FIGURE 5.1 A schematic diagram of the operating principle of STEM, showing BF-STEM, DF-STEM and HAADF-STEM detectors.

FIGURE 5.2 Ray diagram for a round lens with spherical aberration. Because of spherical aberration, rays entering a round lens system away from the optical axis are refracted more strongly than those entering closer to the optical axis.
FIGURE 5.3 Phase diagrams of the structure of Au nanoparticles, presented in (A) by Marks in 1994\textsuperscript{2} and (B) Barnard et al.\textsuperscript{49} in 2009. In (A), the dashed lines were extrapolated from the experimental results shown in the solid lines. In (B), The solid lines were from the simulation whiles the different symbols were experimental data. It is apparent that the general trend is similar in both studies, though the actual phase boundaries are slightly different. In both cases, experimental data were missing for nanoparticles smaller than 5nm in diameter.
FIGURE 5.6  Three-dimensional atomic structure of an Au$_{309}$ cluster. (A) 3D intensity profile plot of Au$_{309}$ derived from Figure 5.5A. A hard-sphere model for an Ino-decahedral structure is shown with the electron beam (arrow) parallel to the fivefold axis. (B) Experimental intensity line profile taken from the central atom column of the cluster to one of the corners. (C) Simulated HAADF-STEM image (inset), obtained with a simple kinematical approach, of an Au$_{309}$ cluster with Ino-decahedral geometry. An intensity profile (solid curve) across one ridge is compared with the result from a full dynamical multislice calculation (dashed line). 8

FIGURE 5.7  HAADF intensity as a function of number of Au atoms along the column, by multislice simulation. 58
FIGURE 5.8 (A–E) HAADF-STEM images of Au nanoparticles on TiO$_2$(110) arranged in the order of projected particle size. The lattice coherency between Au nanoparticles and TiO$_2$ substrate changes according to the Au particle size. Panels (A) and (B) are coherent and (C)–(E) are incoherent. (F) Magnified image of the epitaxial Au structure shown in (A). Here, two types of Au sites are identified: on top of Ti–O columns and on top of O columns in the troughs of Ti-containing columns (along the arrows). (G) A histogram of the formation of coherent or incoherent interfaces as a function of Au nanoparticle lateral size.
FIGURE 5.9 Cross-sectional HAADF-STEM images of Au nanoparticles, supported on TiO$_2$(110), with width (A) 10.9 and (B) 4.3 nm. (C) An atomistic model of Au nanoparticle on TiO$_2$. (D) A schematic Au nanoparticle showing measurements of nanoparticle dimensions.$^{60}$
FIGURE 5.12  Relationship between particle diameter and $N^{1/3}$ for Au nanoparticles prepared by three different methods: (A) colloidal nanoparticles, (B) nanoparticles by thermal evaporation and (C) size-selected clusters performed in gas phase and soft-landed on the surface. Spherical cluster approximation (the blue solid line) and hemispherical cluster approximation (the red dashed line) are shown to allow comparison of overall particle geometry. 

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FIGURE 5.14  Weighing monolayer-protected (MP) Au$_{38}$ clusters using size-selected Au clusters. (A) Schematics showing that both types of clusters are co-deposited on the same TEM grid. (B and C) Typical HAADF images of size-selected Au$_{38}$ clusters and MP-Au$_{38}$ clusters (with a monomer arrowed). (D and E) Integrated HAADF intensities of MP-Au$_{38}$ monomers are compared with size-selected Au$_{38}$ and Au$_{25}$ clusters, respectively.\textsuperscript{65}
FIGURE 5.15  Schematic representation of some possible atomic structures of bimetallic nanoparticles. (A) Core–shell, (B) sub-cluster segregation, (C) mixed and (D) three shells.66

FIGURE 5.20  (A) One-dimensional HAADF-STEM (black) and EELS (red) intensity profiles across a Pd$_{\text{core}}$Pt$_{\text{shell}}$ nanoparticle, showing that the Pt shell is two layer thick. The EELS signal is the background-subtracted Pd core loss around 420eV. (B) Two-dimensional mapping using HAADF-STEM (left) and Pd EELS signals (right) with 0.27nm per pixel resolution.51
FIGURE 5.21  (A) HAADF image of a RhIr cluster adsorbed on a MgO(110) surface. (B) Intensity surface plot of the image in (A). (C) Three-dimensional model showing the cluster structure determined by quantitative analysis.