

Prof. Dr. Albrecht Beutelspacher

Mathematisches Institut
Justus-Liebig-Universität Gießen

17.04.2012
16⁴⁵ Uhr / HS I

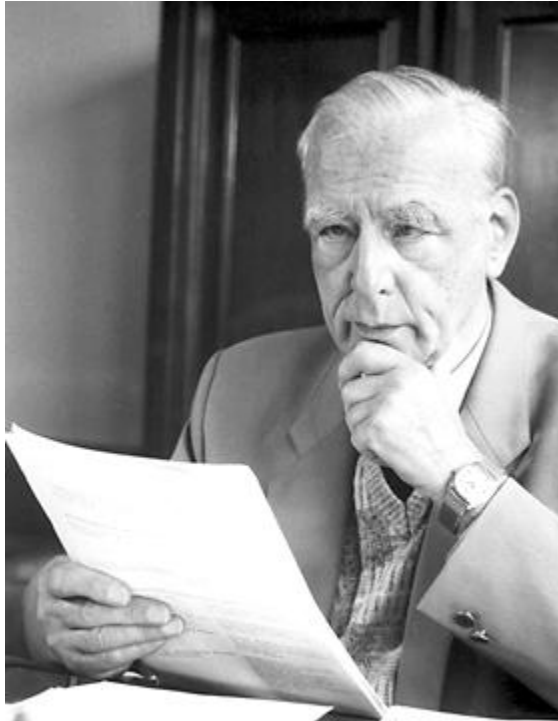
Mathematische Experimente

” In dem Vortrag „Mathematische Experimente“ führt Professor Beutelspacher mit Hilfe einfachster Materialien faszinierende Experimente vor und erläutert deren mathematische Bedeutung. All diese Experimente können von den Zuhörern zu Hause direkt nachgemacht werden.

Professor Beutelspacher ist Professor für Geometrie und Diskrete Mathematik am Mathematischen Institut der Justus-Liebig-Universität Gießen und Leiter des Mathematikums in Gießen. Dort hat auch die bekannte Wanderausstellung „Mathematik zum Anfassen“ ihren Ausgangspunkt. Professor Beutelspacher wurde mehrfach ausgezeichnet, unter anderem mit dem Communicator Preis für herausragende Leistungen in der Vermittlung seiner Wissenschaft in die Öffentlichkeit.

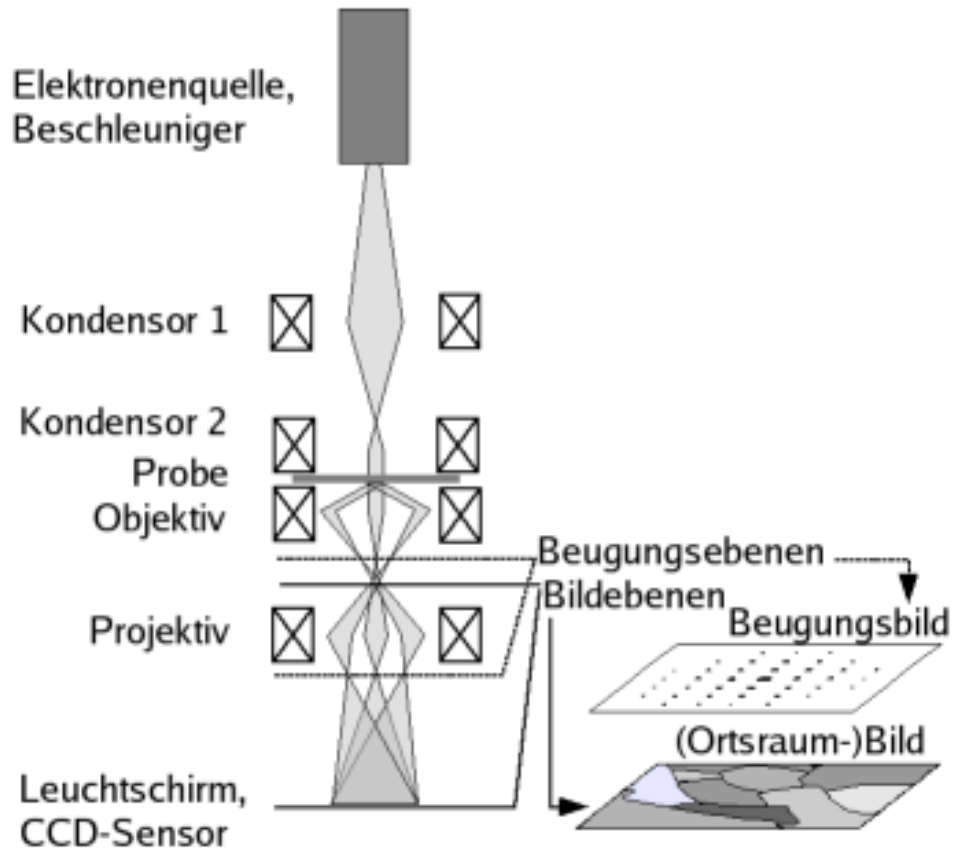


Bildquelle: Mathematikum Gießen/Fotograf: Rolf K. Wegst



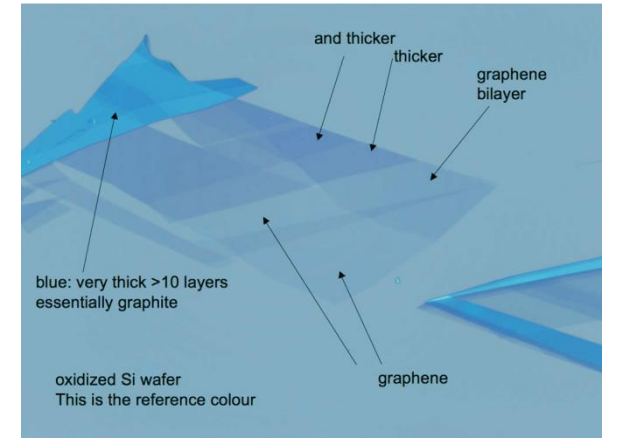
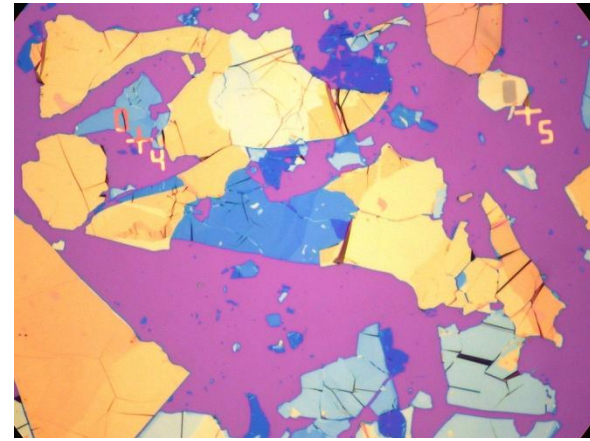
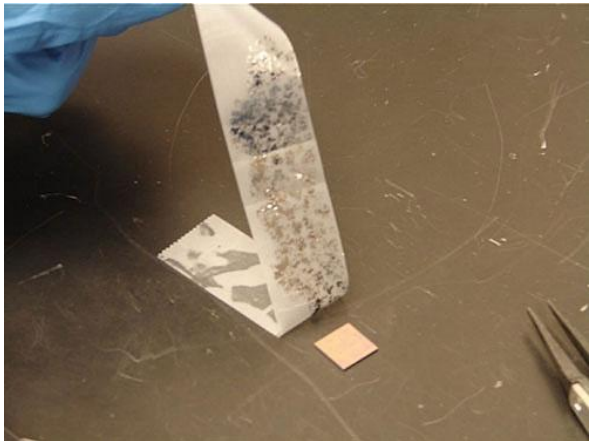
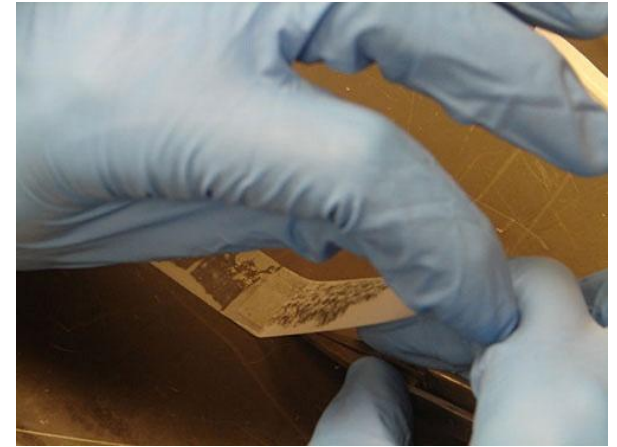
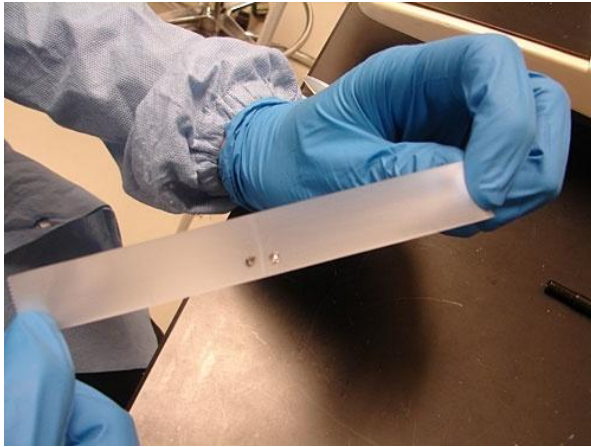
E. Ruska

Nobel price in physics 1988 " *for his fundamental work in electron optics, and for the design of the first electron microscope*" **(work done in the 1930s-1940s)**



2004: Tesafilm-Graphen

scotch tape on Si wafer with
300 nm SiO₂ on top



interference-like contrast in optical
microscope allows detection of single-layered
graphene

Nobelpreis in Physik 2010



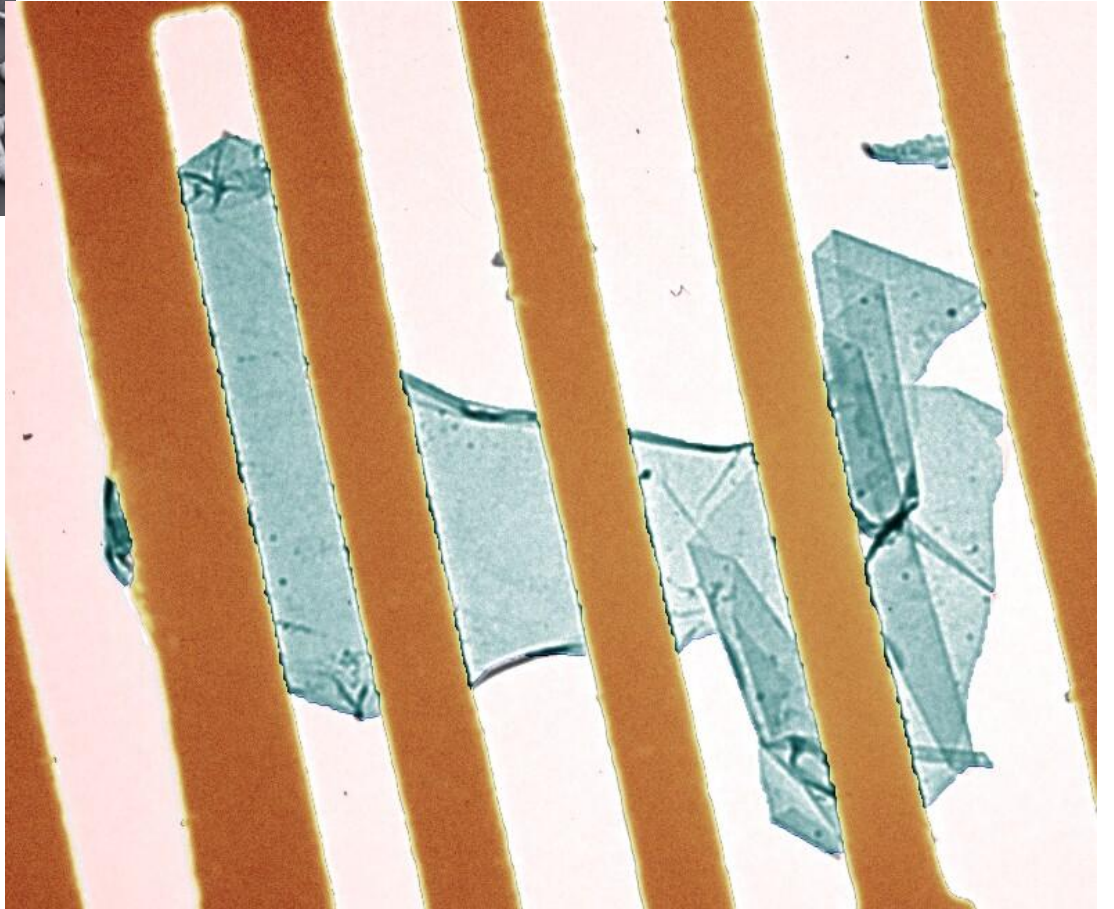
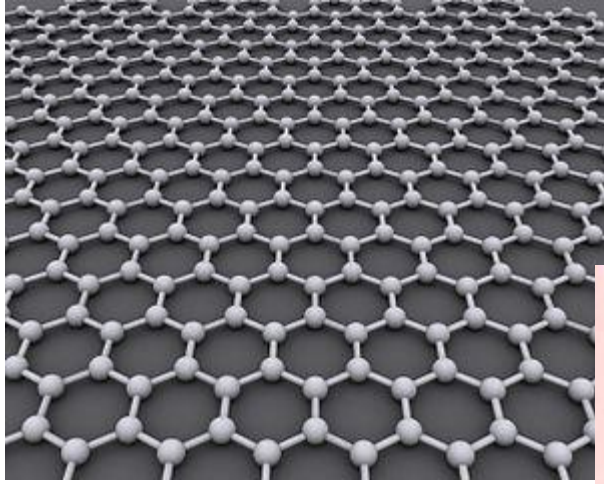
A. Geim

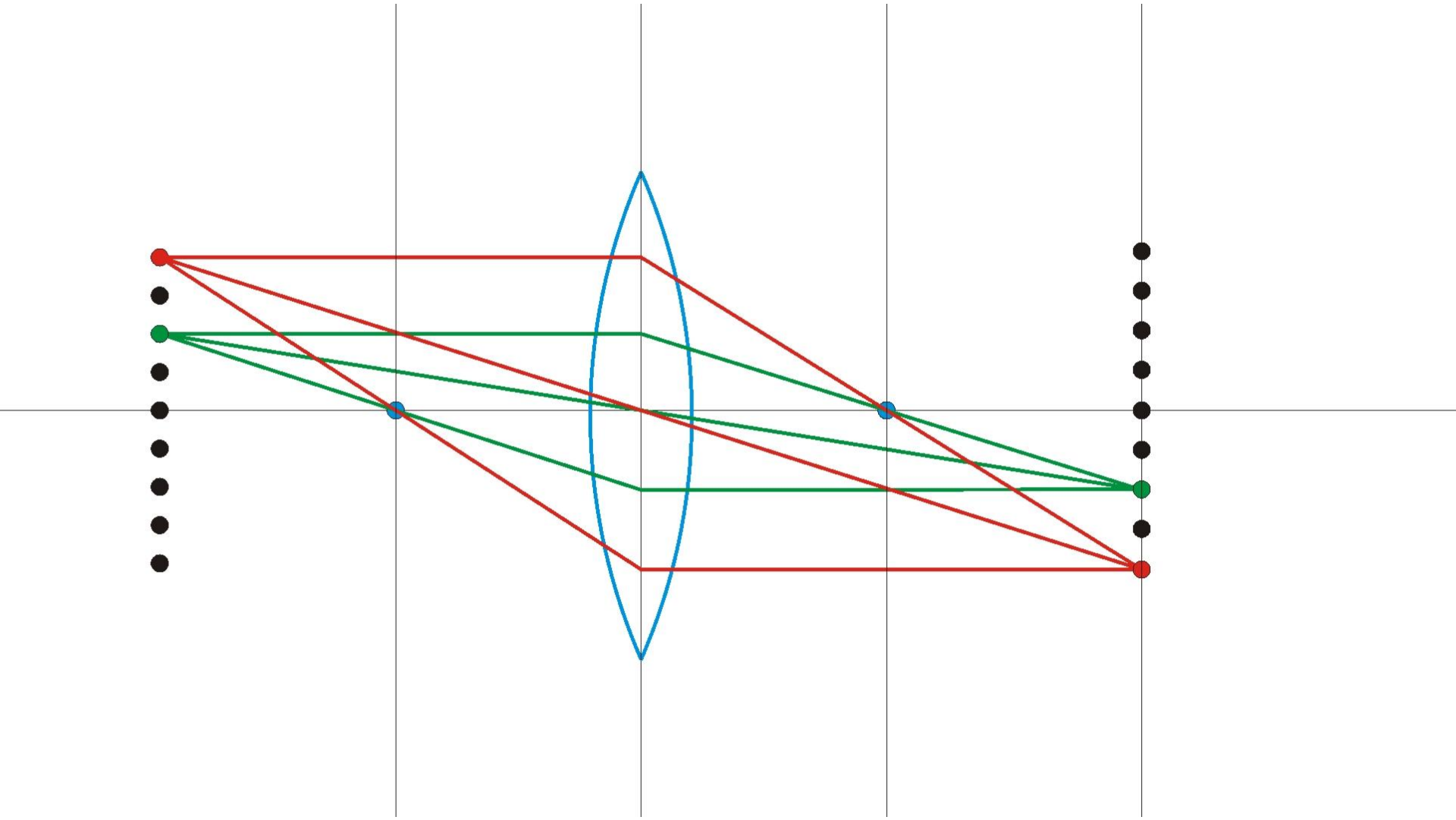


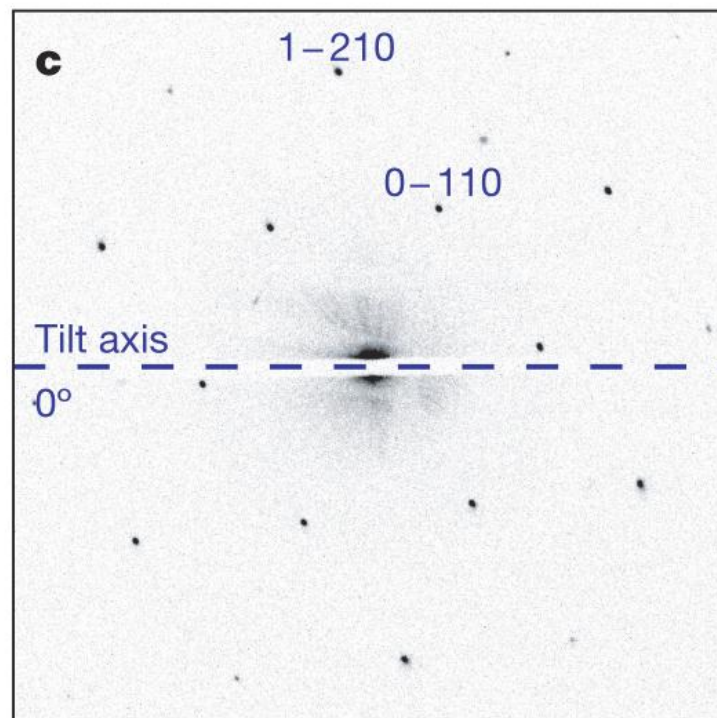
K. Novoselov

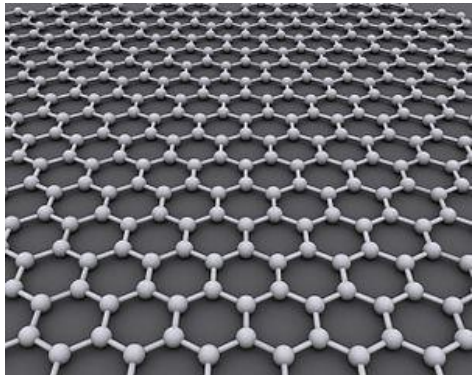


“für grundlegende Experimente mit dem zweidimensionalen Material Graphen”

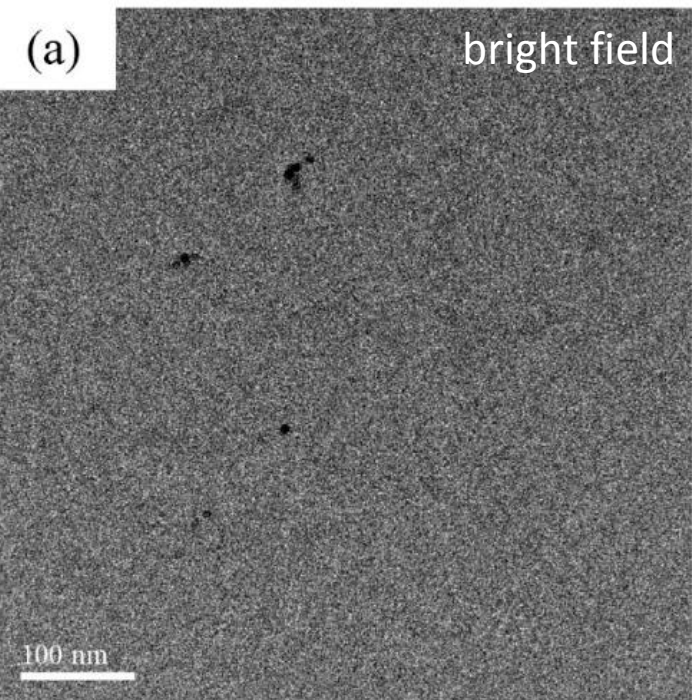




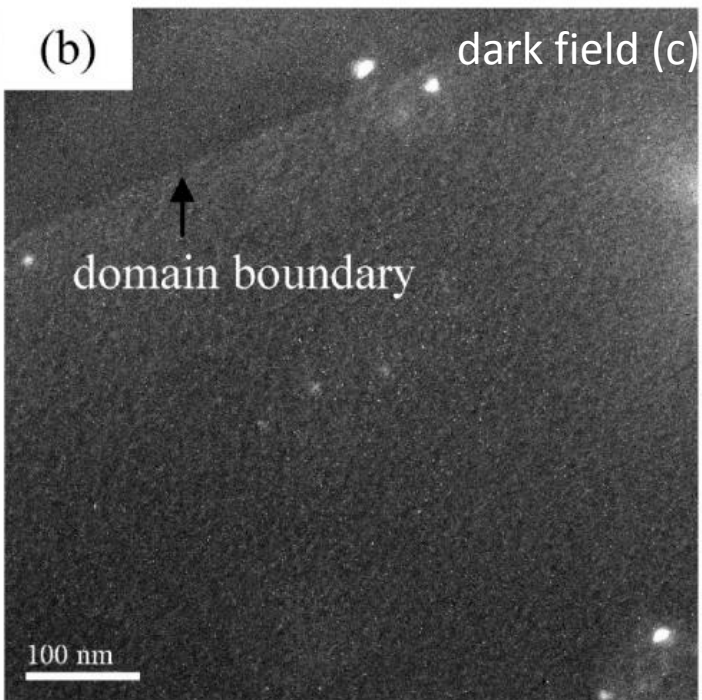




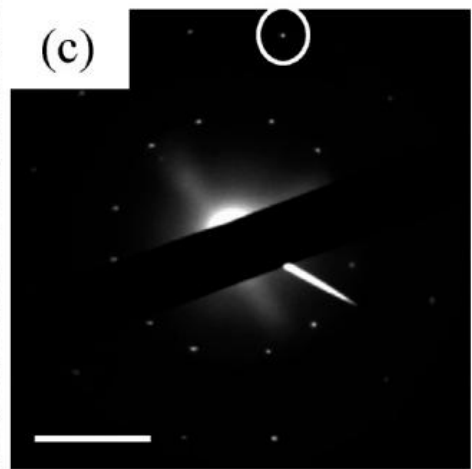
(a) bright field

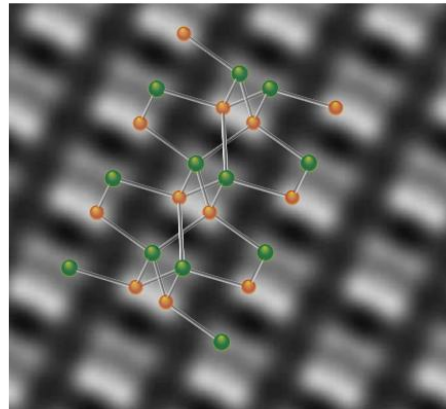
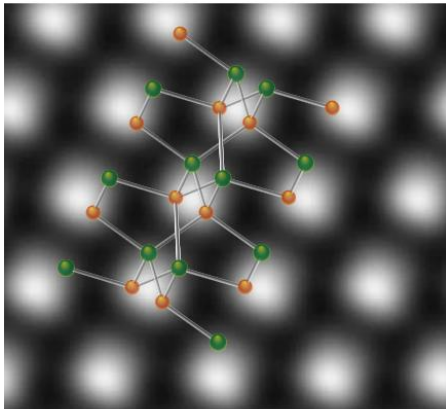
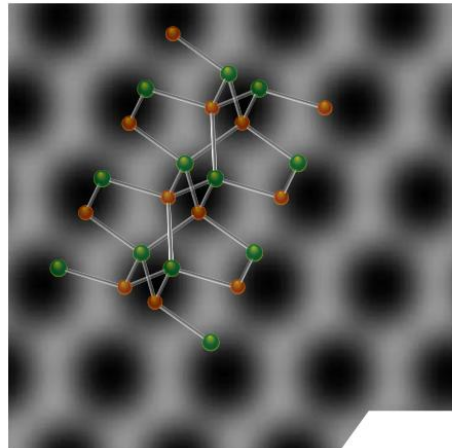


(b) dark field (c)

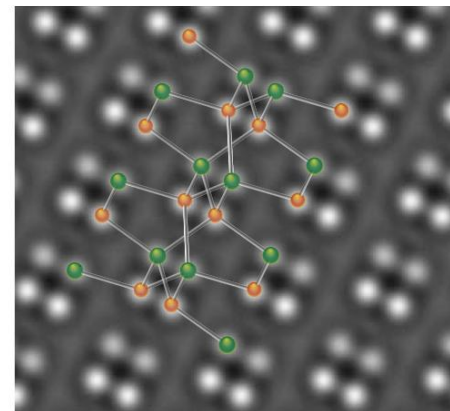
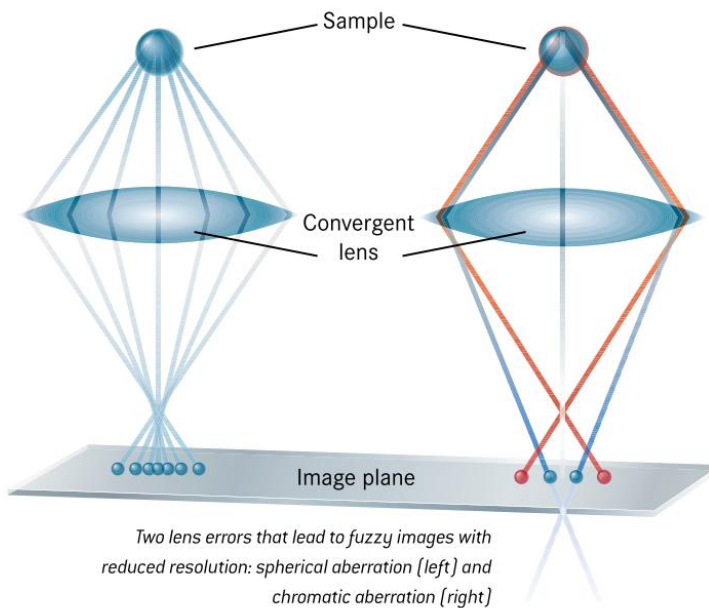


(c)



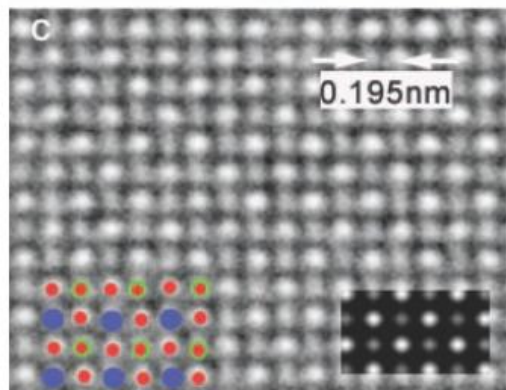
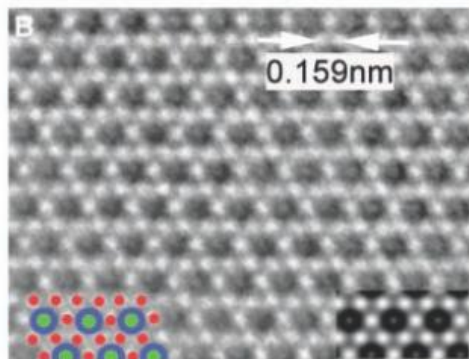
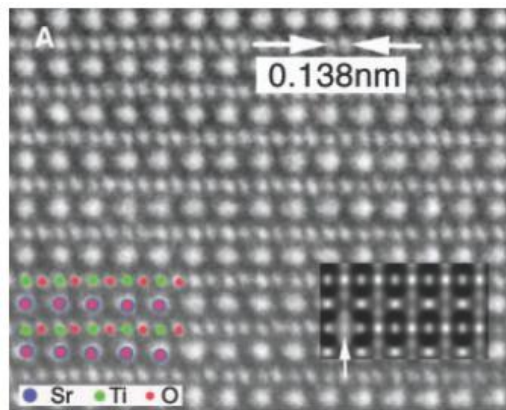


These simulated images of aluminium nitride illustrate how much resolution has improved with each generation of electron microscopes from 1992, 1998 and 2005 up to the present day (from left to right).

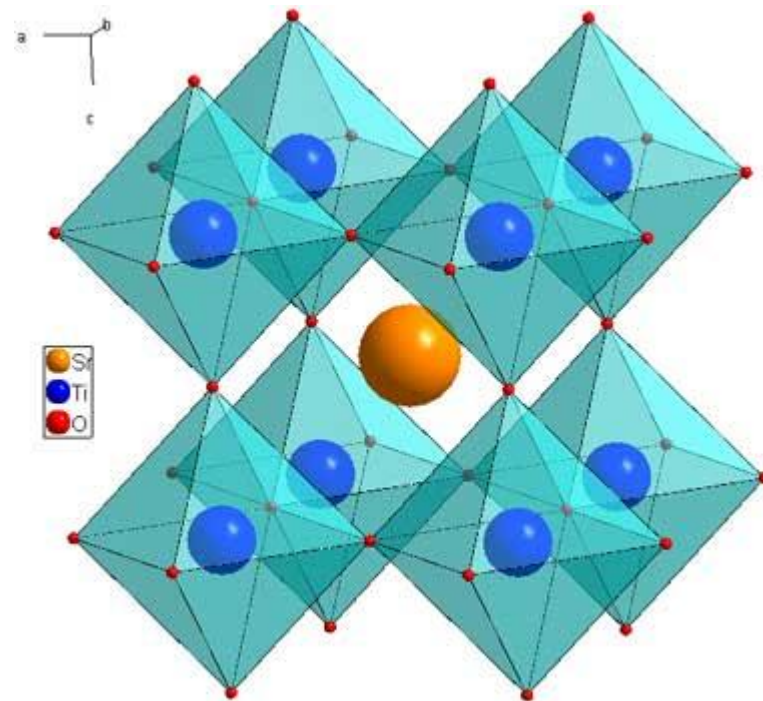


Only PICO makes it possible to actually recognize the atoms in this material. The atoms are shown as green and red spheres as an aid to recognition.

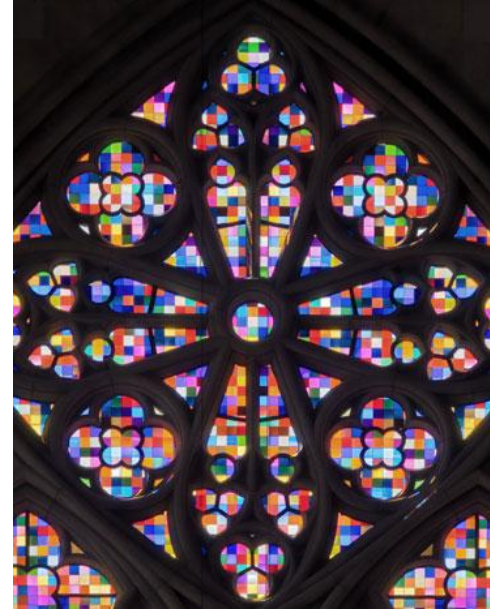
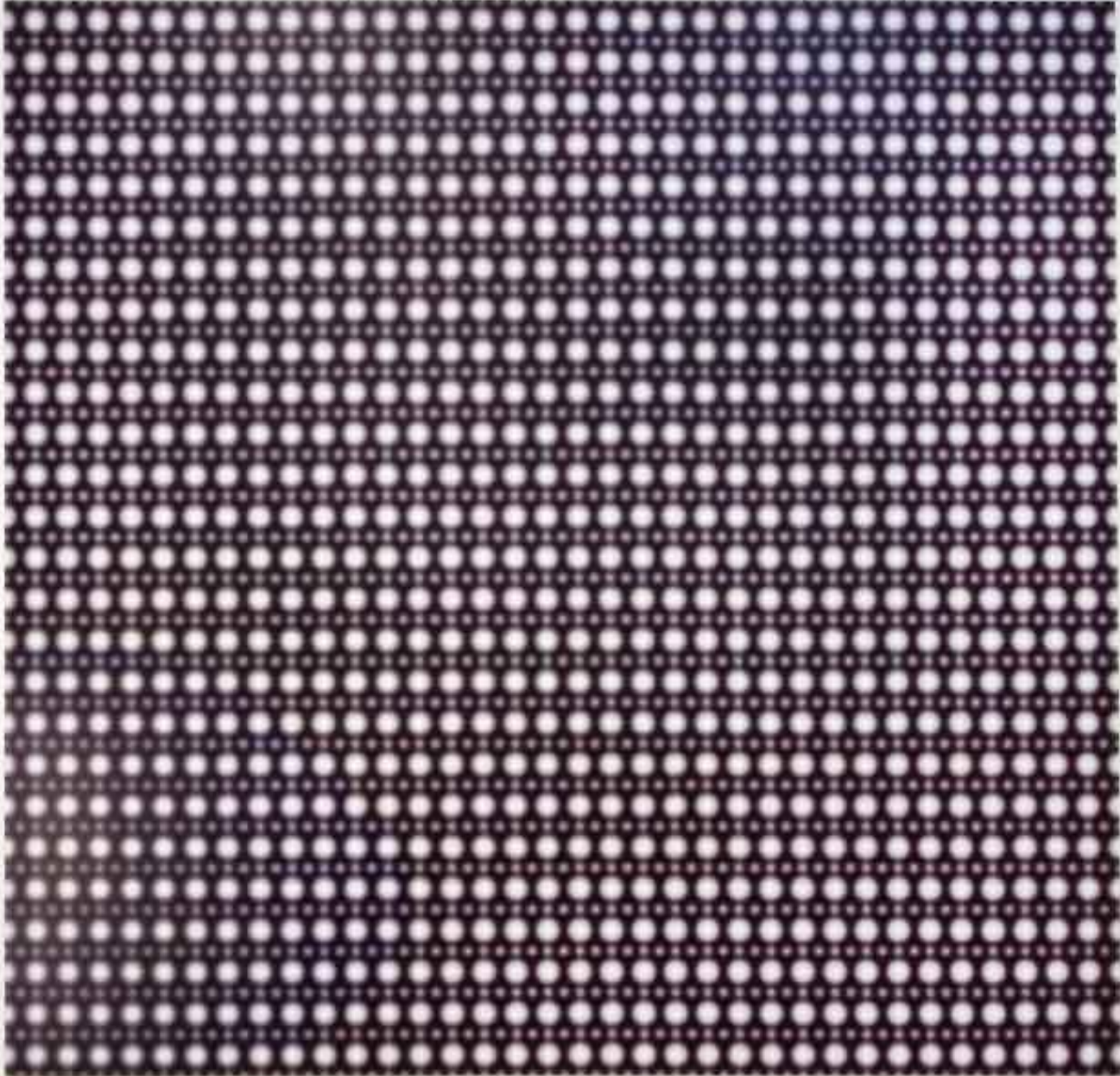
HRTEM of SrTiO₃



SrTiO₃ (strontium titanate)
perovskite structure

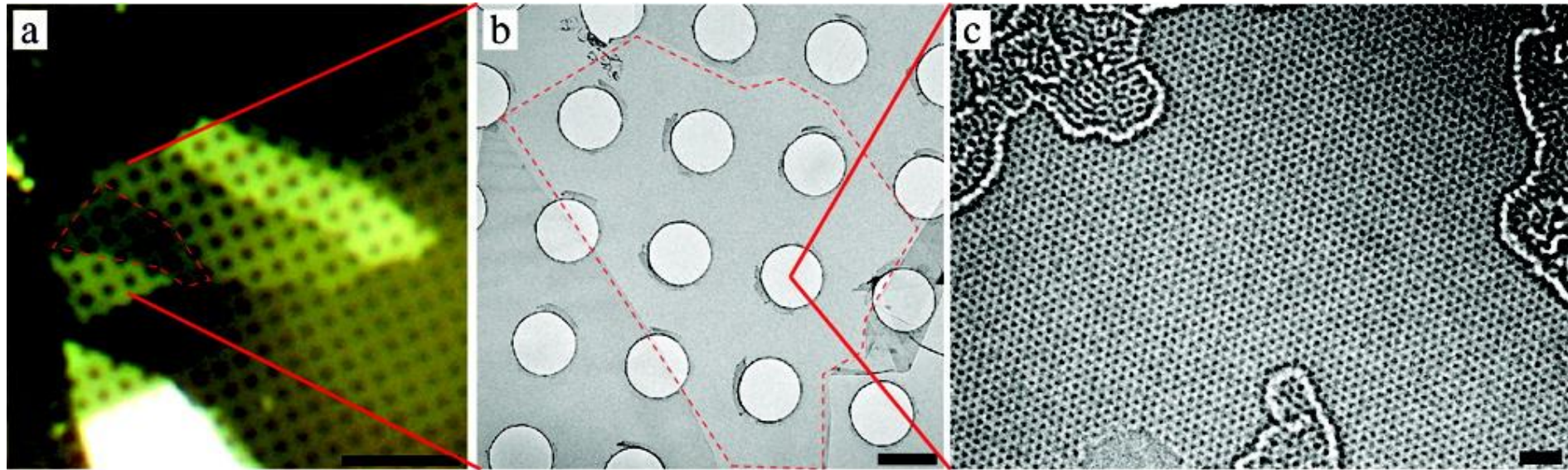


Z. Zhang, W. Sigle, F. Phillipp, M. Rühle,
Science 302, 846 (2003)



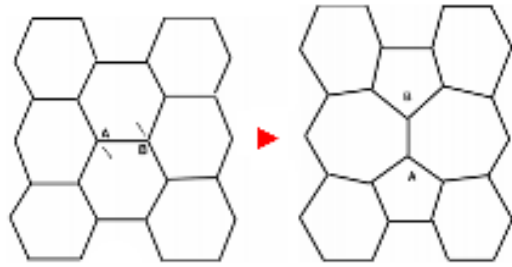
G. Richter, Strontium (2005)

HRTEM of graphene

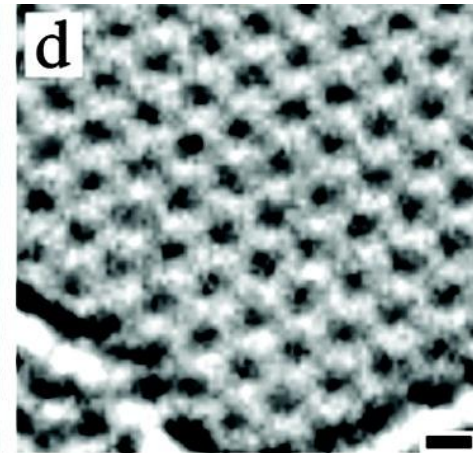
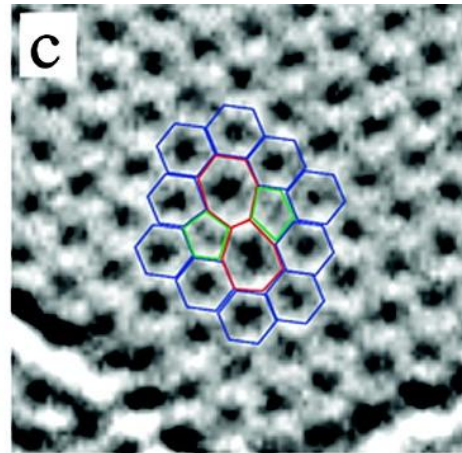
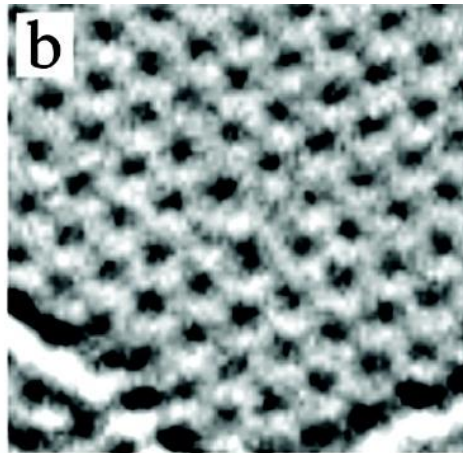
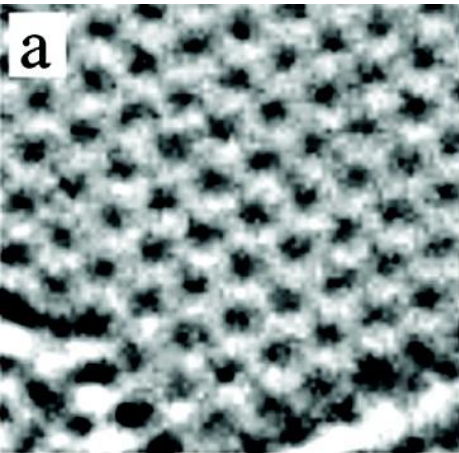
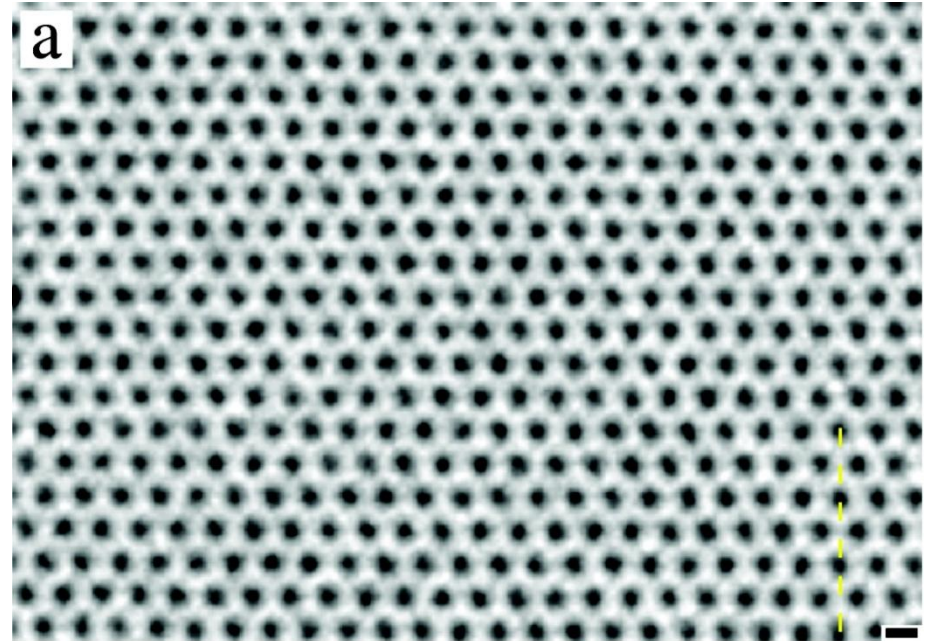


J. C. Meyer, C. Kisielowski, R. Erni, M. D. Rossell,
M. F. Crommie, A. Zettl, *Nano Lett.* 8, 3582 (2008)

HRTEM of graphene

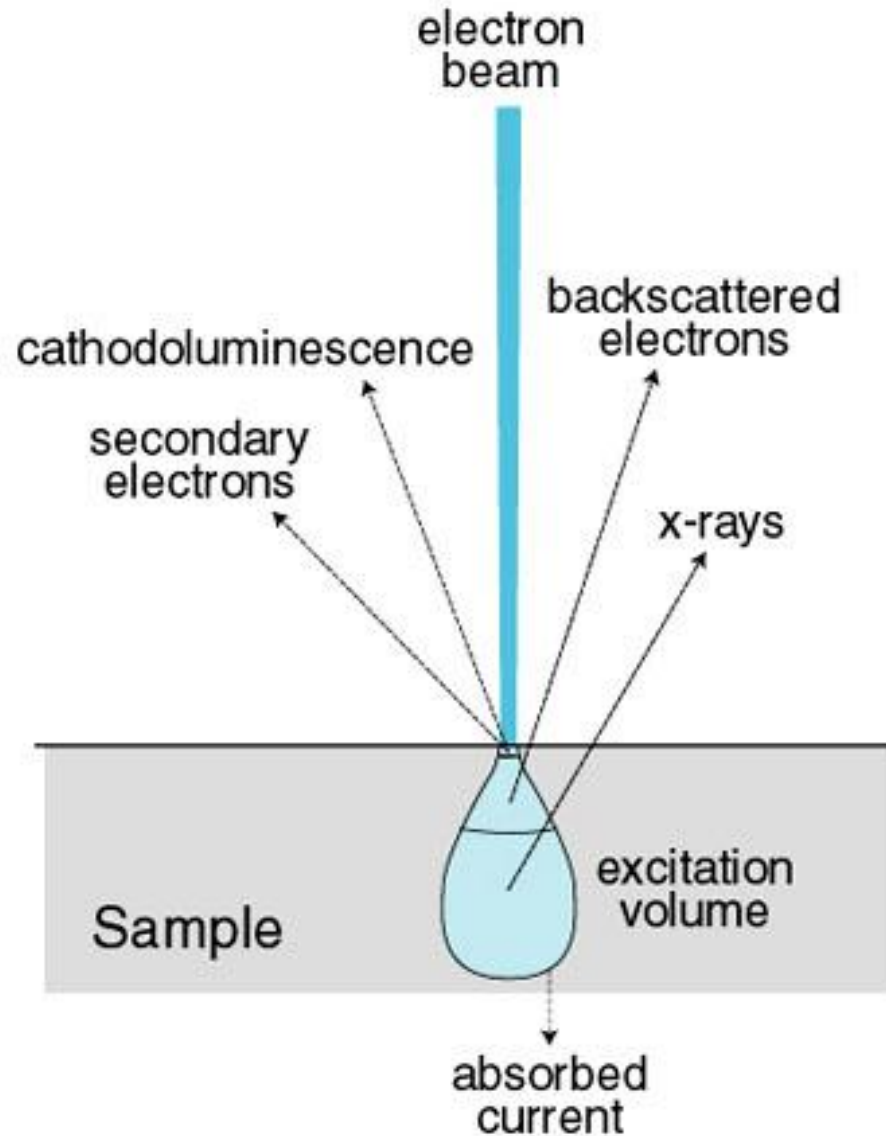


Stone-Wales defect

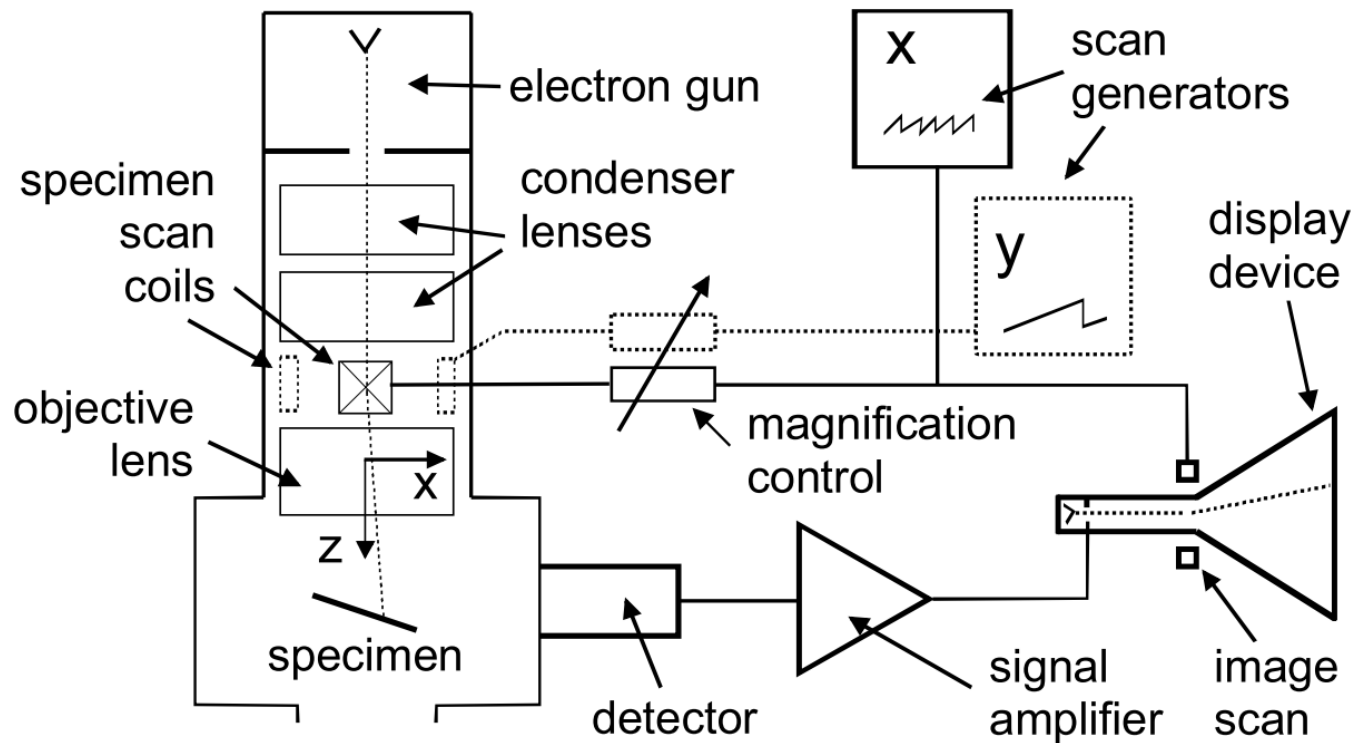


J. C. Meyer, C. Kisielowski, R. Erni, M. D. Rossell, M. F. Crommie, A. Zettl, Nano Lett. 8, 3582 (2008)

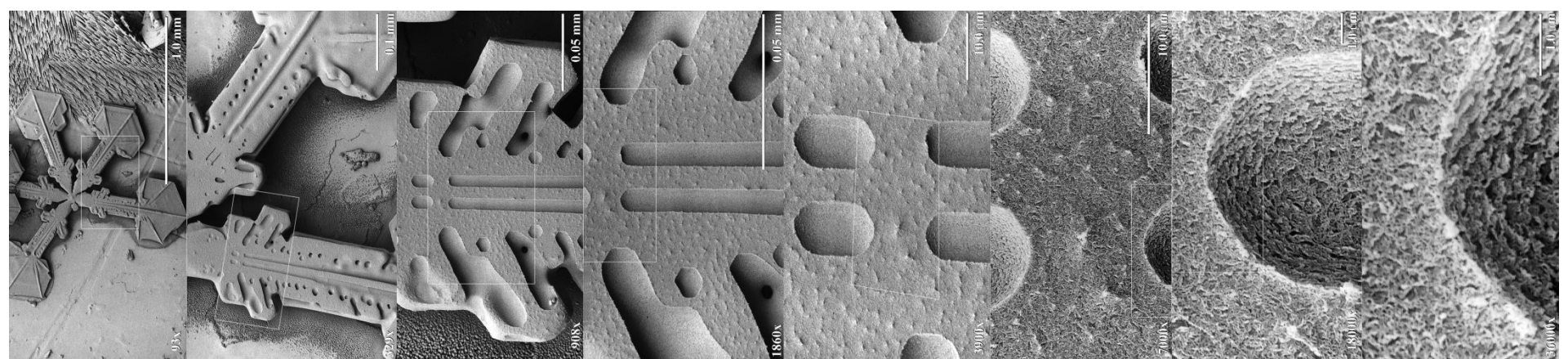
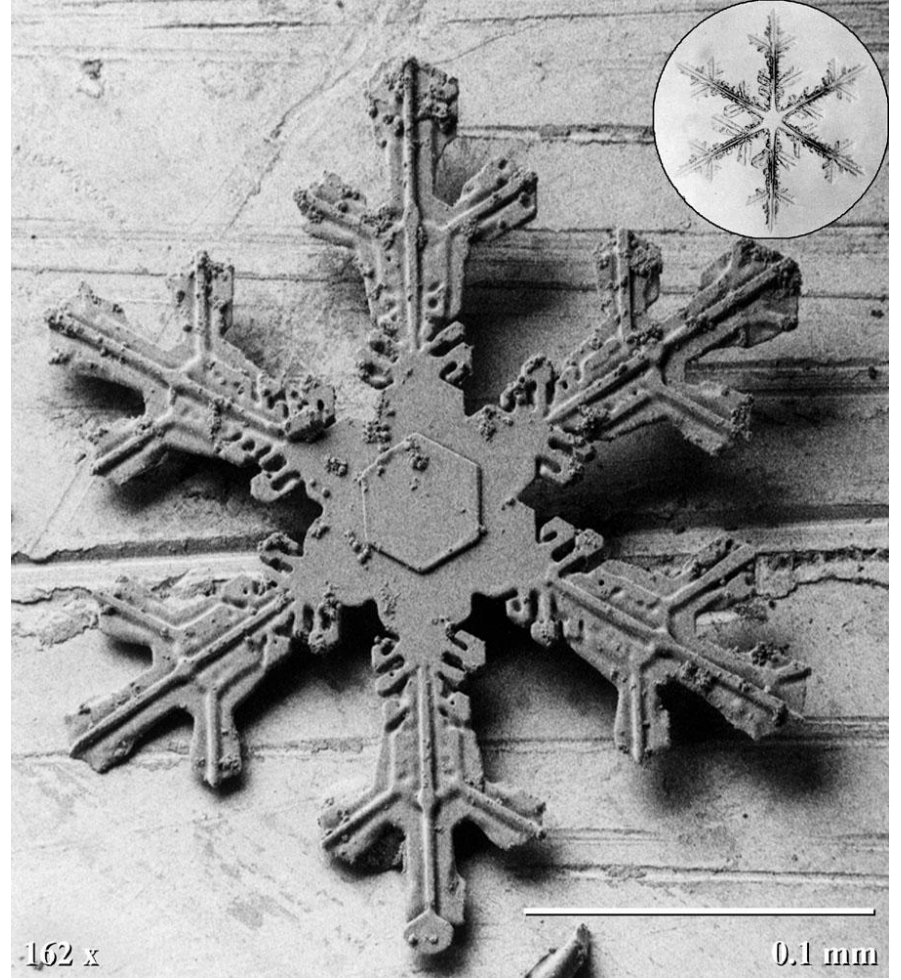
Interaction of e^- with matter



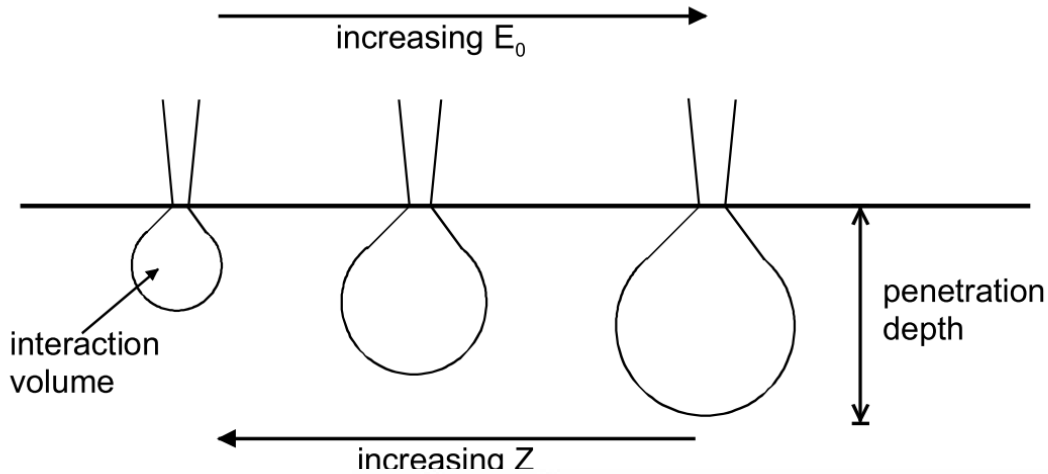
SEM – principle of operation



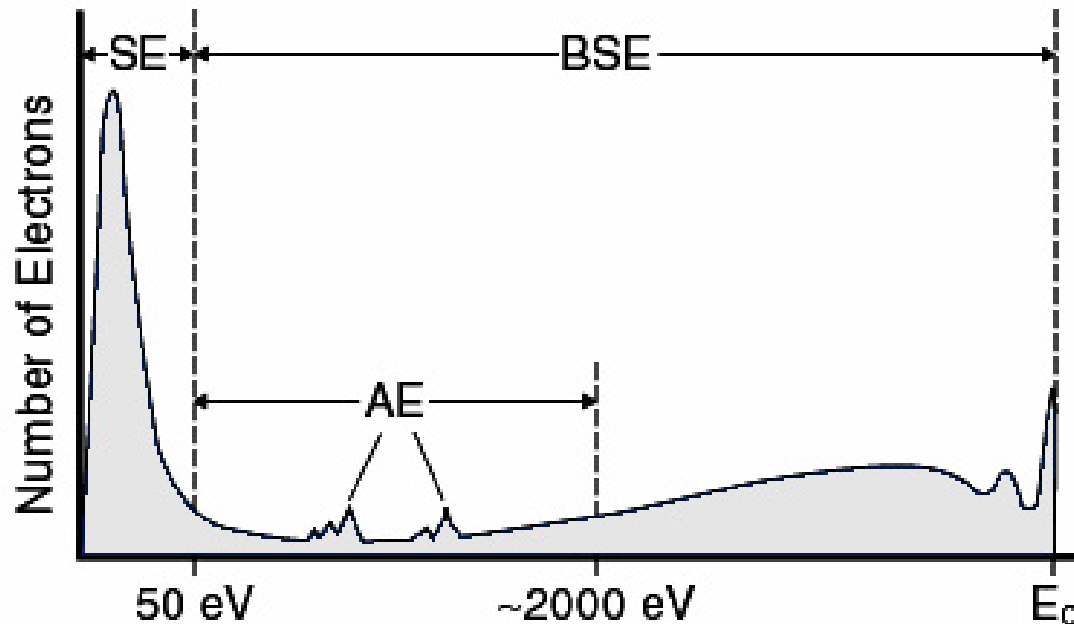
SEM



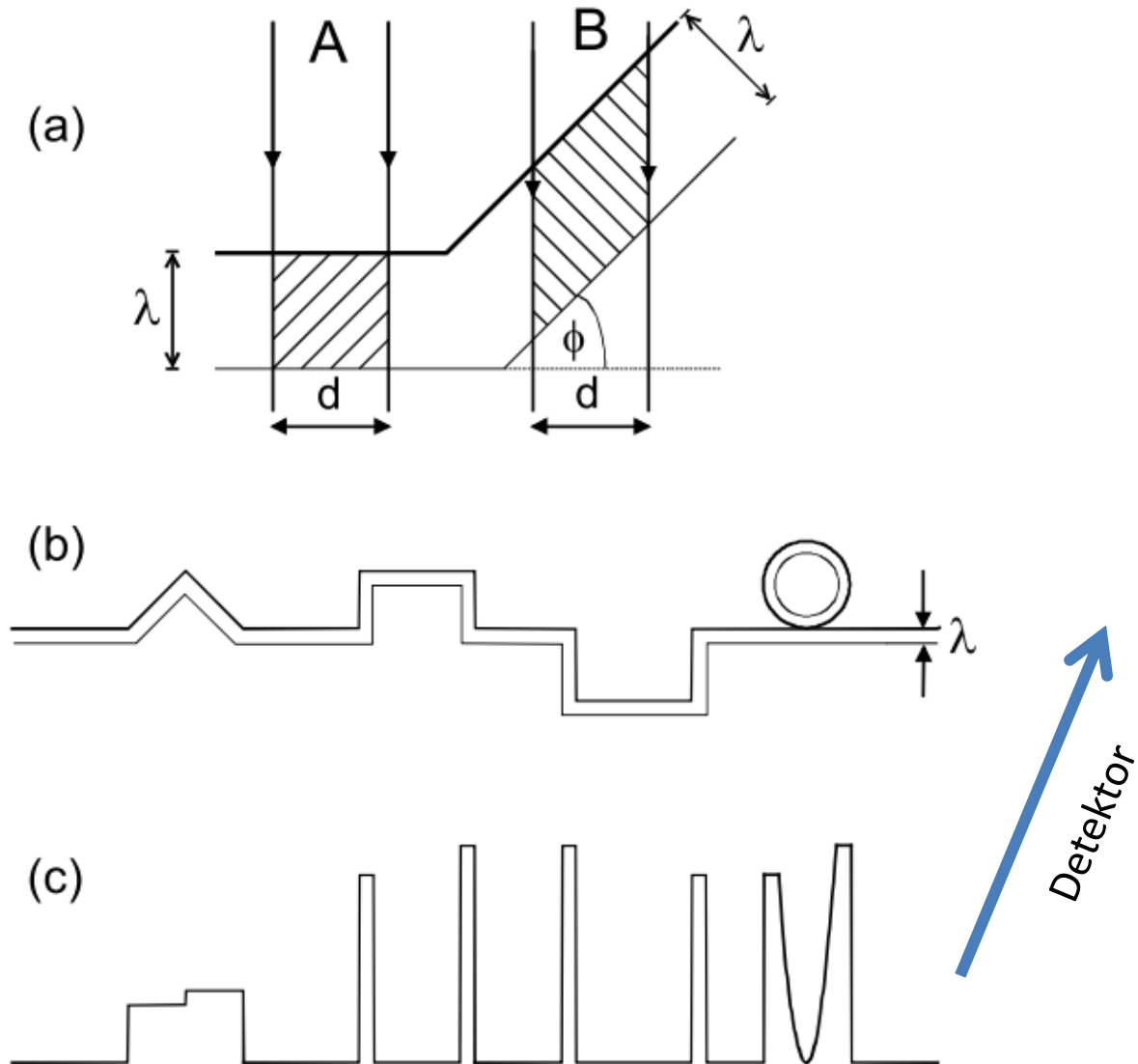
Interaction of electrons with matter



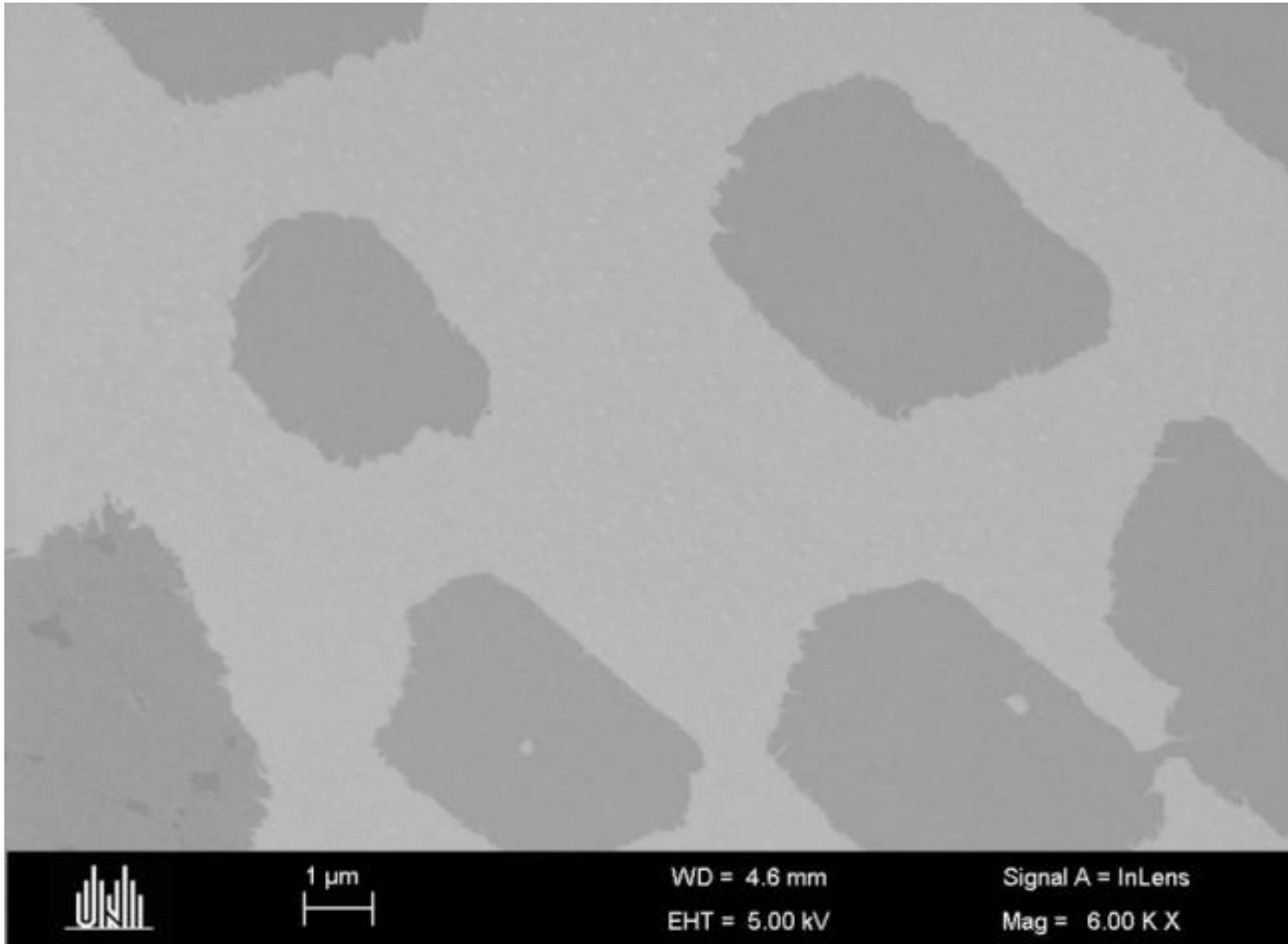
	1 keV	10 keV
C	50 nm	1000 nm
Au	10 nm	200 nm



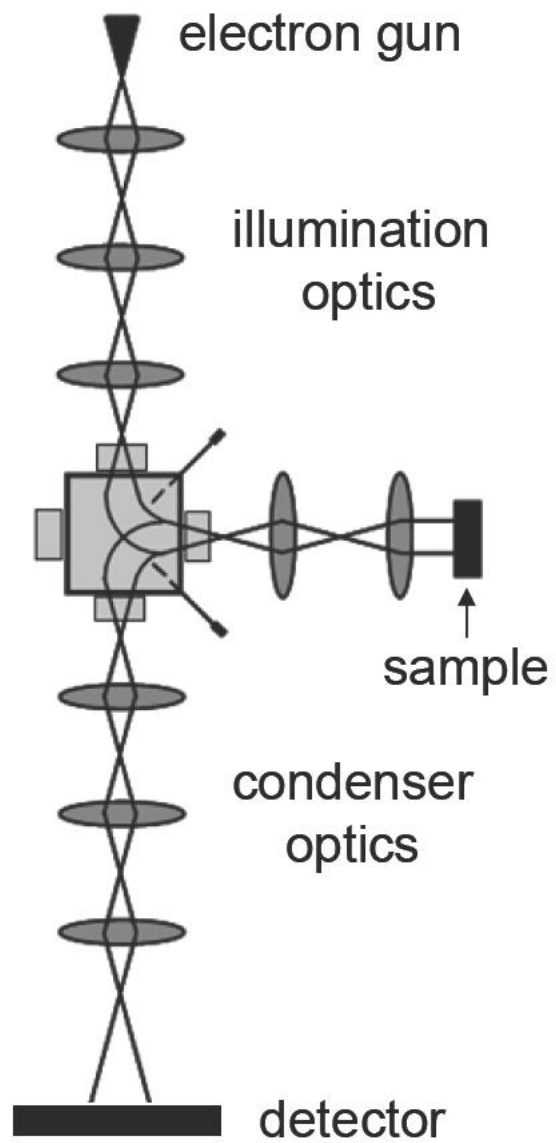
Contrast formation by secondary e⁻

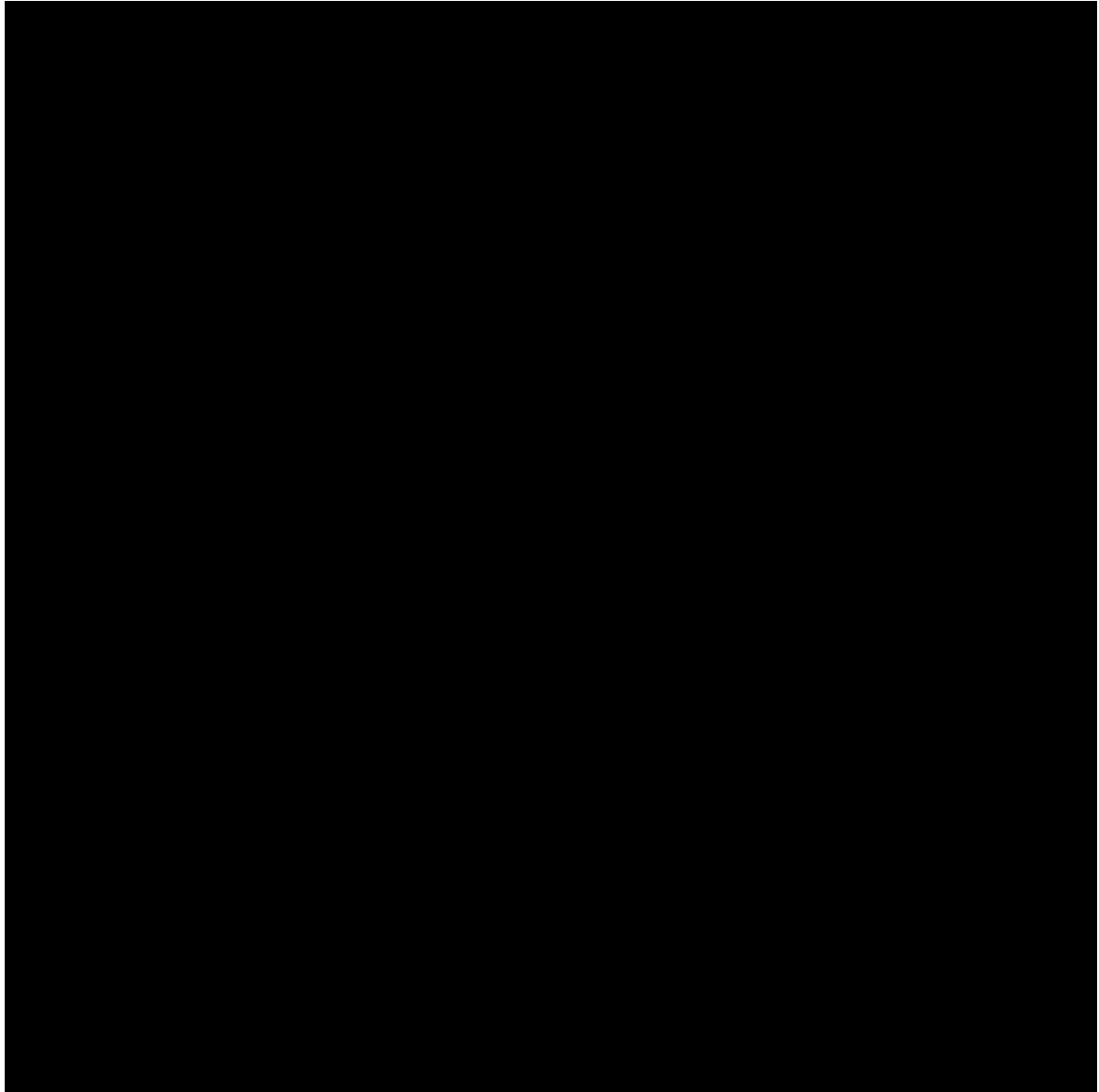


SEM of graphene on Ir(111)



LEEM

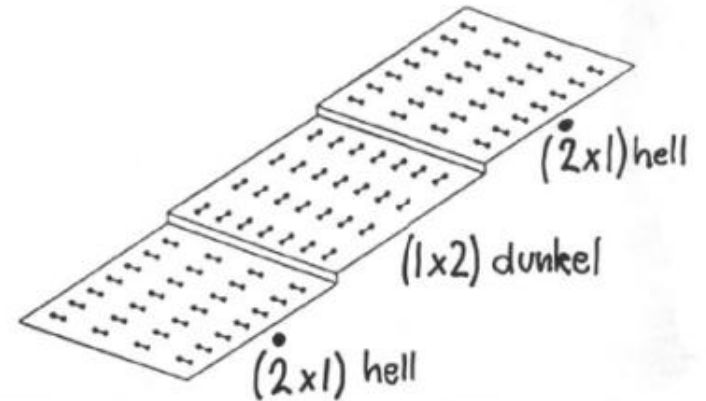




Dark Field Imaging: Si(100) – 2x1



4 μm



600°C

Si
↓
Si(001)



Bright Field Imaging:
Pattern Formation by
Pb on Cu/Pb on
Cu(111)

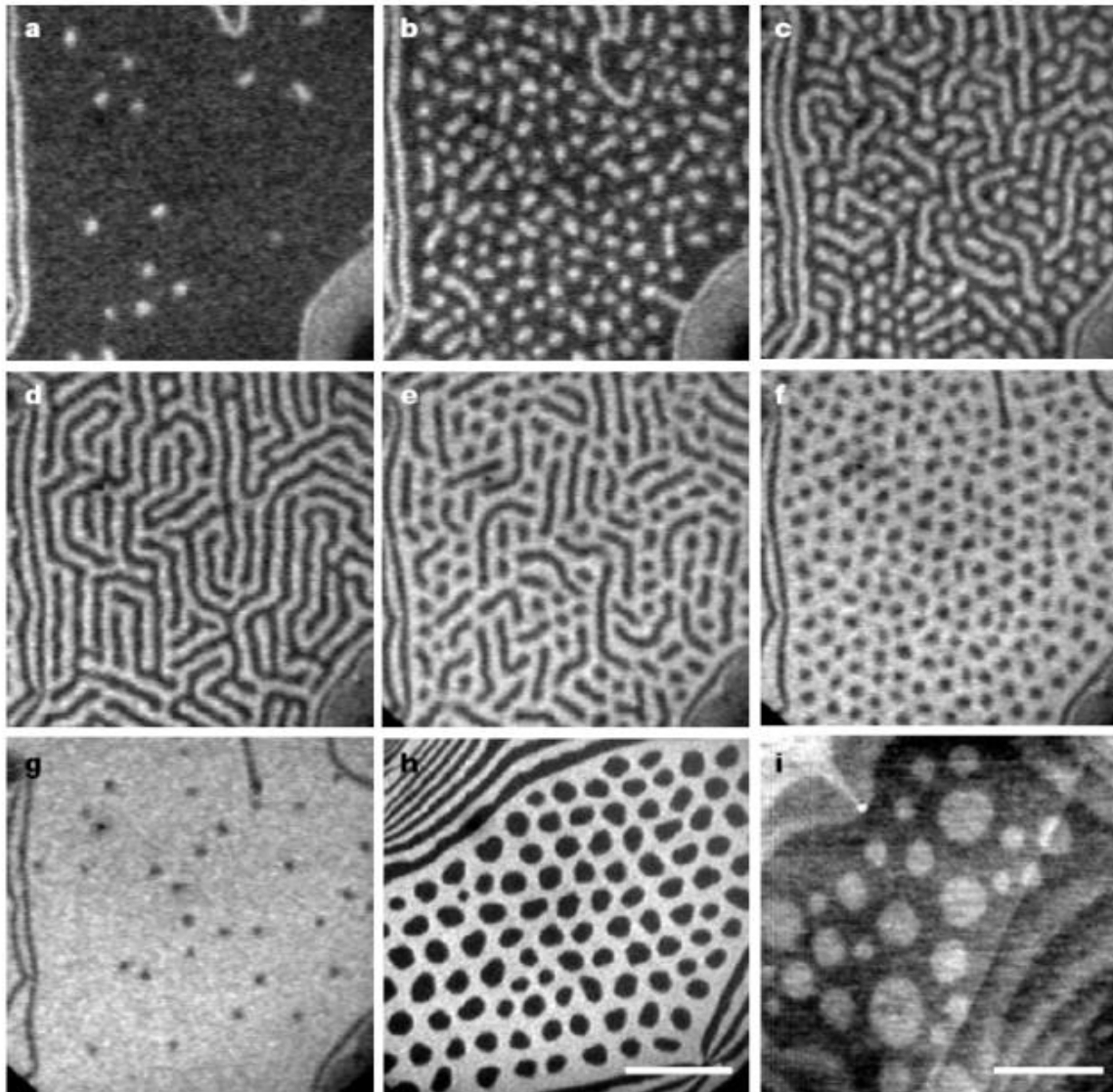


Figure 1 Self-assembly of Pb on Cu(111). Low-energy electron micrographs of the Cu(111) surface at 673 K with different area fractions of the lead-overlayer phase (bright) in the surface alloy phase (dark). **a–g**, Area fractions 0.03, 0.28, 0.35, 0.50, 0.65, 0.73 and 0.95, respectively. The domain pattern evolves from circular islands (droplets) to stripes, to vacancy islands (inverted droplets) with increasing lead coverage. **h**, Ordered droplet configuration at 623 K. Scale bar, 0.5 μm . **i**, Atomic-force micrograph of a droplet pattern after cooling down to room temperature and 2 hours of exposure to air. Scale bar, 0.3 μm .

R. Plass, J.A. Last, N.C.
Bartelt, G.L. Kellogg,
Nature 412 (2001) 875L

Fig. 21b