Progettazione strumentazione
- Sviluppo di software per acquisizione e analisi dati e modellizzazione
- Dottorato PON e Industriale
- Attività di servizio per imprese (SME)



Grazie per la attenzione