Welcome to 3.091

Lecture 19

October 23, 2009

Point & Line Defects

Taxonomy of Defects: Classify by Dimensionality

0-dimensional: point defects

1-dimensional: line defects

2-dimensional: interfacial defects

3-dimensional: bulk defects

Point Defects

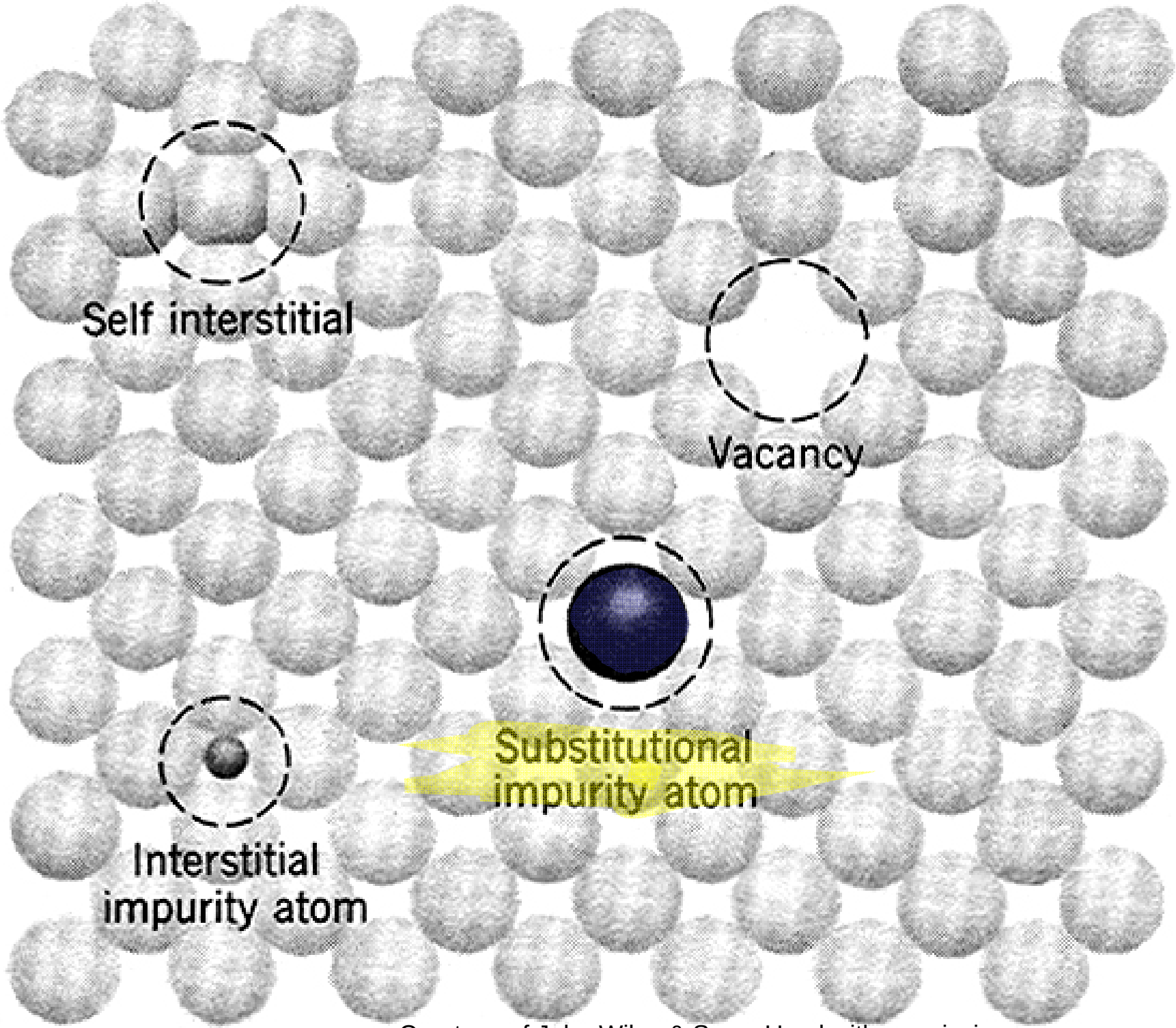
- localized disruption in regularity of the lattice
- on and between lattice sites

1. Substitutional Impurity

- occupies normal lattice site
- dopant ☺, e.g., P in Si; B in $C_{(diamond)}$
- alloying element ☺, e.g., Mg in Al; or Ni in Au
- contaminant ☹, Li^+ in NaCl

2. Interstitial Impurity

- occupies position between lattice sites
- alloying element ☺, e.g., C in Fe; or H in $LaNi_5$
- contaminant ☹, H in Fe



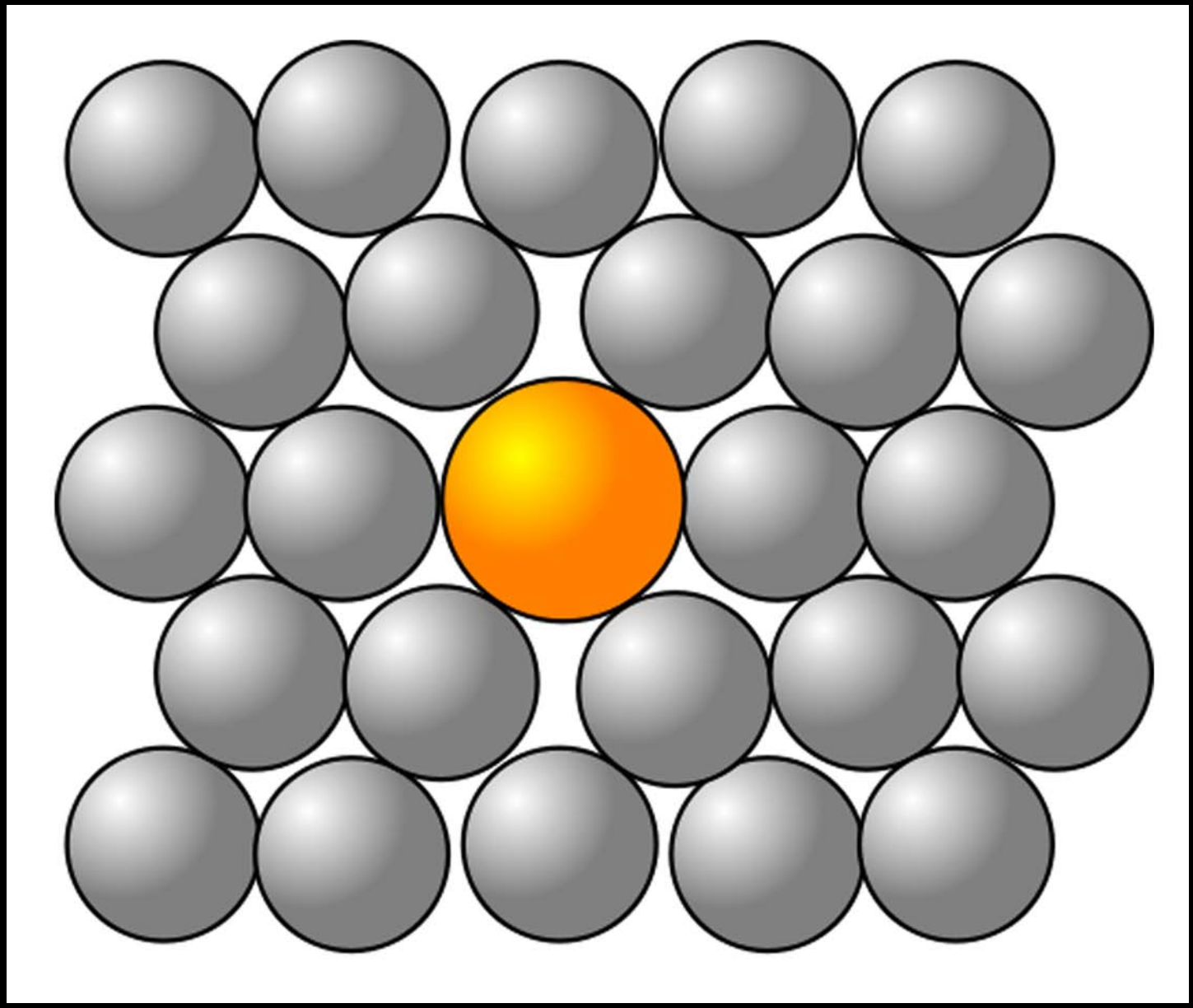


Image by Cdang on Wikipedia.

Point Defects

- localized disruption in regularity of the lattice
- on and between lattice sites

1. Substitutional Impurity

- occupies normal lattice site
- dopant ☺, e.g., P in Si; B in $C_{(diamond)}$
- alloying element ☺, e.g., Mg in Al; or Ni in Au
- contaminant ☹, Li^+ in NaCl

2. Interstitial Impurity

- occupies position between lattice sites
- alloying element ☺, e.g., C in Fe; or H in $LaNi_5$
- contaminant ☹, H in Fe

Photo of the Hope Diamond removed due to copyright restrictions.

Image removed due to copyright restrictions. Please see the cover of Post, Jeffrey E. *The National Gem Collection*. Washington, DC: Smithsonian Institution, 1997. ISBN: 9780810936904.

Point Defects

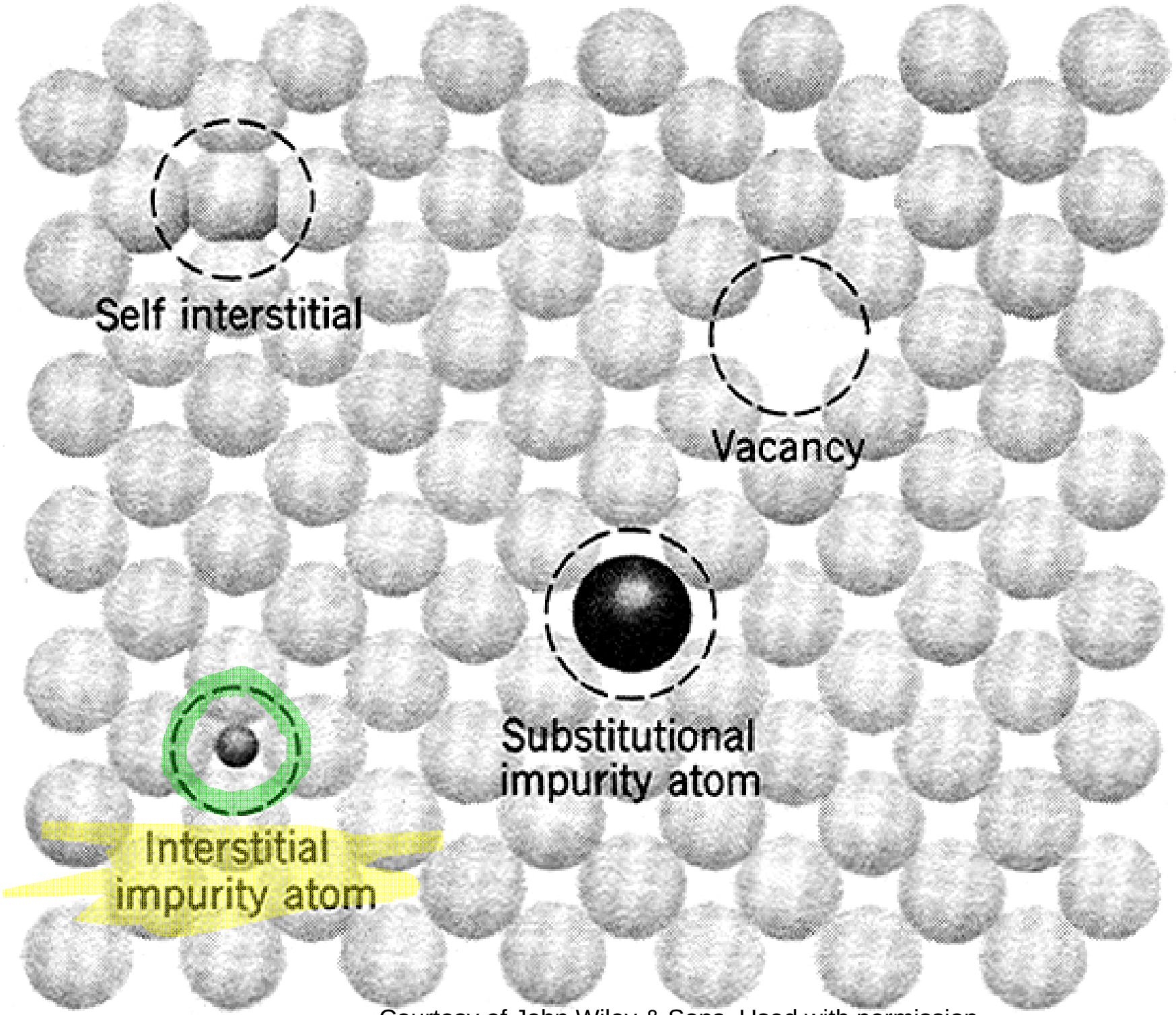
- localized disruption in regularity of the lattice
- on and between lattice sites

1. Substitutional Impurity

- occupies normal lattice site
- dopant ☺, e.g., P in Si; B in $C_{(diamond)}$
- alloying element ☺, e.g., Mg in Al; or Ni in Au
- contaminant ☹, Li^+ in NaCl

2. Interstitial Impurity

- occupies position between lattice sites
- alloying element ☺, e.g., C in Fe; or H in $LaNi_5$
- contaminant ☹, H in Fe



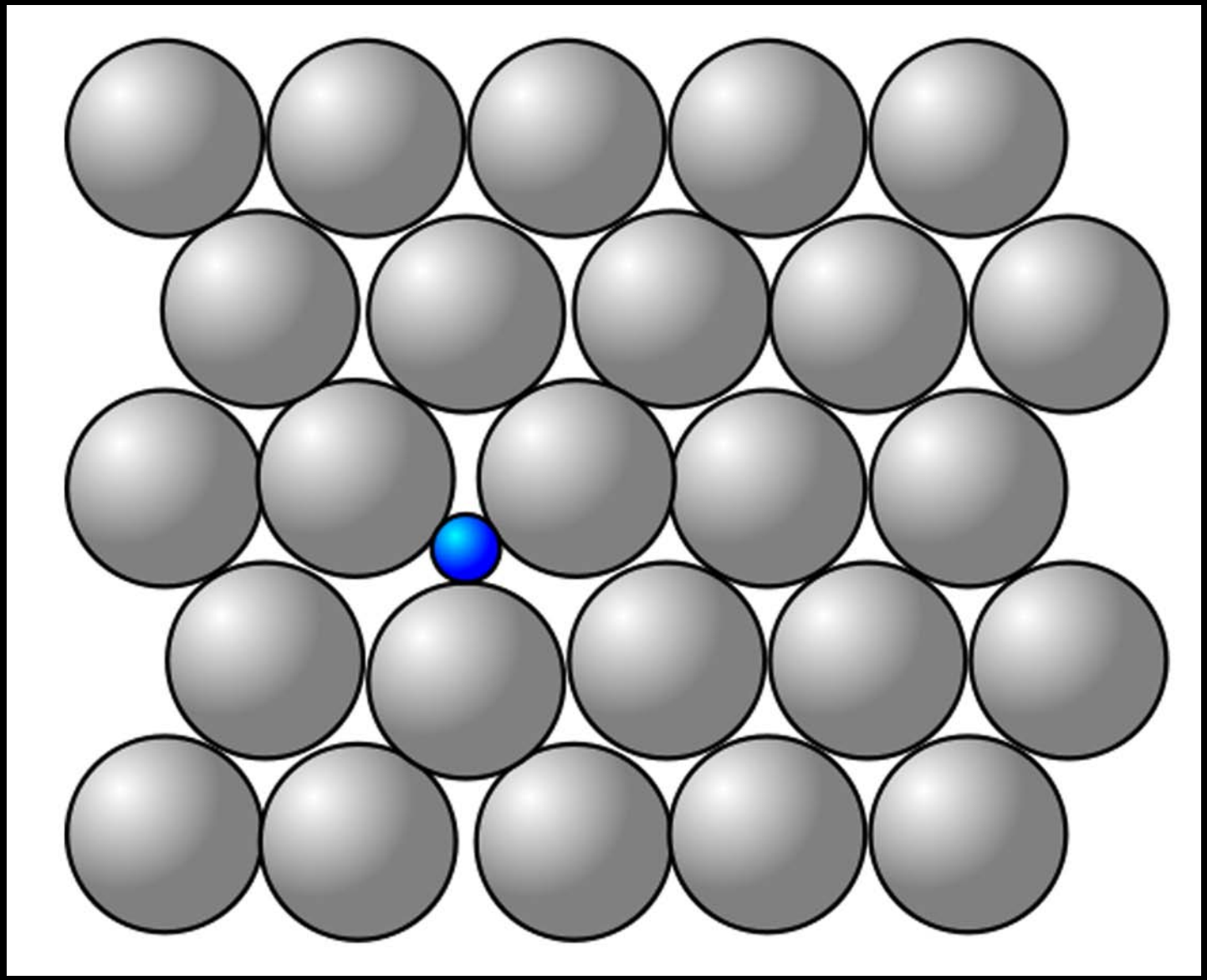


Image by Cdang on Wikipedia.

Point Defects

- localized disruption in regularity of the lattice
- on and between lattice sites

1. Substitutional Impurity

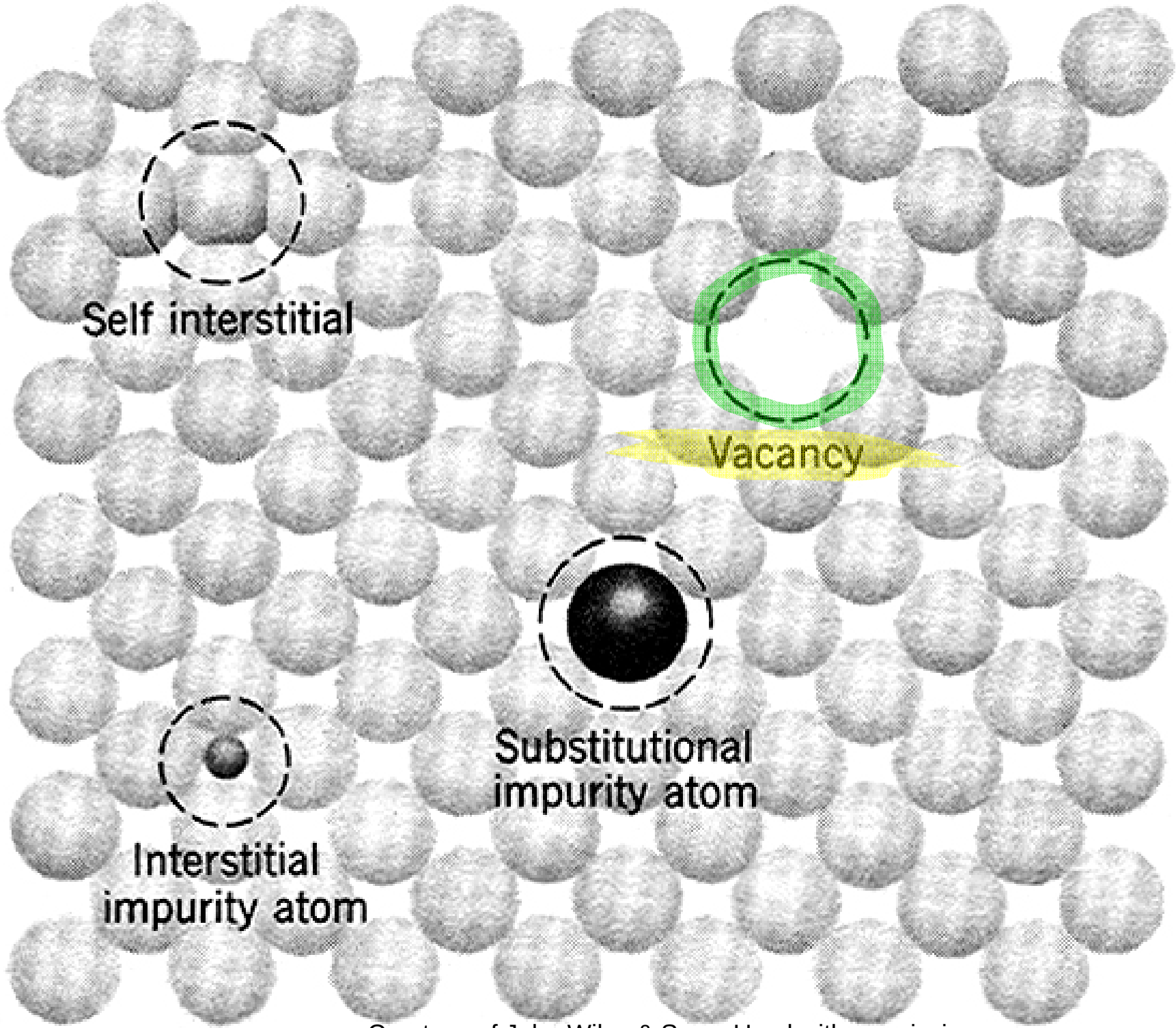
- occupies normal lattice site
- dopant ☺, e.g., P in Si; B in $C_{(diamond)}$
- alloying element ☺, e.g., Mg in Al; or Ni in Au
- contaminant ☹, Li^+ in NaCl

2. Interstitial Impurity

- occupies position between lattice sites
- alloying element ☺, e.g., C in Fe; or H in $LaNi_5$
- contaminant ☹, H in Fe

3. Vacancy

- unoccupied lattice site
- formed at time of crystallization
- formed in service under extreme conditions



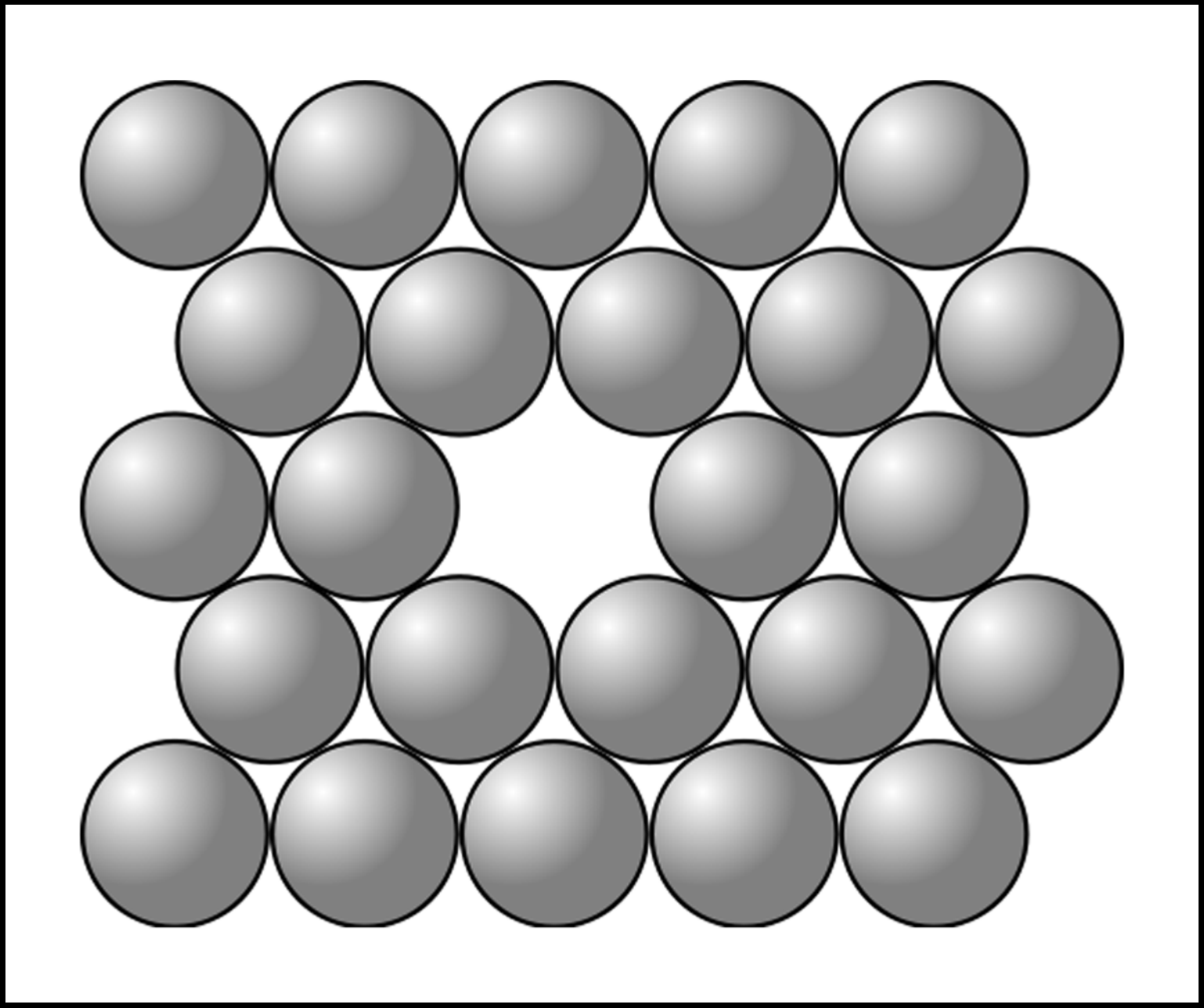


Image by Cdang on Wikipedia.

3. Vacancy

- unoccupied lattice site
- formed at time of crystallization
- formed in service under extreme conditions

ELSEVIER

Physica B 271 (1999) 21–27

PHYSICA B

www.elsevier.com/locate/physb

Monovacancies and divacancies in copper Reanalysis of experimental data

G. Neumann[a], V. Tölle[a], C. Tuijn[b,*]

[a]*Institut für Physikalische Chemie, Freie Universität Berlin, Takustraße 3, 14195 Berlin, Germany*
[b]*Department of Physics, University of Amsterdam, Valckenierstraat 65, 1018 XE Amsterdam, The Netherlands*

Received 31 May 1999

Abstract

The vacancy concentrations c_v in copper measured by means of the absolute technique (Hehenkamp et al., Phys. Rev. B 45 (1992) 1998) and those derived from positron lifetime studies (Kluin, Philos. Mag A 65 (1992) 1263) are reanalysed. Taking into account the results of quenching and annealing investigations the best fit to the temperature function of c_v is described by $H^F_{1v} = 1.03$ eV and $S^F_{1v}/k = 1.1$ for the monovacancy formation enthalpy and entropy and a divacancy binding enthalpy and entropy of $H^B_{2v} = -0.23$ eV (attractive interaction) and $S^B_{2v}/k = 2.8$, respectively. Accordingly, the divacancy concentration amounts to 1.5×10^{-4} at the melting temperature.

Keywords: Vacancies; Monovacancies; Divacancies; Copper

Point Defects in Ionic Crystals

- special issues associated with the need to maintain global charge neutrality

1. Schottky Imperfection

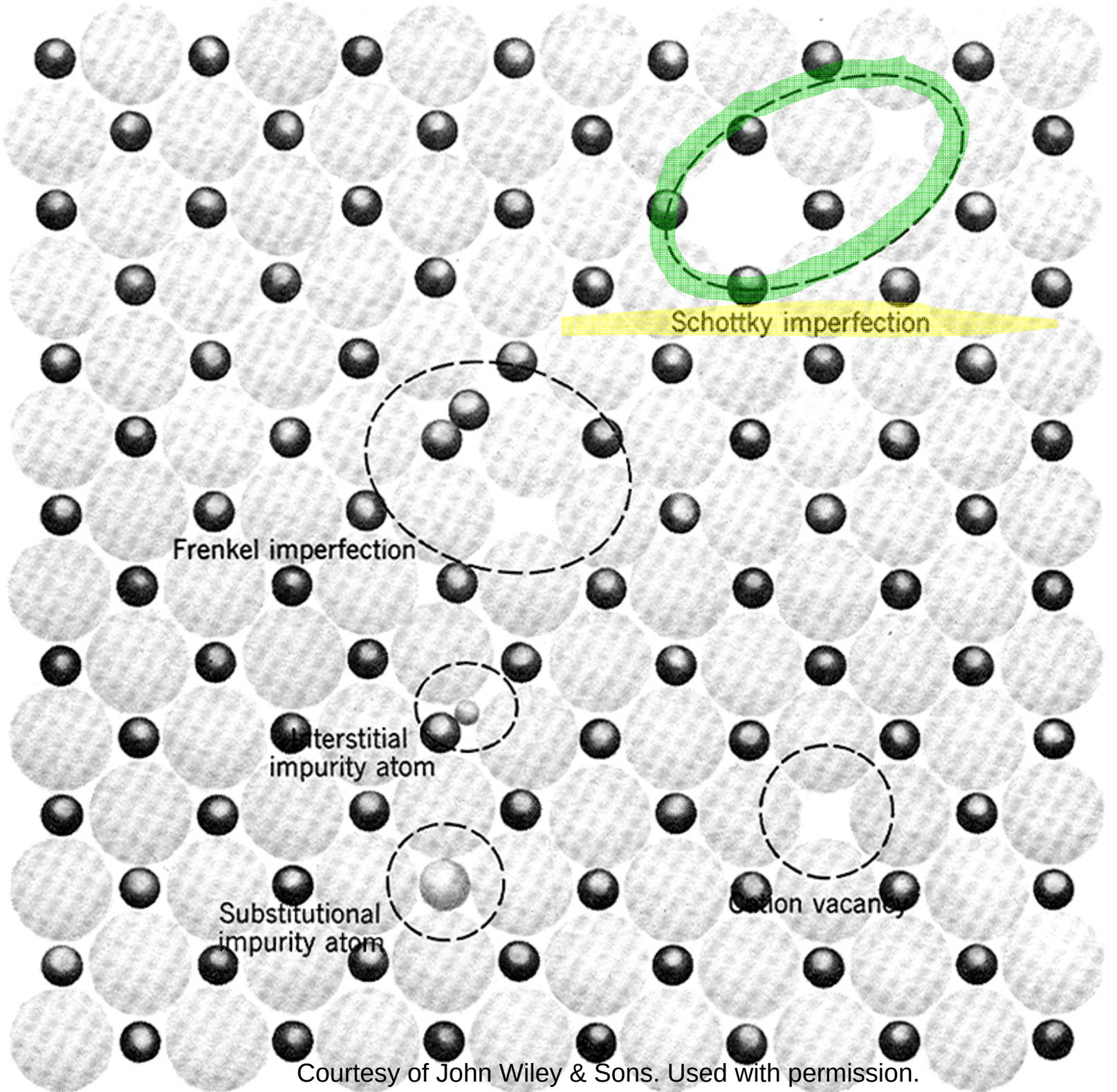
- formation of equivalent (not necessarily equal) numbers of cationic and anionic vacancies

2. Frenkel Imperfection

- formation of an ion vacancy and an ion interstitial

3. F-Center

- formation of an ion vacancy and bound electron



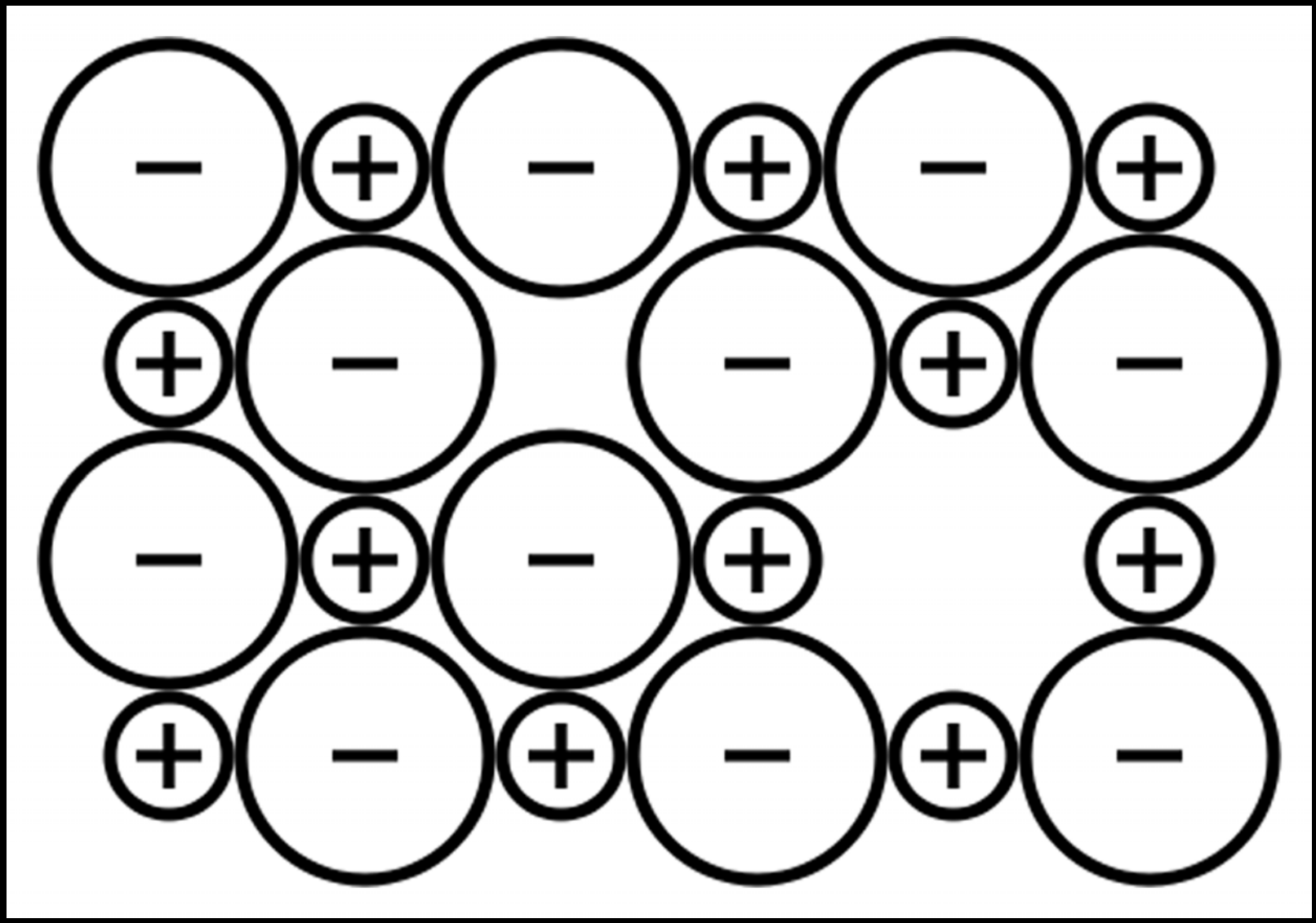


Image by Leyo on Wikipedia.

Point Defects in Ionic Crystals

- special issues associated with the need to maintain global charge neutrality

1. Schottky Imperfection

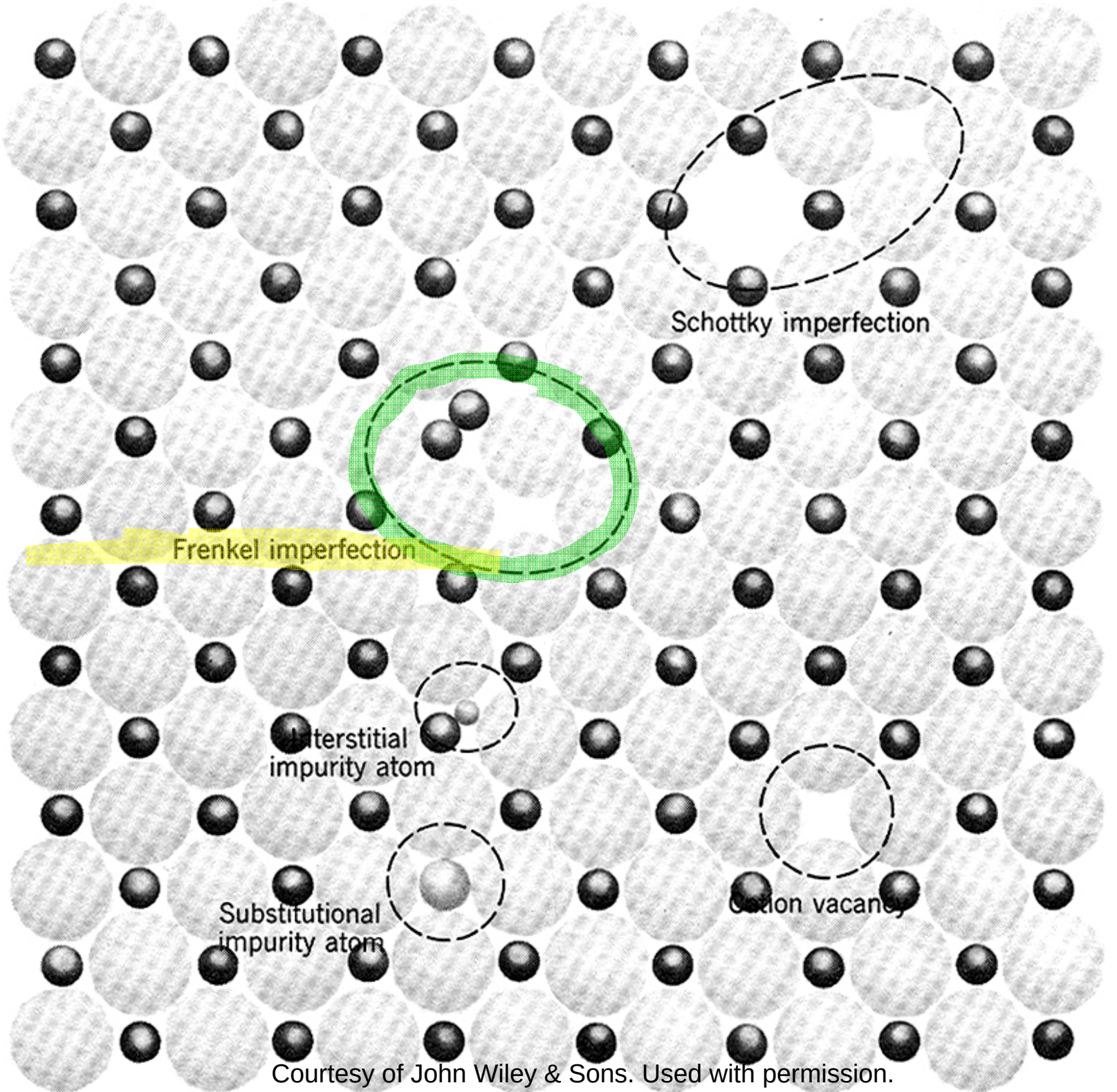
- formation of equivalent (not necessarily equal) numbers of cationic and anionic vacancies

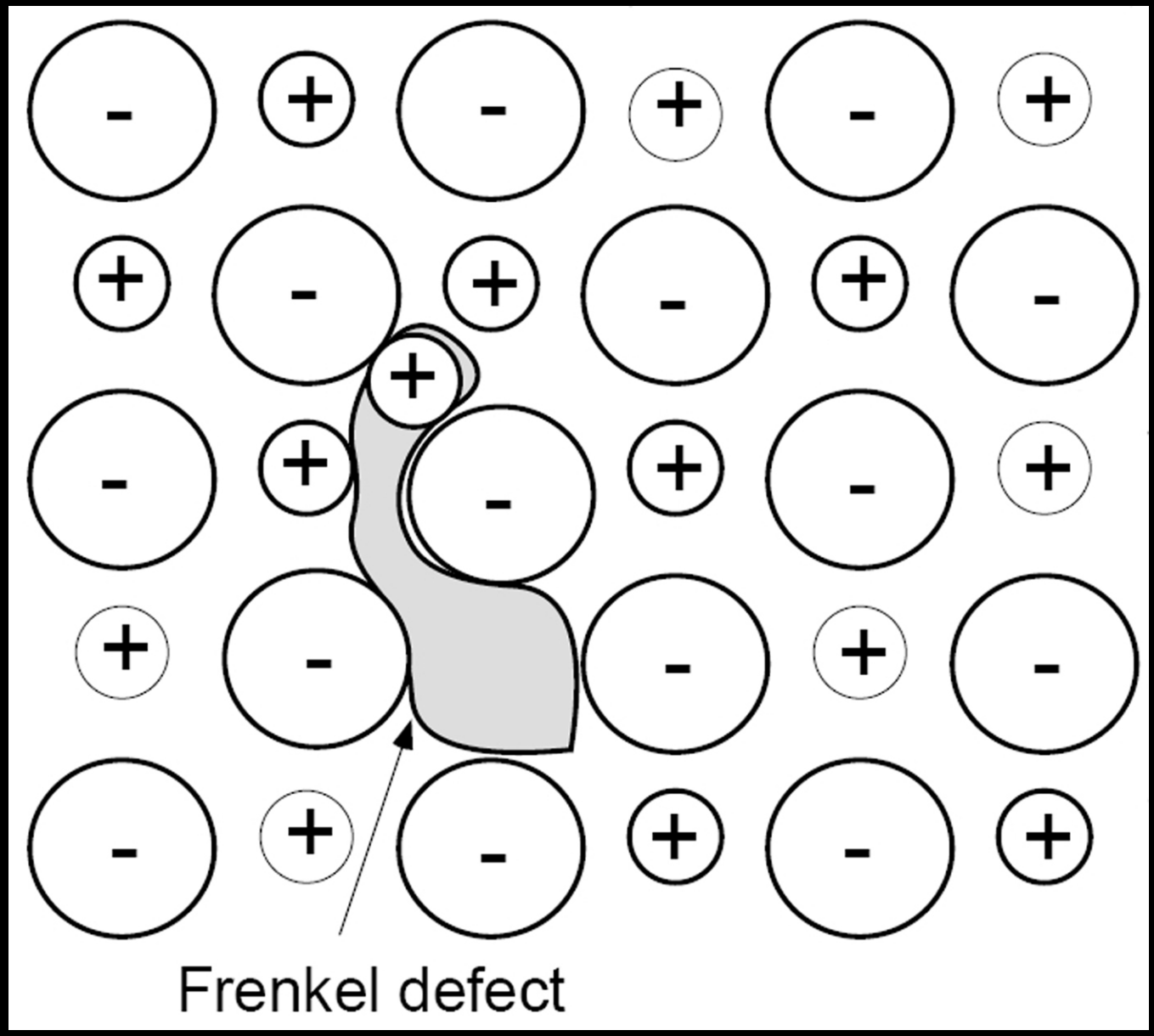
2. Frenkel Imperfection

- formation of an ion vacancy and an ion interstitial

3. F-Center

- formation of an ion vacancy and bound electron




Frenkel defect

Point Defects in Ionic Crystals

- special issues associated with the need to maintain global charge neutrality

1. Schottky Imperfection

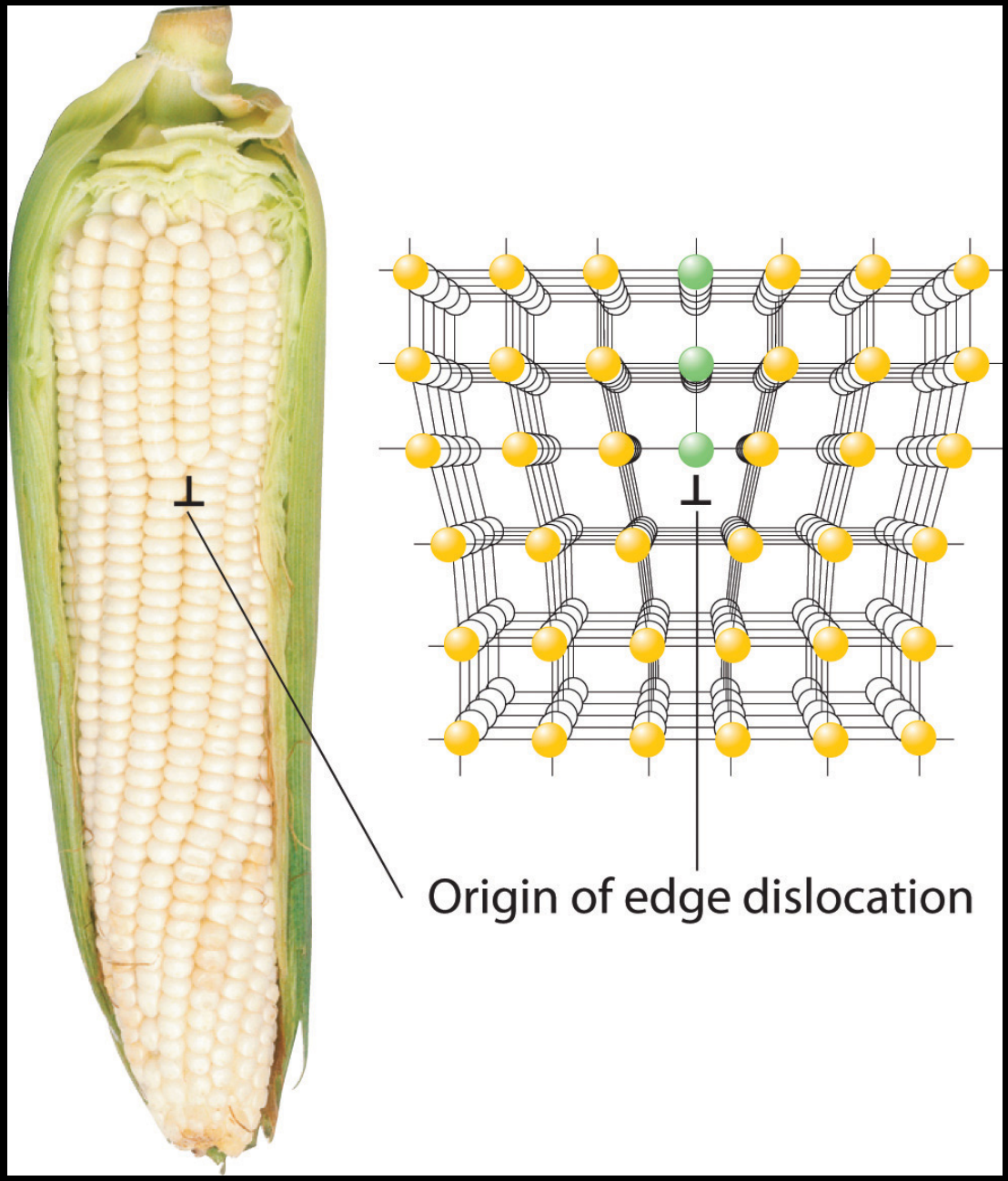
- formation of equivalent (not necessarily equal) numbers of cationic and anionic vacancies

2. Frenkel Imperfection

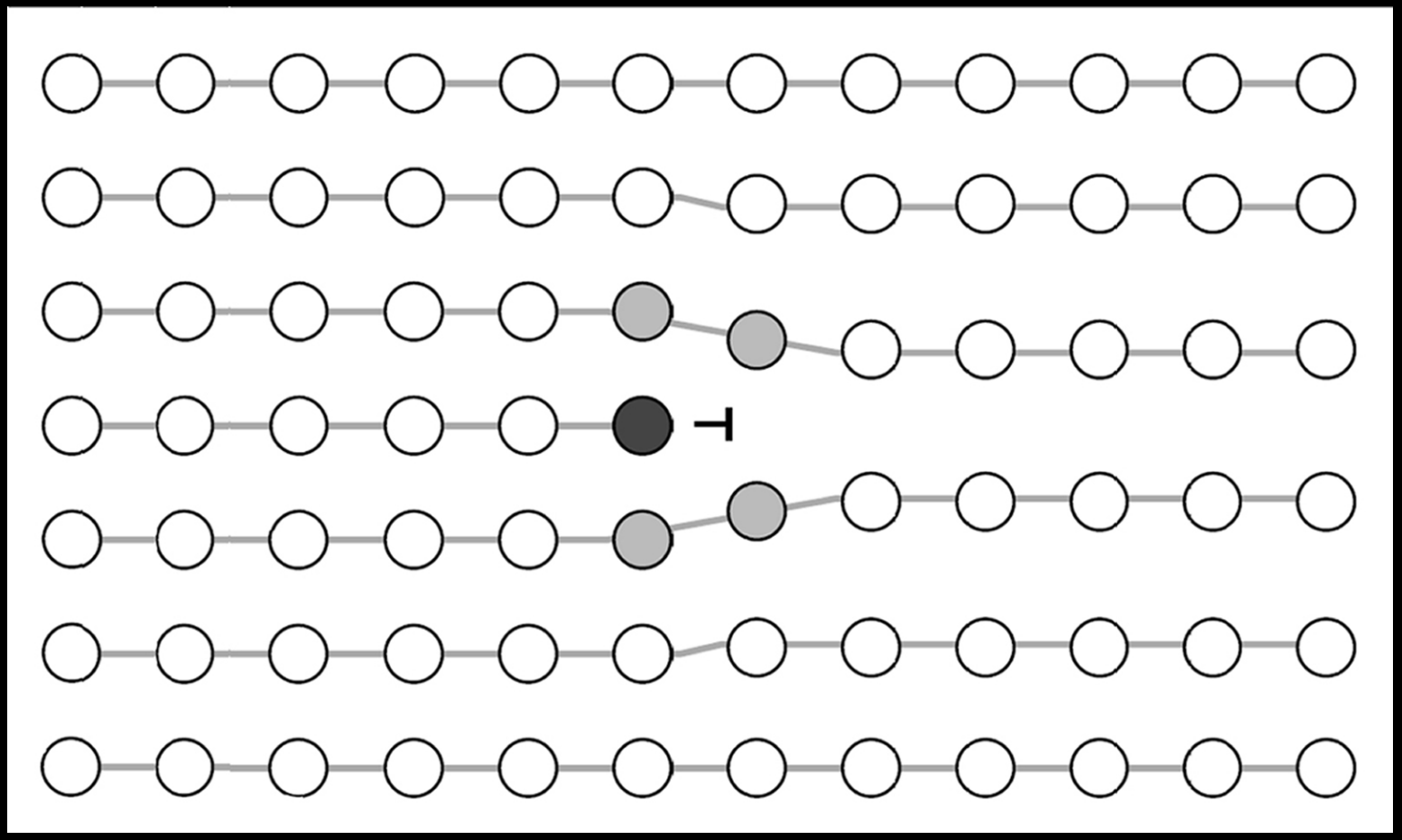
- formation of an ion vacancy and an ion interstitial

3. F-Center

- formation of an ion vacancy and bound electron



Averill, B., and P. Eldredge. *Chemistry: Principles, Patterns, and Applications*. Flat World Knowledge, 2011. ISBN: 9781453331224.



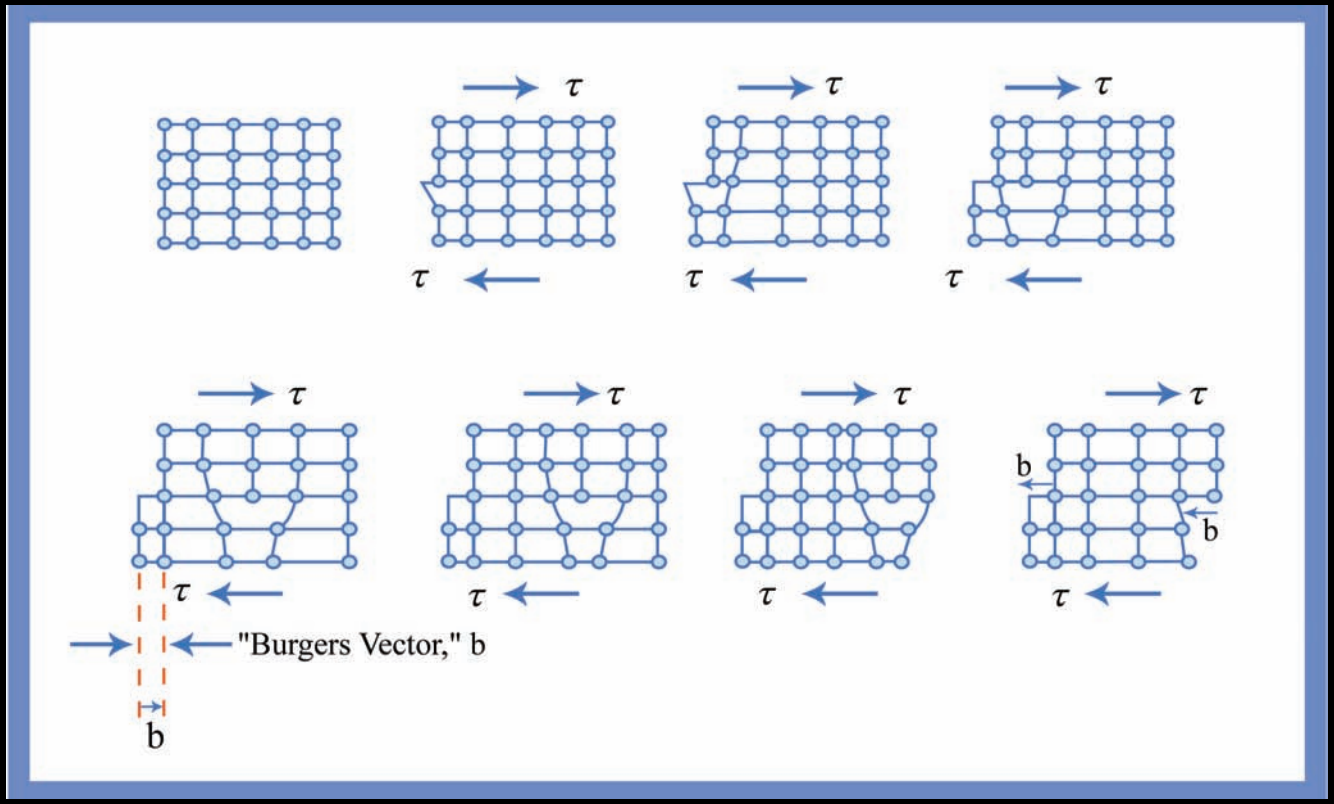


Image by MIT OpenCourseWare. Adapted from Fig. 9.4 in Ashby, M. F., and D. R. H. Jones. Engineering Materials 1. Boston, MA: Elsevier Butterworth-Heinemann, 2005.

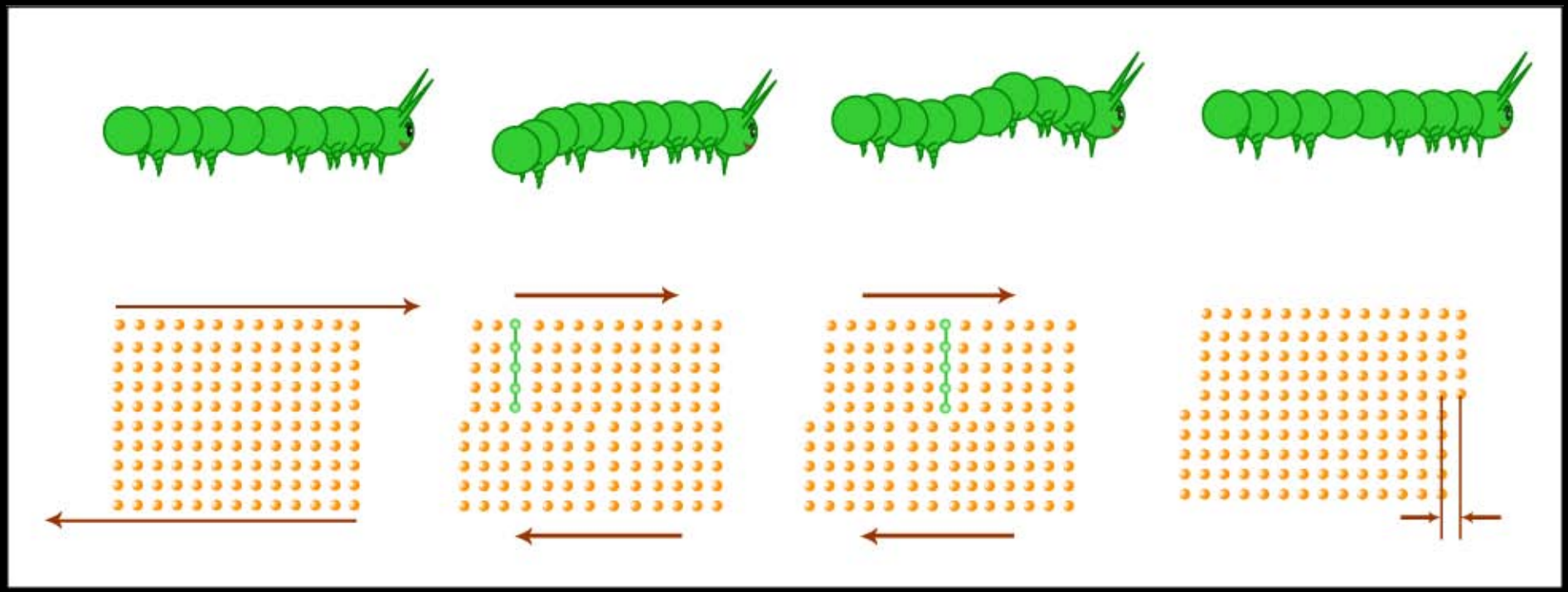
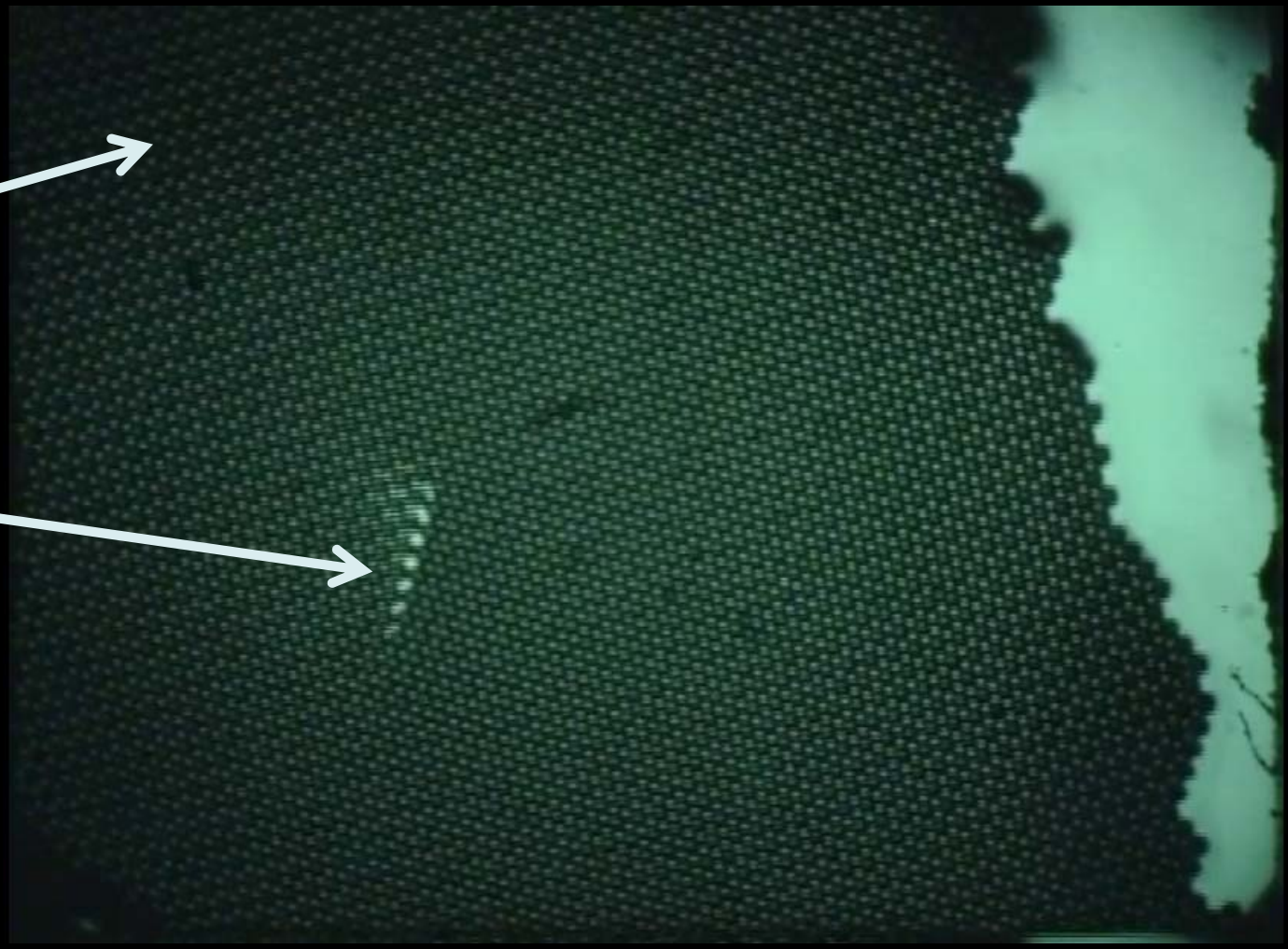


Image by MIT OpenCourseWare.

Modeling dislocations in a soap bubble raft (Bragg and Nye)



3.091SC Introduction to Solid State Chemistry

Fall 2009