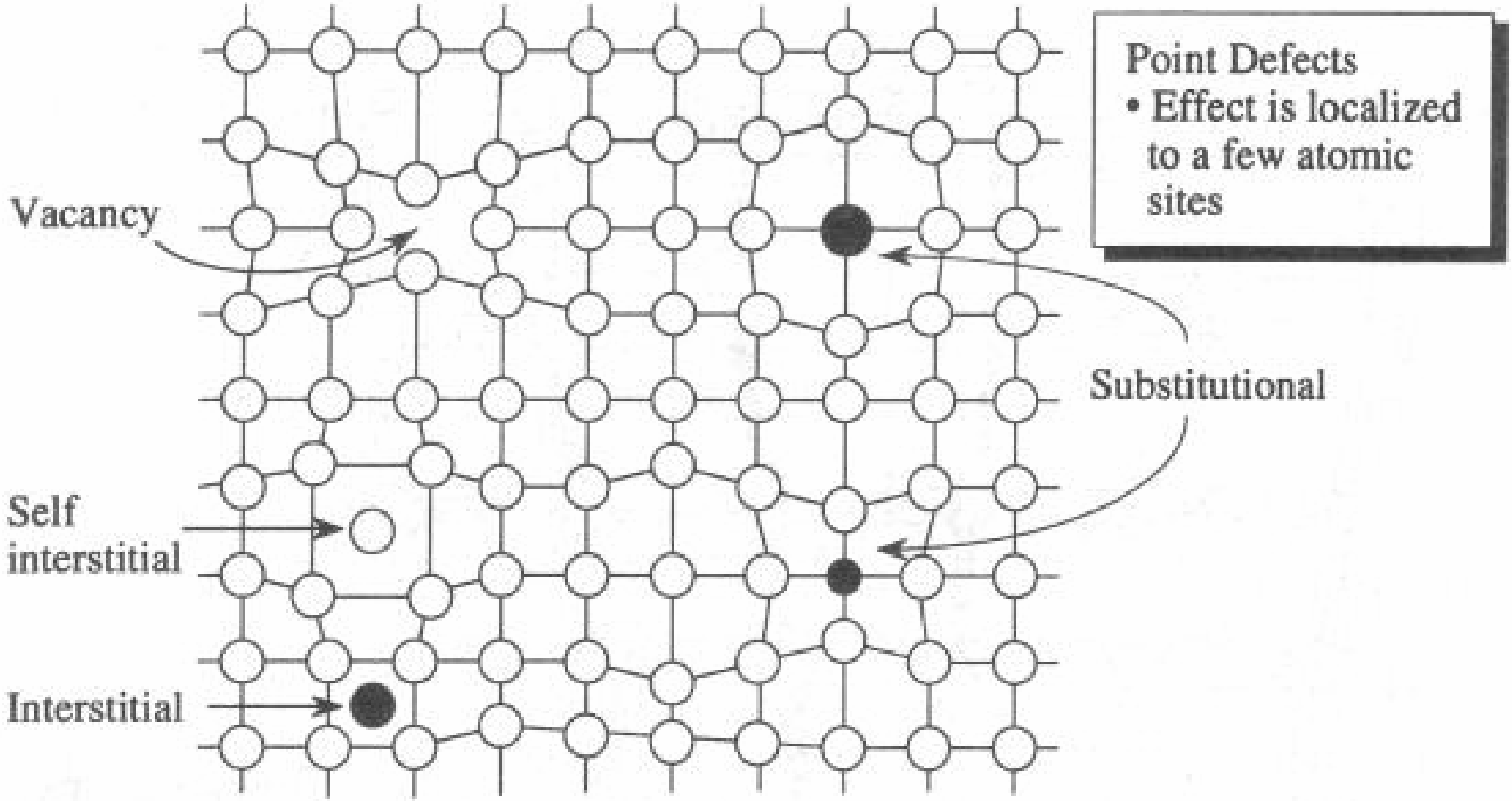
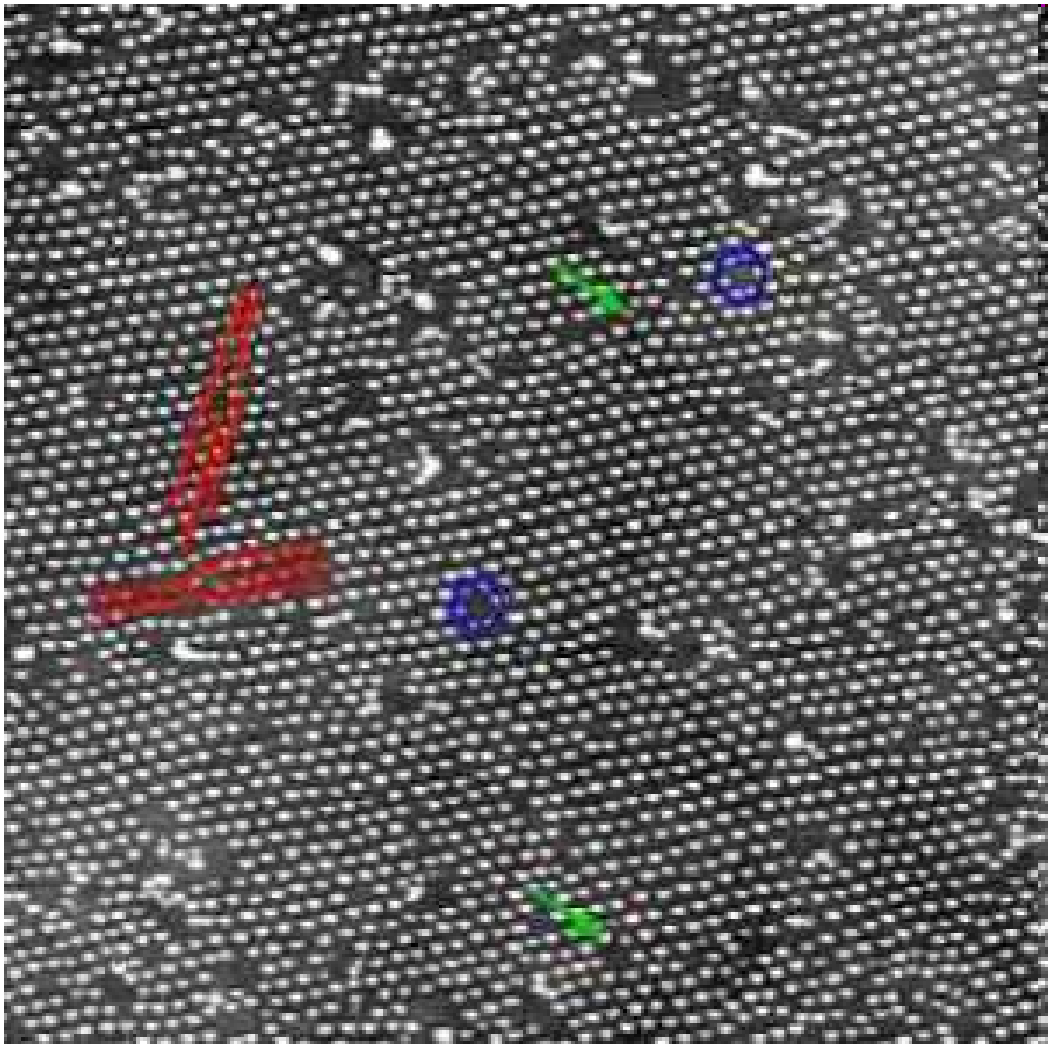
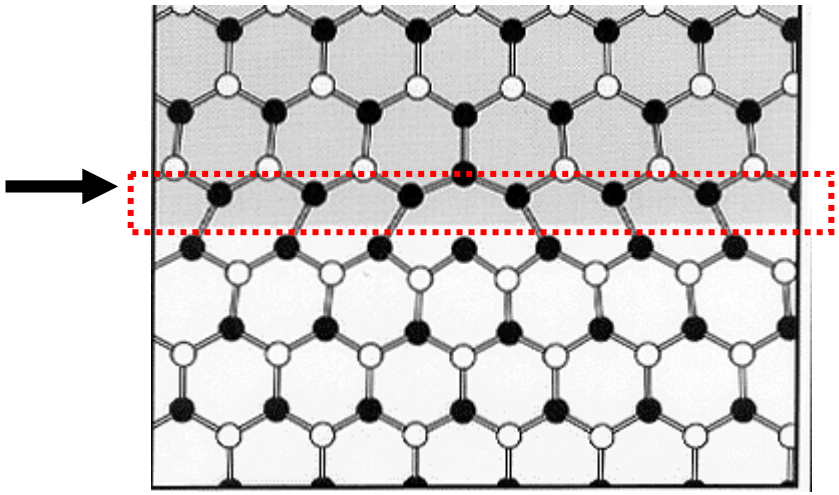
Difetti di punto

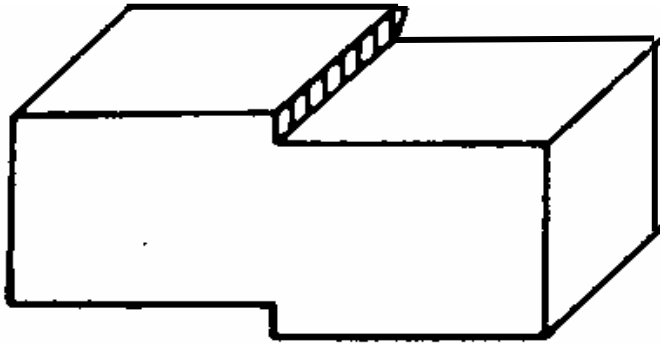


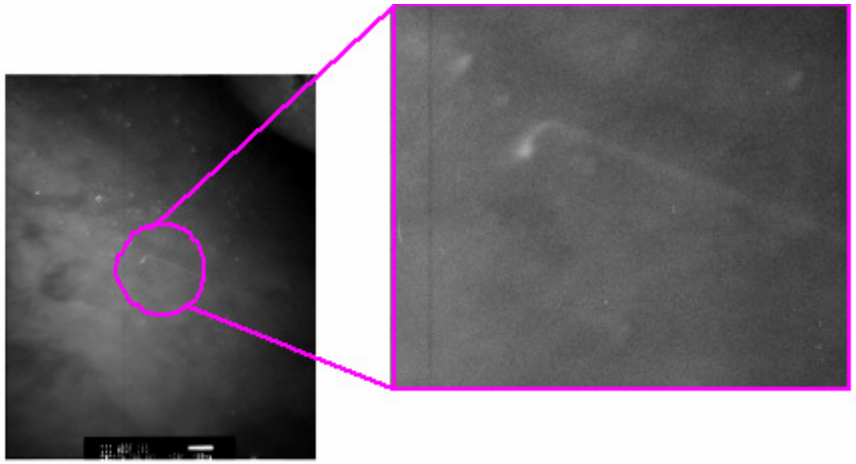


AFM image of the last PbSe layer of a 60-period PbSe/PbEuTe superlattice grown by MBE. The tensily strained PbSe layers relax via Stranski-Krastanow growth mode. The strain fields in the PbEuTe spacer layers induced by the PbSe islands lead to a nearly perfect hexagonal lateral ordering, disrupted only by point defects, such as vacancies (blue), dots at interstitional positions (green), or by additionally inserted dot rows ("dislocations", red).

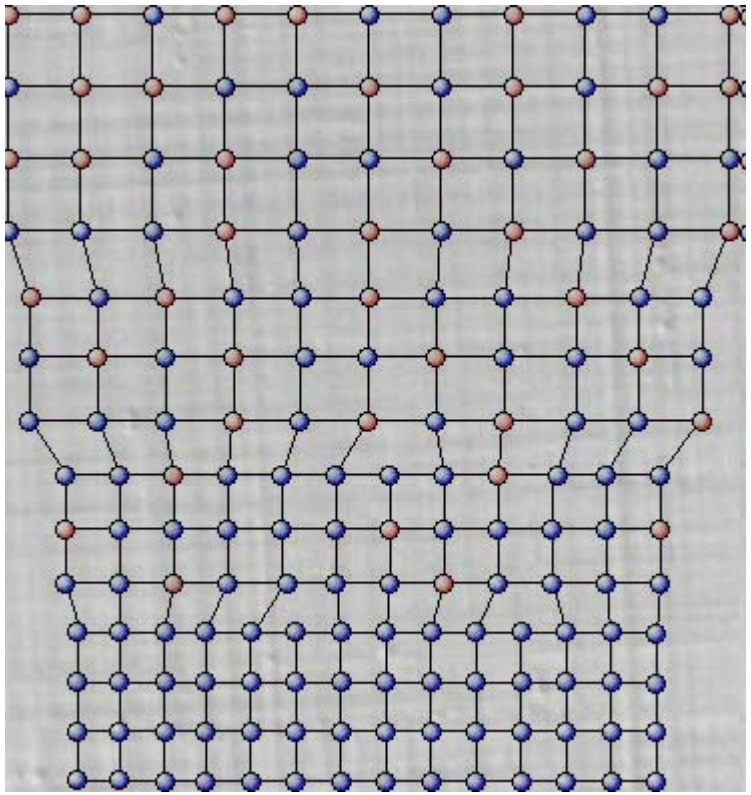
Difetti di linea (dislocazioni)



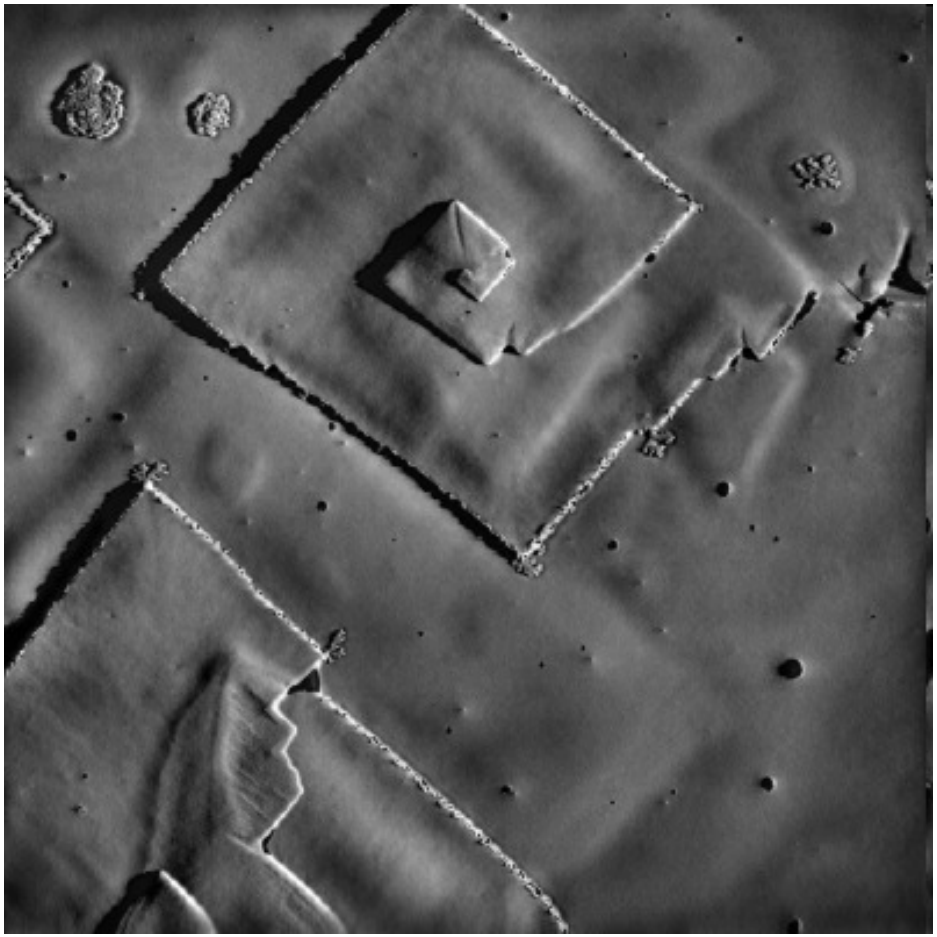


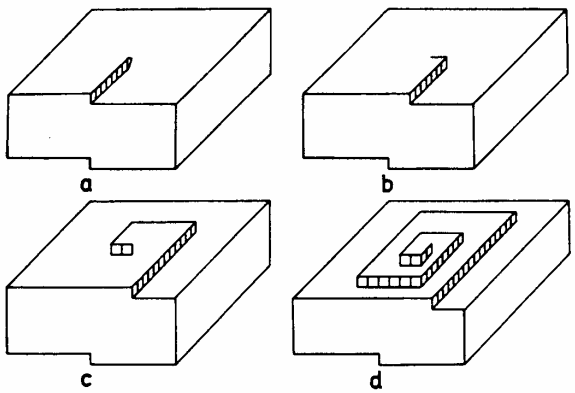


Misfit dislocations

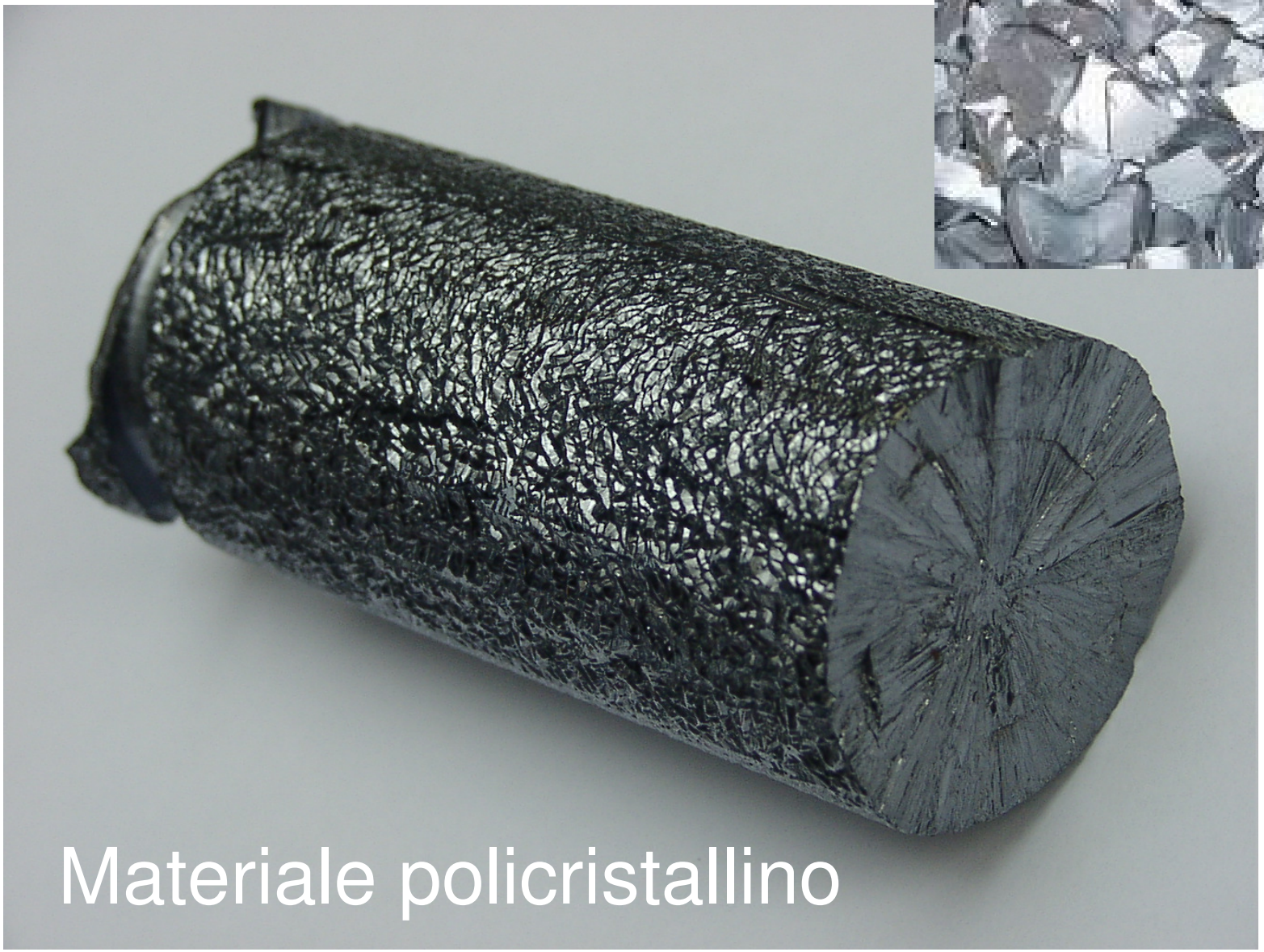


Difetti di linea (screw dislocations)

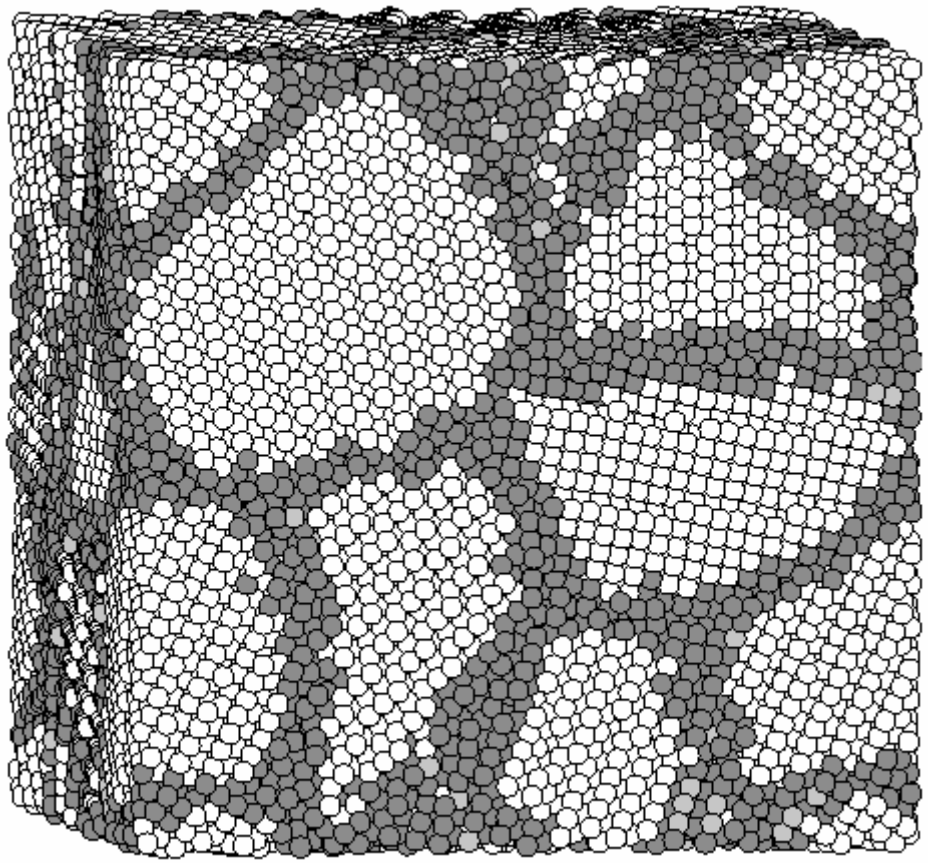




Difetti di superficie



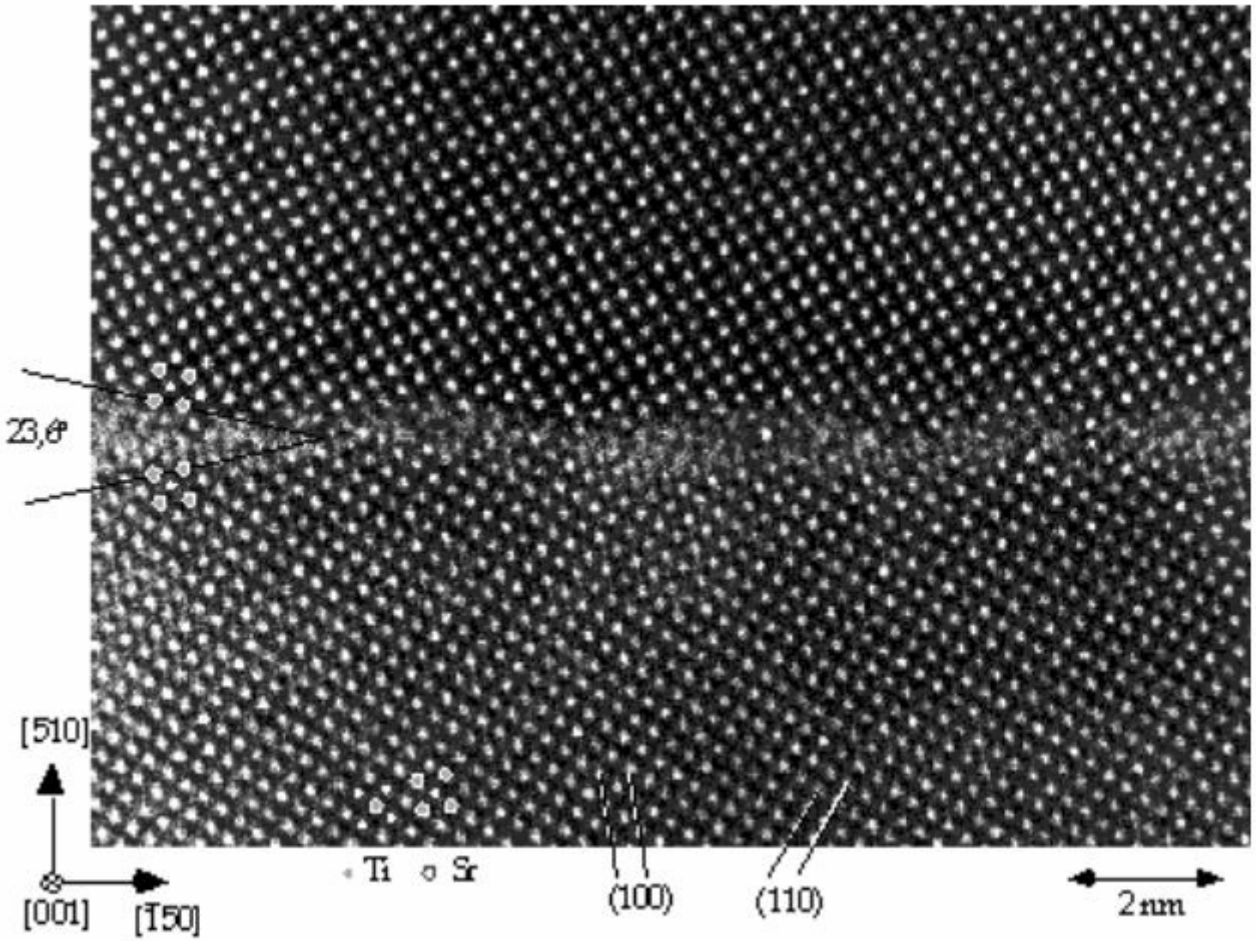
Difetti di superficie



Materiale policristallino

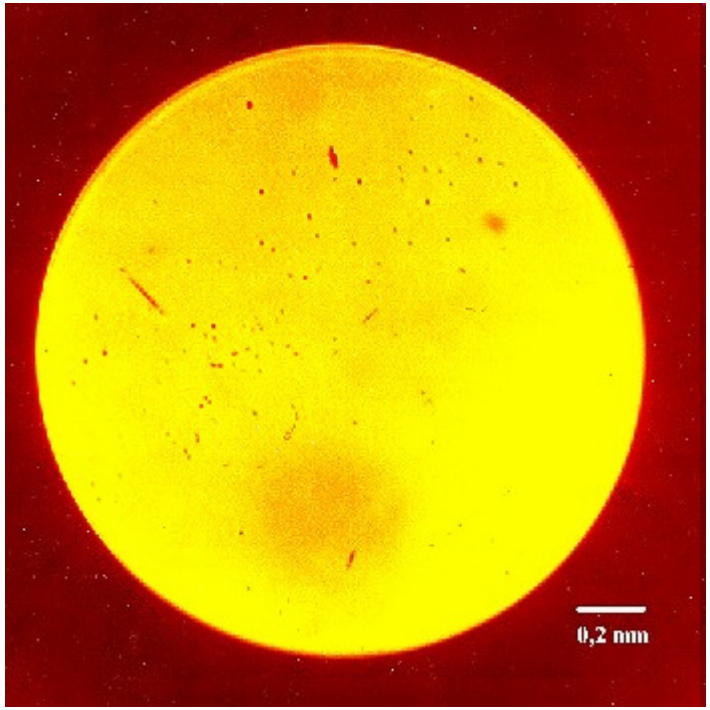
Bordi di grano

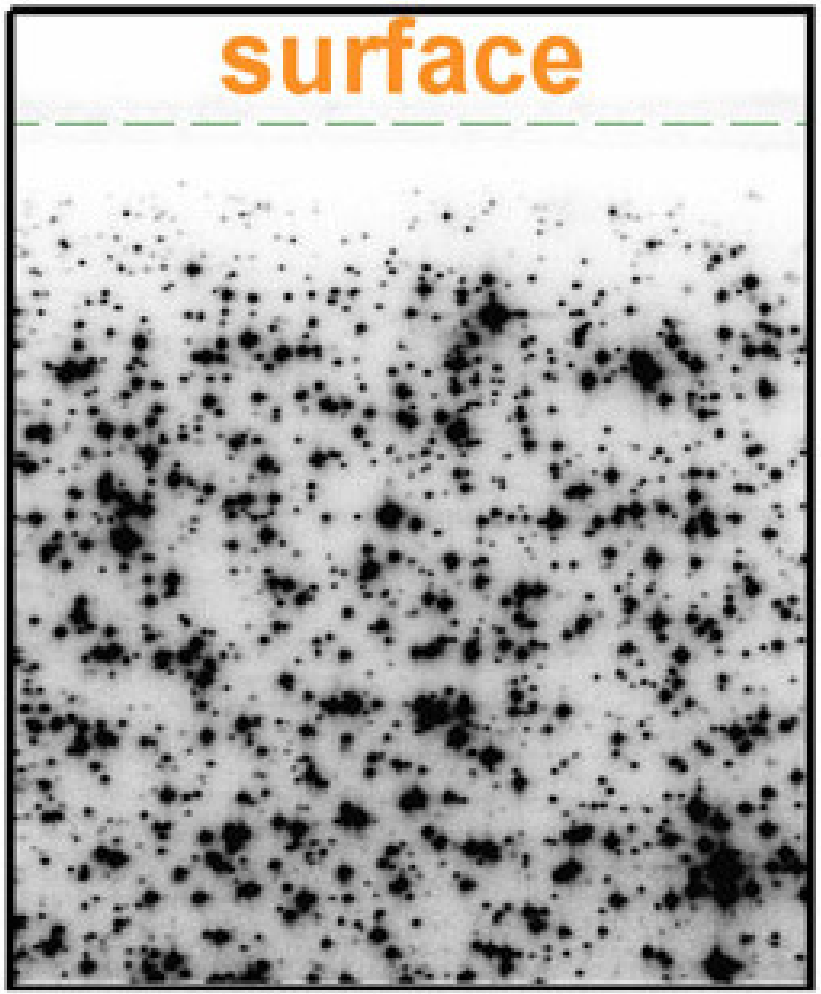
Difetti di superficie



Bordo
di grano

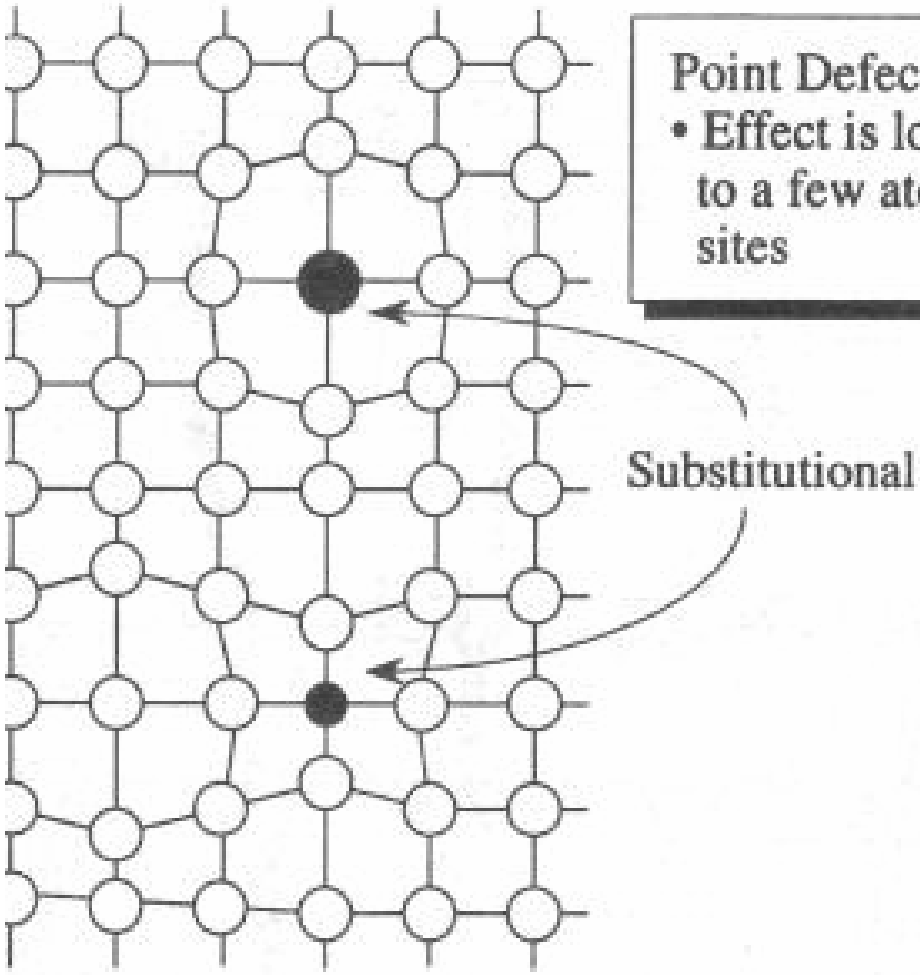
Difetti di Volume



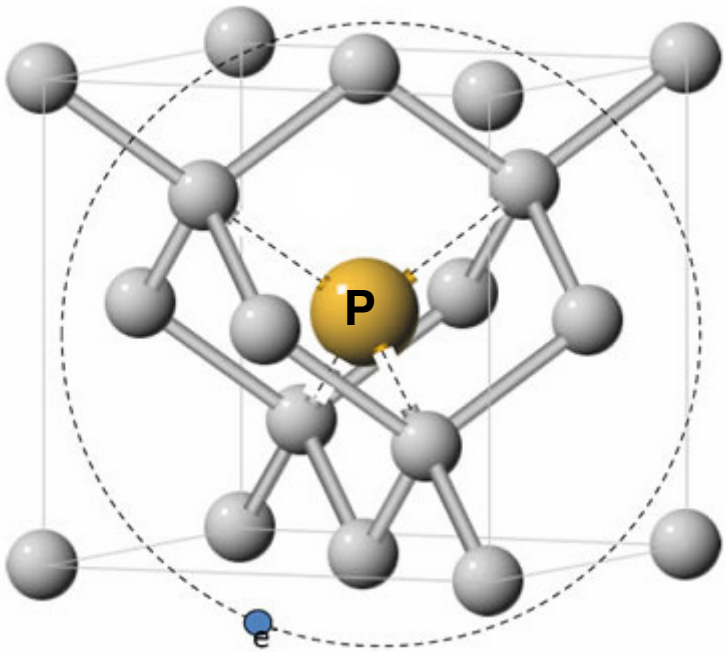


Precipitati (es. Ossigeno in Silicio)

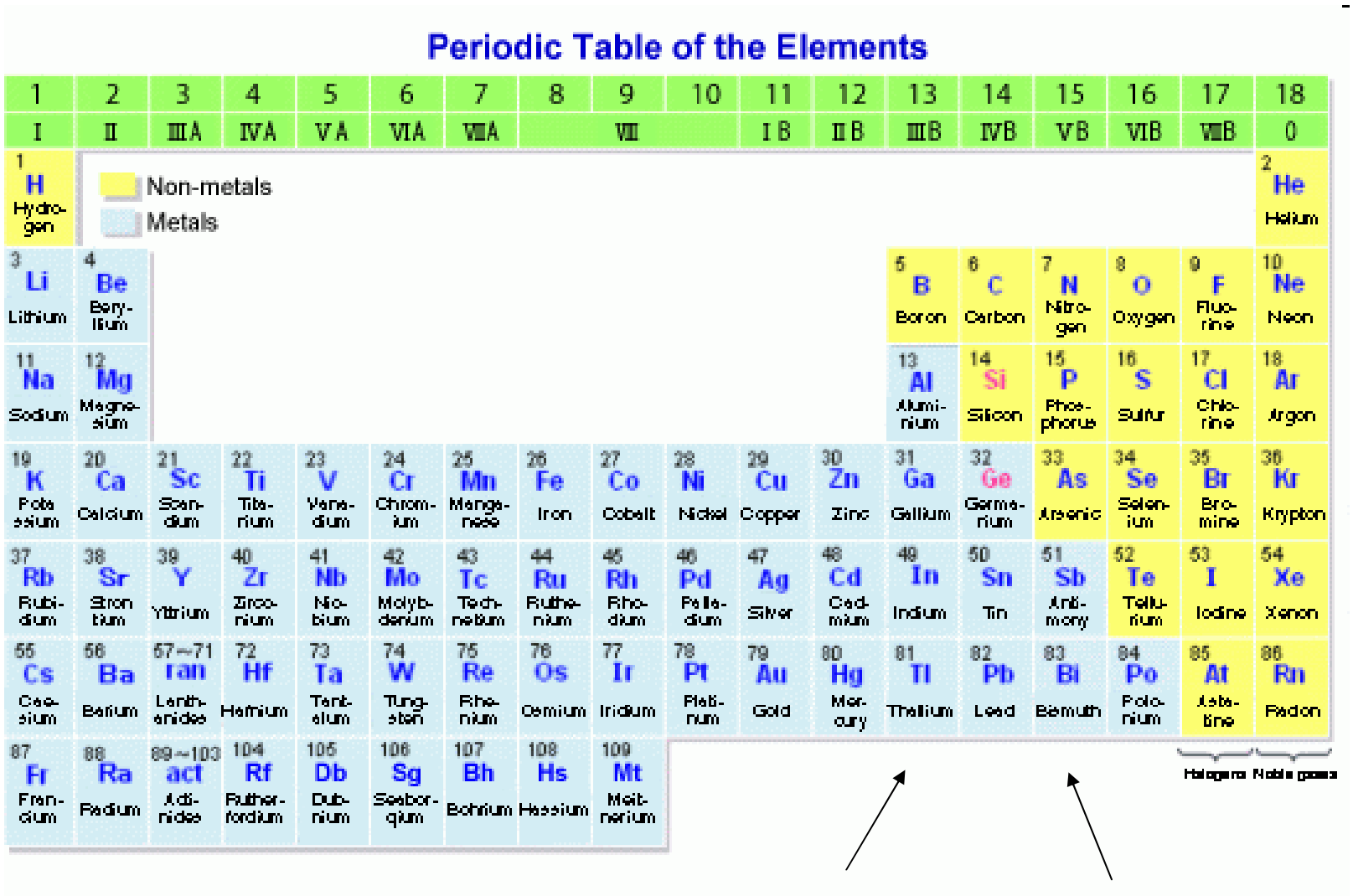
Difetti sostituzionali



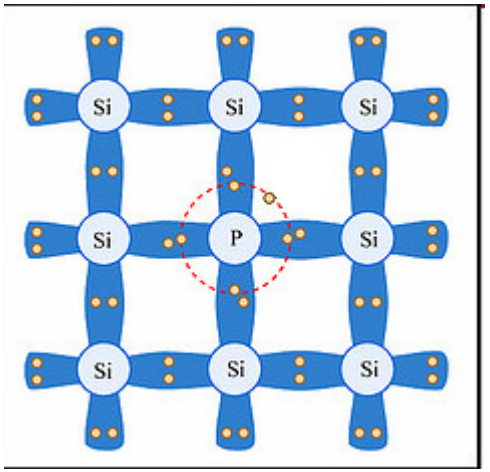
Impurezze sostituzionali non isovalenti

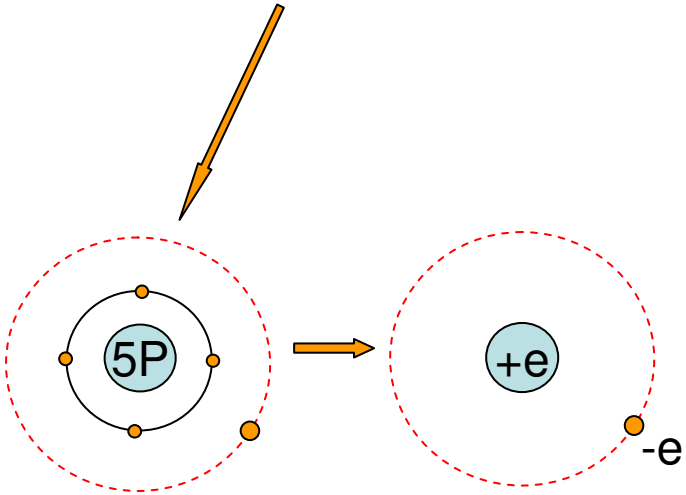


Impurezze sostituzionali non isovalenti



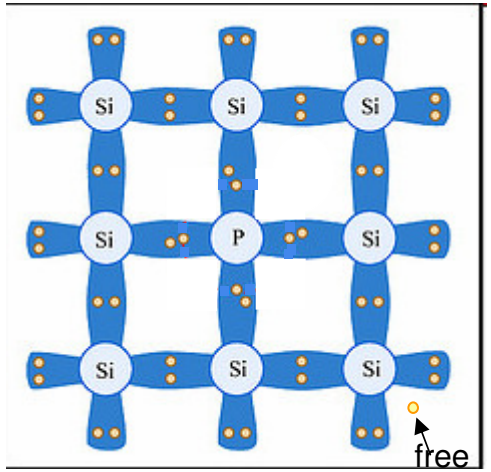
D^0

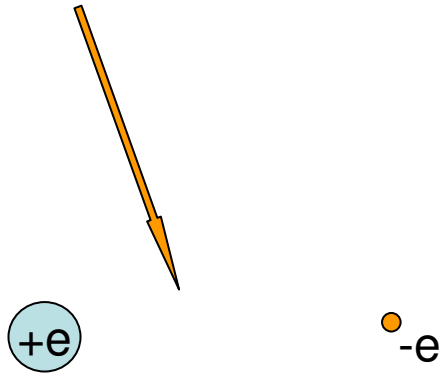




Atomo di idrogeno

D^+

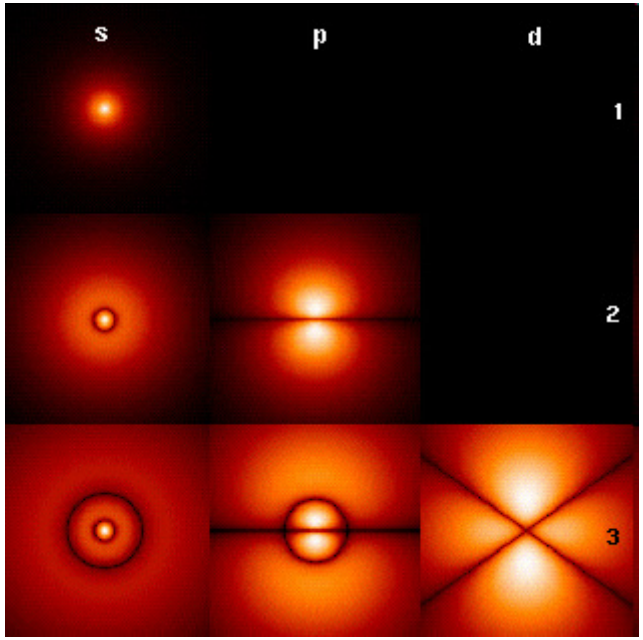


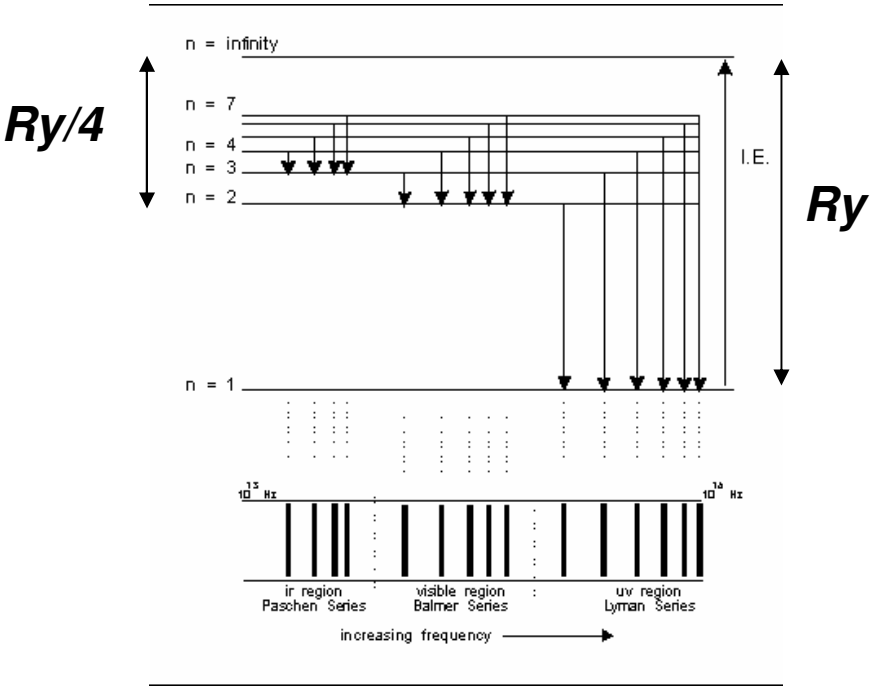


Atomo di idrogeno ionizzato

Atomo di idrogeno

$$E_{\text{total}} = \frac{-m_e e^4}{8\epsilon_0^2 h^2} \cdot \frac{1}{n^2}$$

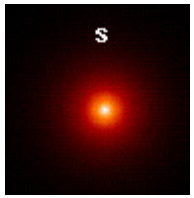


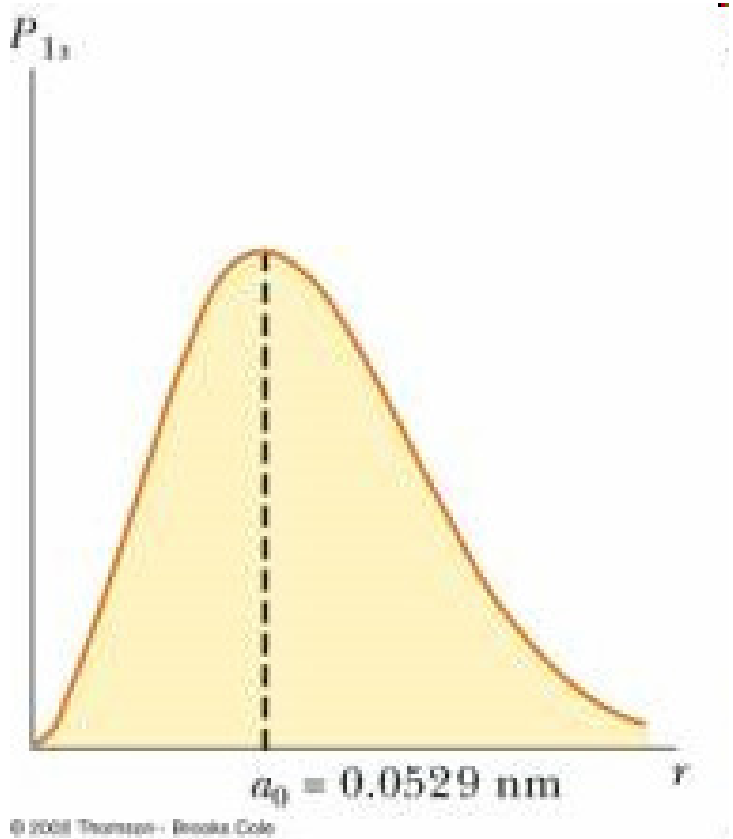


$$Ry = \frac{m_e e^4}{8\varepsilon_o^2 h^2} = 13.6056923(12)\ eV$$

Atomo di idrogeno

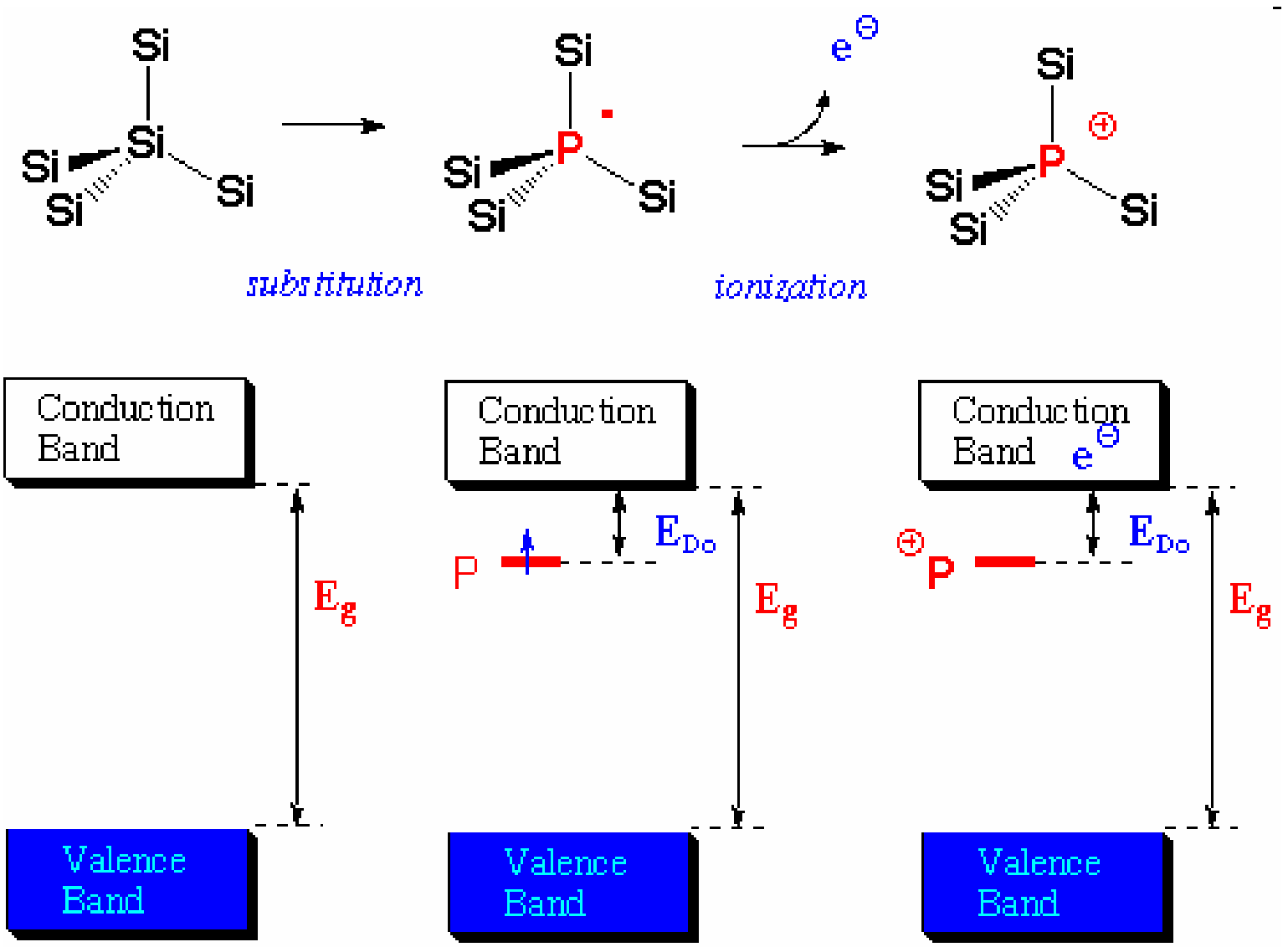
Nei semiconduttori consideriamo solo lo stato 1s





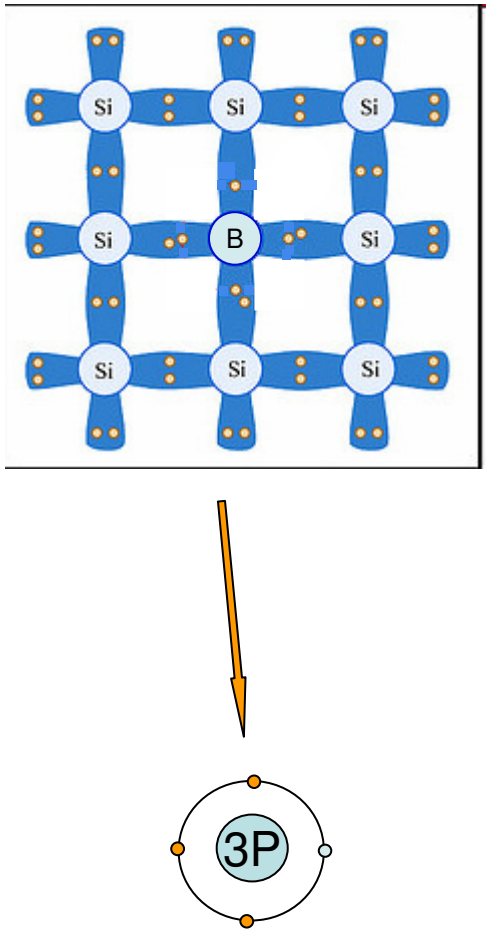
$$a_o = \frac{4\pi\varepsilon_o \hbar^2}{m_e e^2} \longrightarrow a_o^* = \frac{4\pi\varepsilon_o \varepsilon^* \hbar^2}{m_e^* e^2} = a_o \frac{\varepsilon^* m_e}{m_e^*}$$

$$Ry = \frac{m_e e^4}{8\varepsilon_o^2 h^2} \longrightarrow Ry^* = \frac{m_e^* e^4}{8(\varepsilon_o \varepsilon^*)^2 h^2} = Ry \frac{m_e^*}{m_e (\varepsilon^*)^2}$$

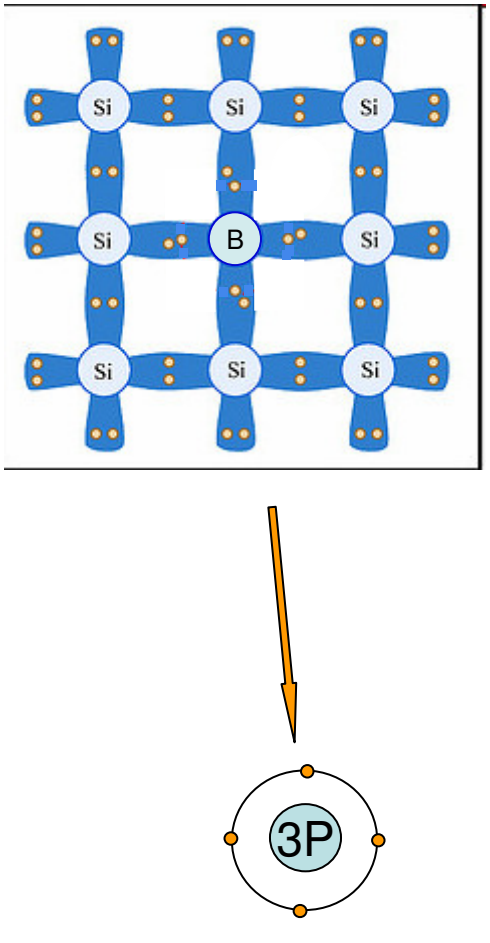


Si
Si
Si
Si
Si
Si
P
Si
Si
Si
e⊖
Si
P
⊕
Si
Si
Si
substitution
ionization
Conduction Band
Valence Band
Eg
Conduction Band
P
EDo
Eg
Valence Band
Conduction Band
e⊖
⊕P
EDo
Eg
Valence Band

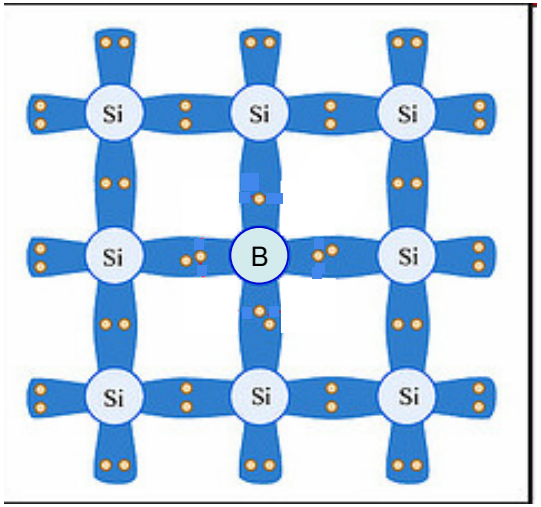
A^0



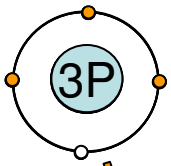
A^-

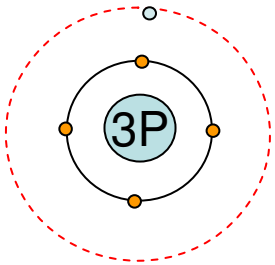


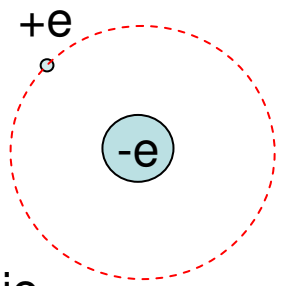
A^0



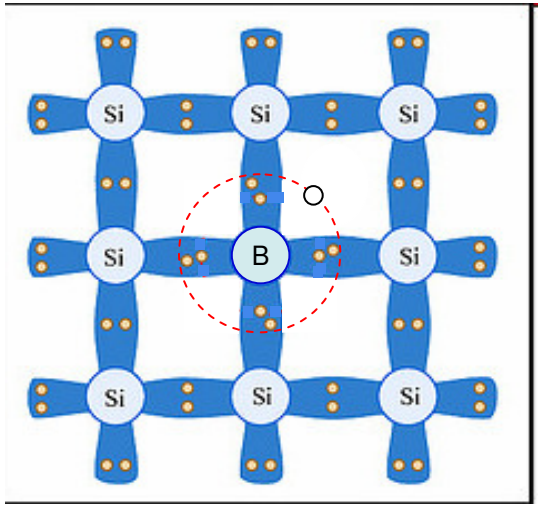
Stato vuoto localizzato intorno al Boro, ma non fisso.







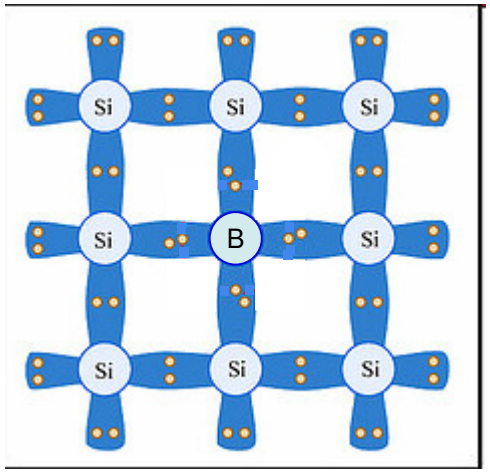
Linguaggio lacuna

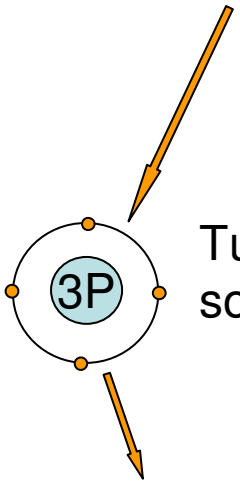


Atomo di antiidrogeno

$$Ry^* = \frac{m_h^* e^4}{8(\varepsilon_o \varepsilon^*)^2 h^2} = Ry \frac{m_h^*}{m_e (\varepsilon^*)^2}$$

A^-

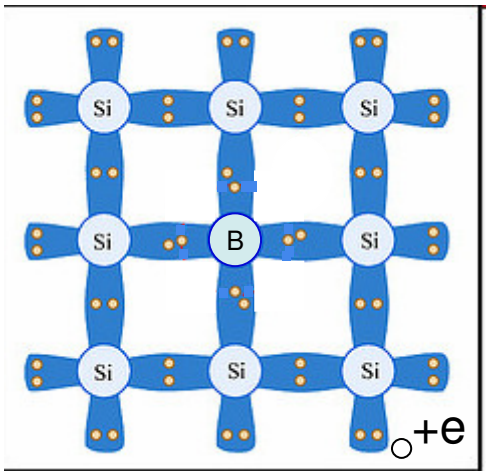




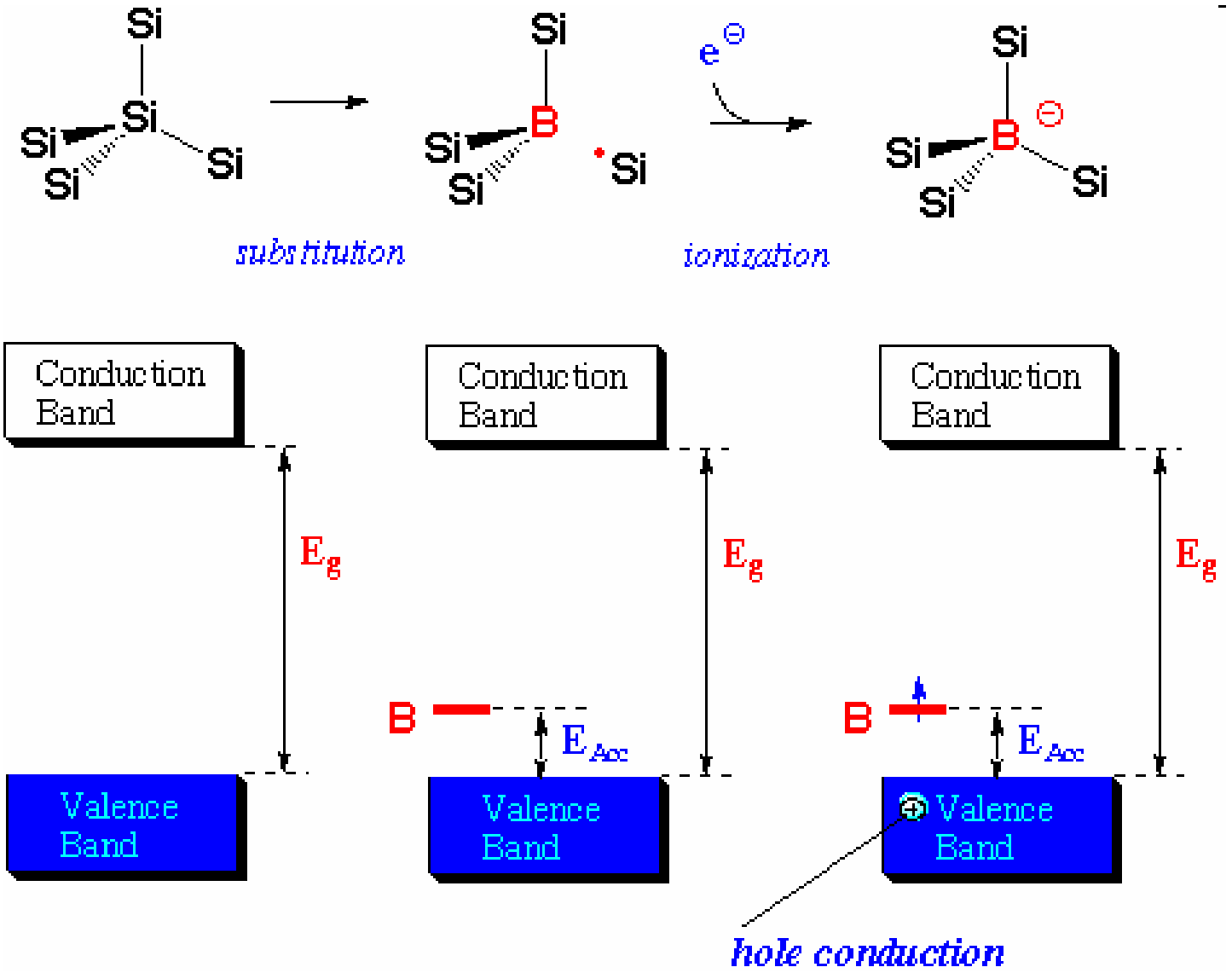
Tutti gli stati intorno al B sono pieni.

+e

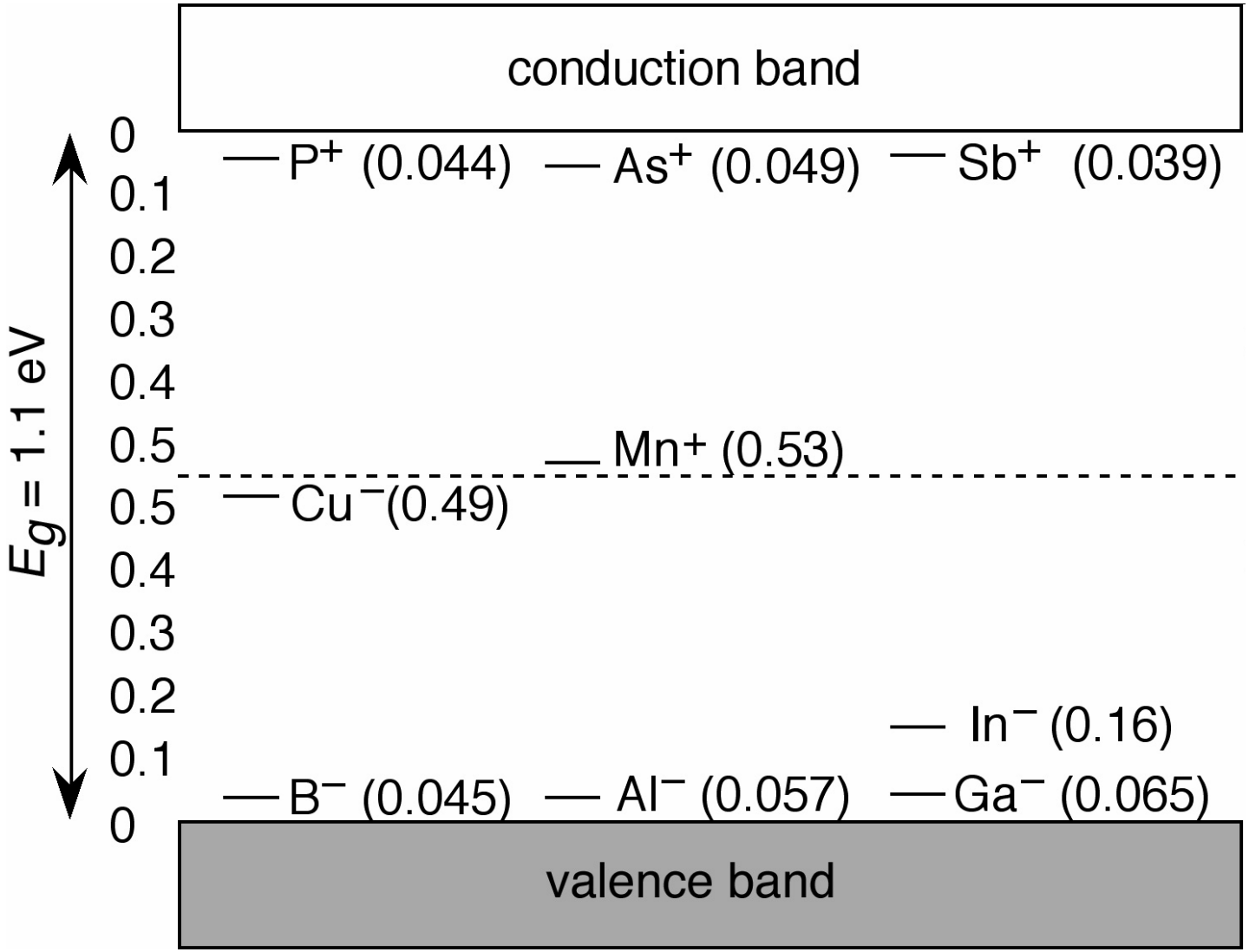
La lacuna è altrove



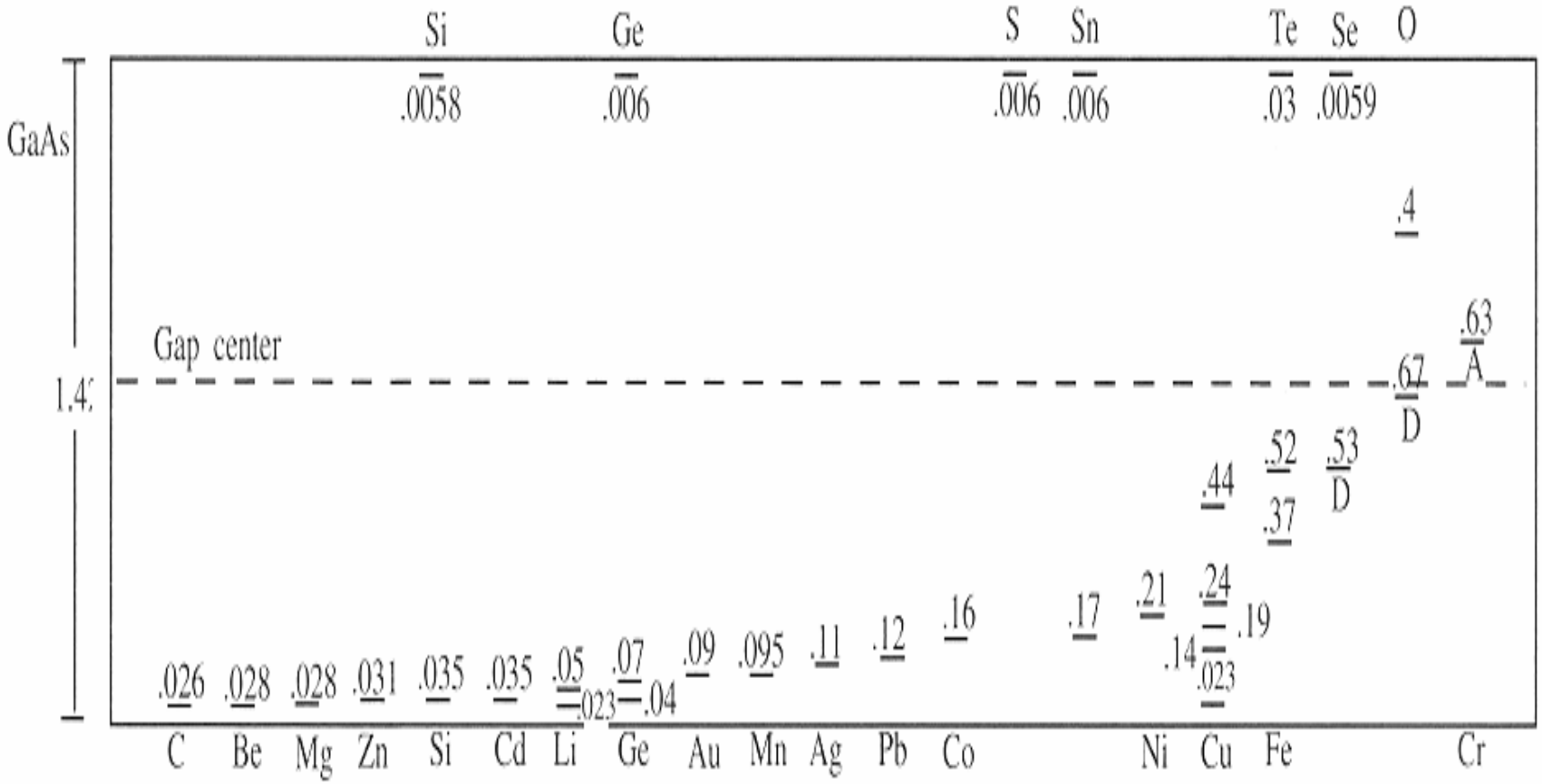
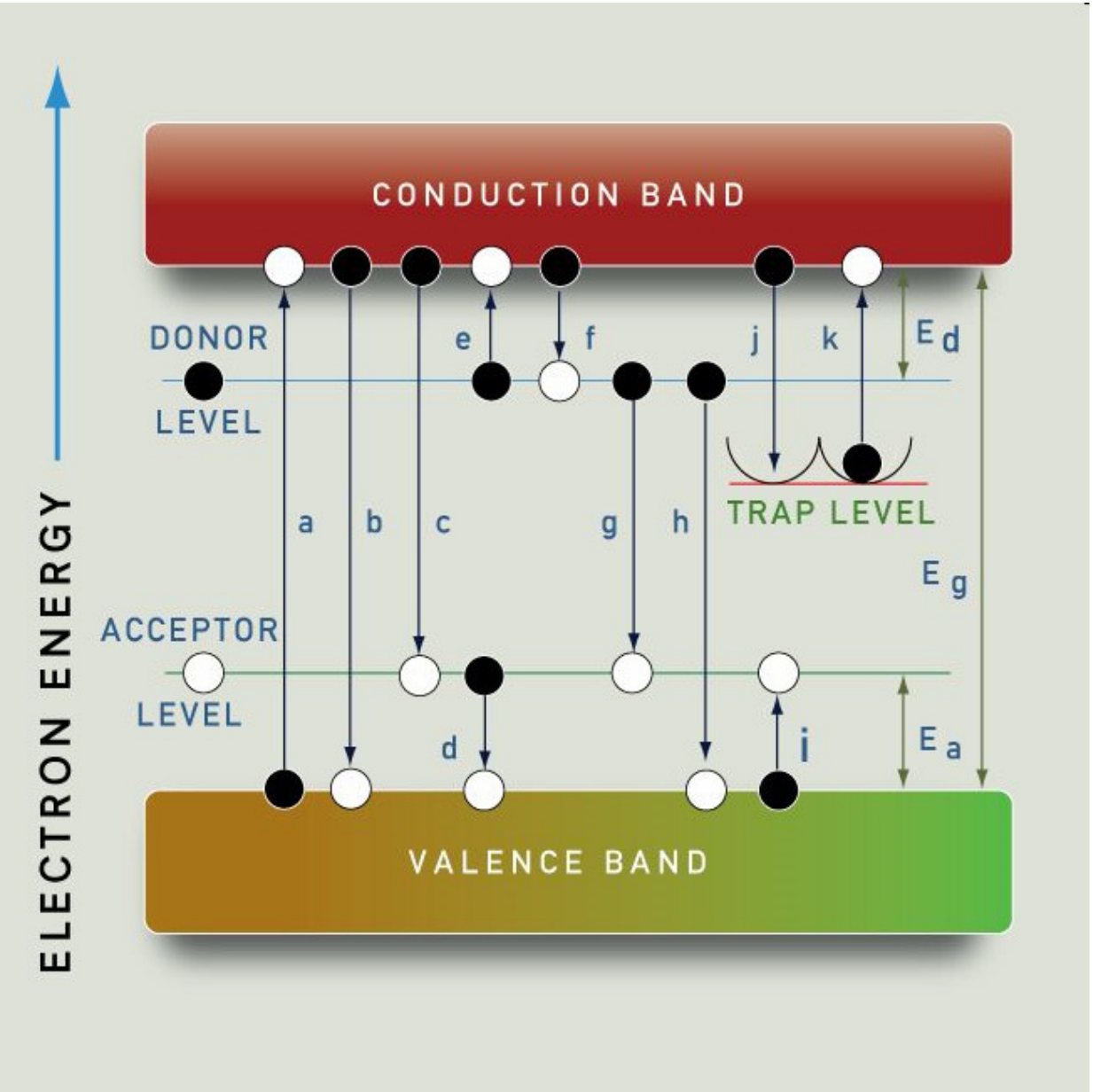
Atomo di antiidrogeno ionizzato


Si
Si
Si
Si
Si
substitution
Si
B
Si
Si
Si
e⊖
ionization
Si
B⊖
Si
Si
Si
Conduction Band
Valence Band
Eg
Conduction Band
Valence Band
Eg
B
EAcc
Conduction Band
Valence Band
Eg
B
EAcc
hole conduction

Donori e accettori in Silicio



Donori e accettori in GaAs



Transizioni elettroniche