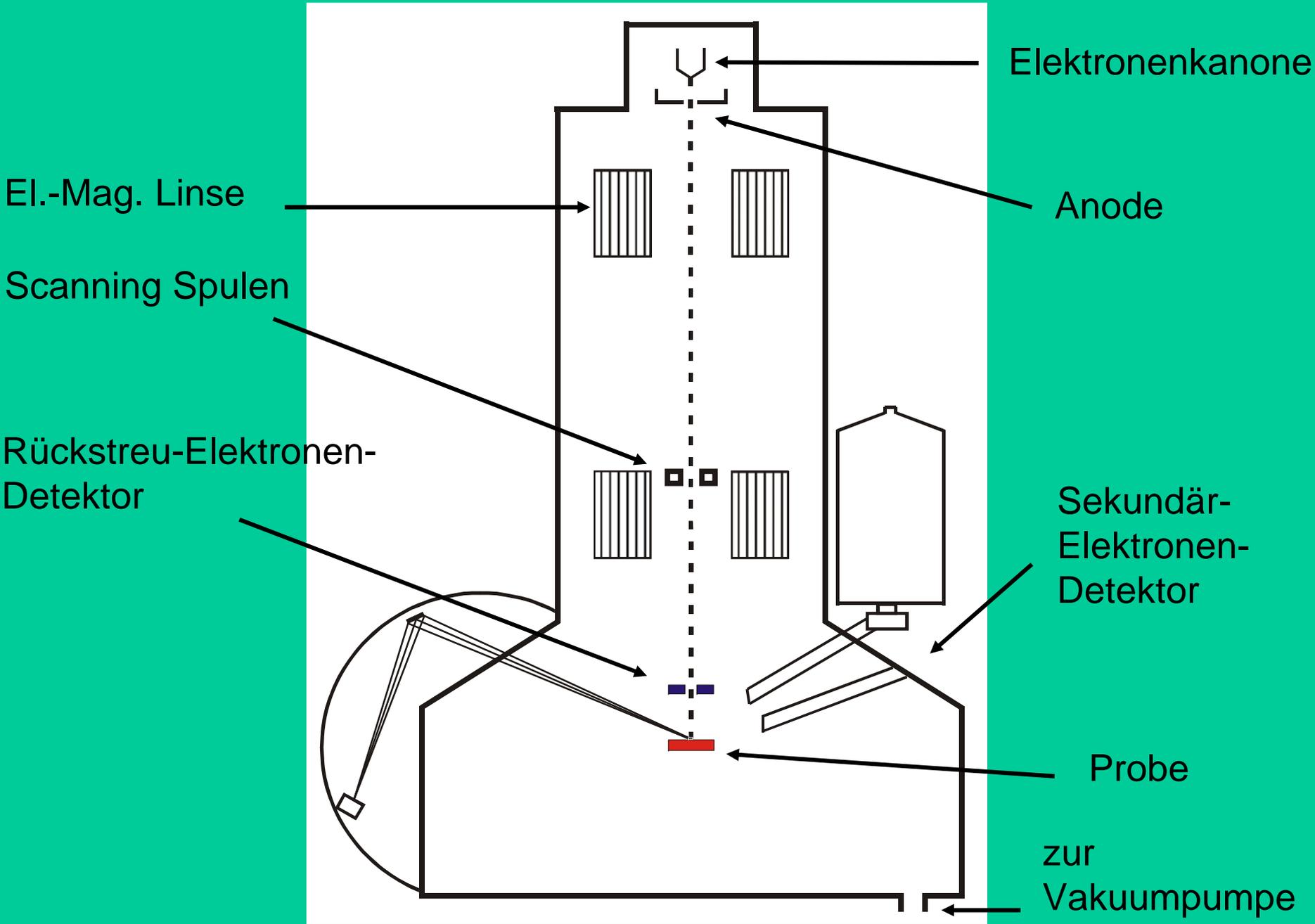


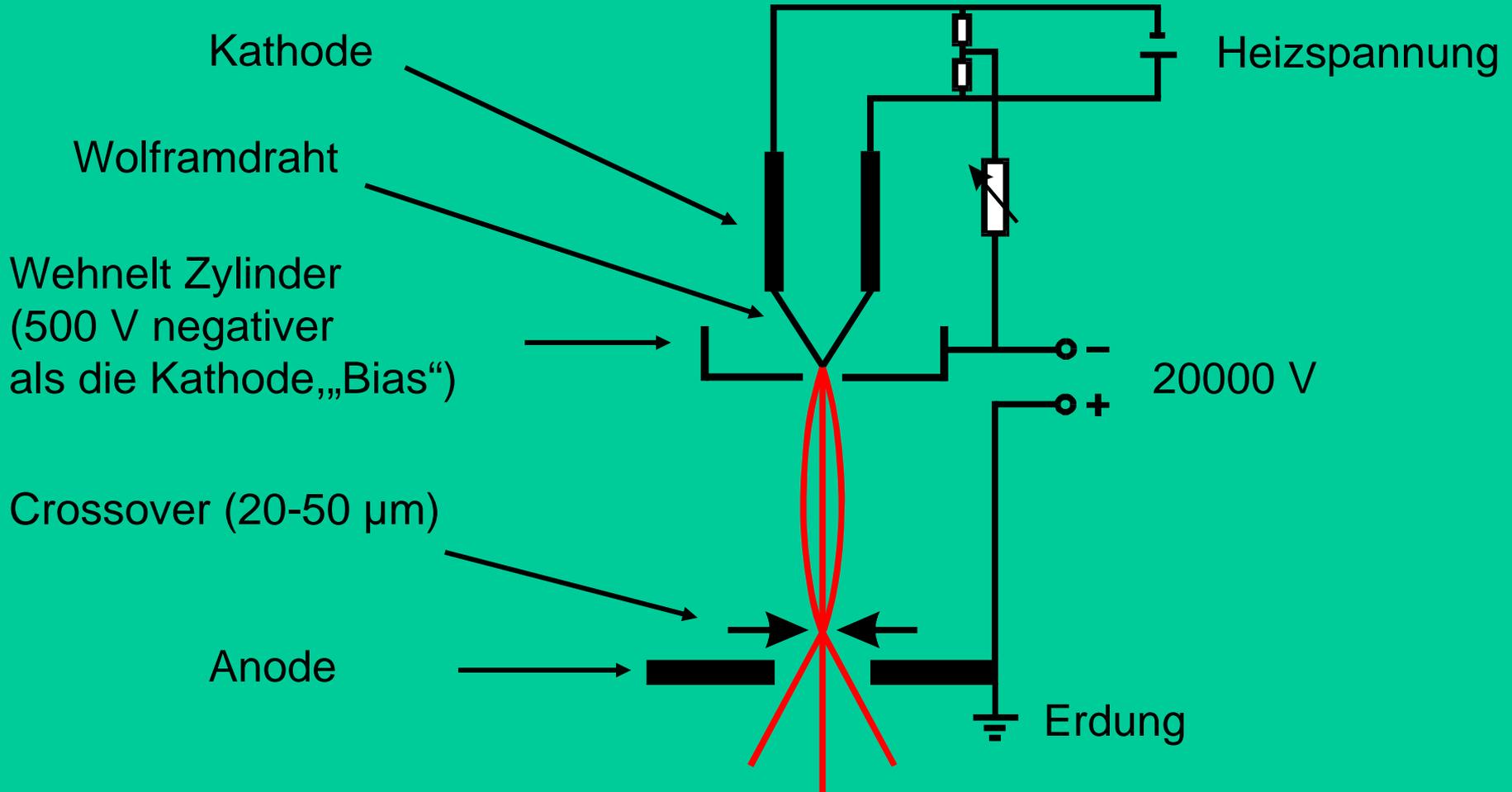
Analytisches Rasterelektronenmikroskop



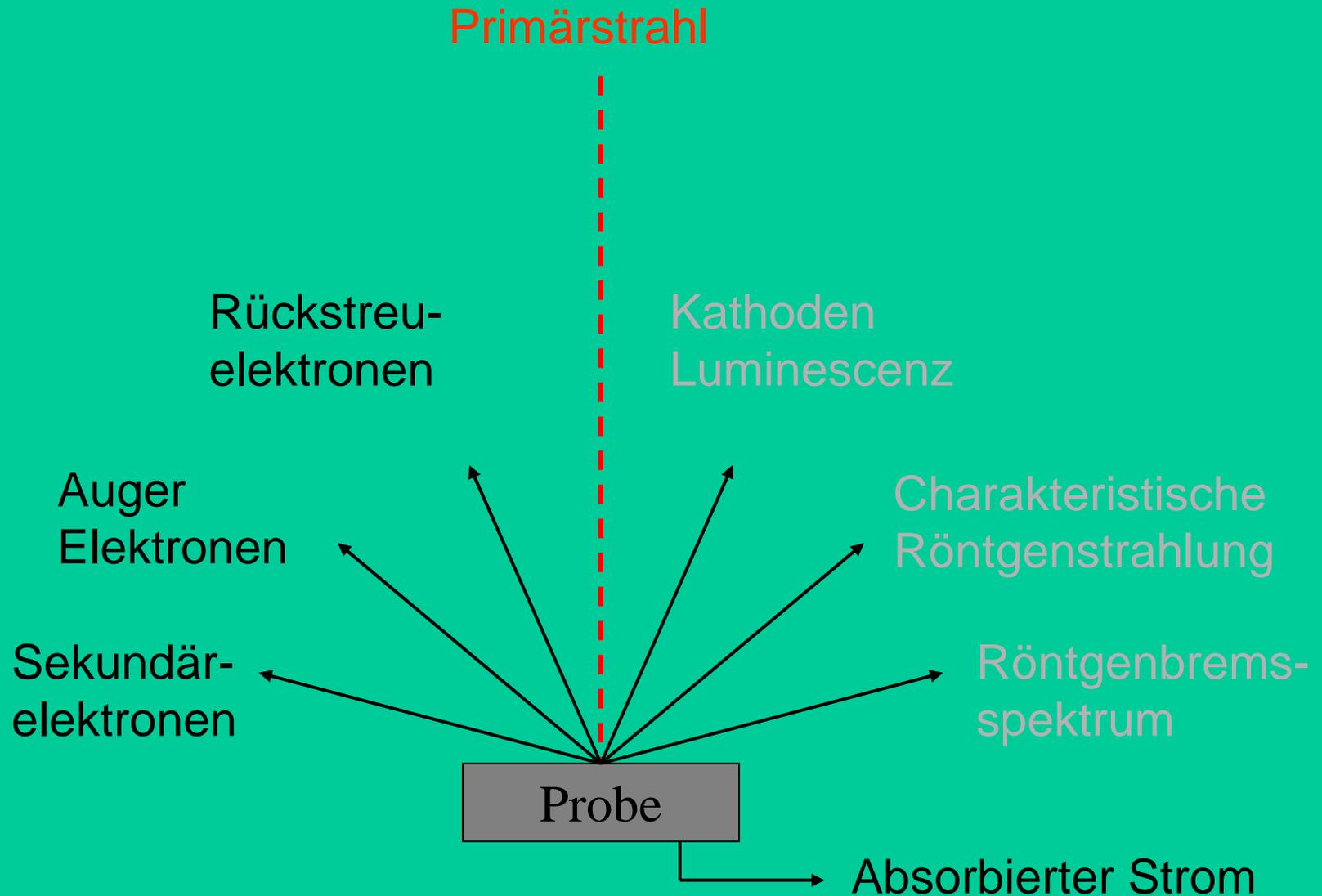
CamScan 44



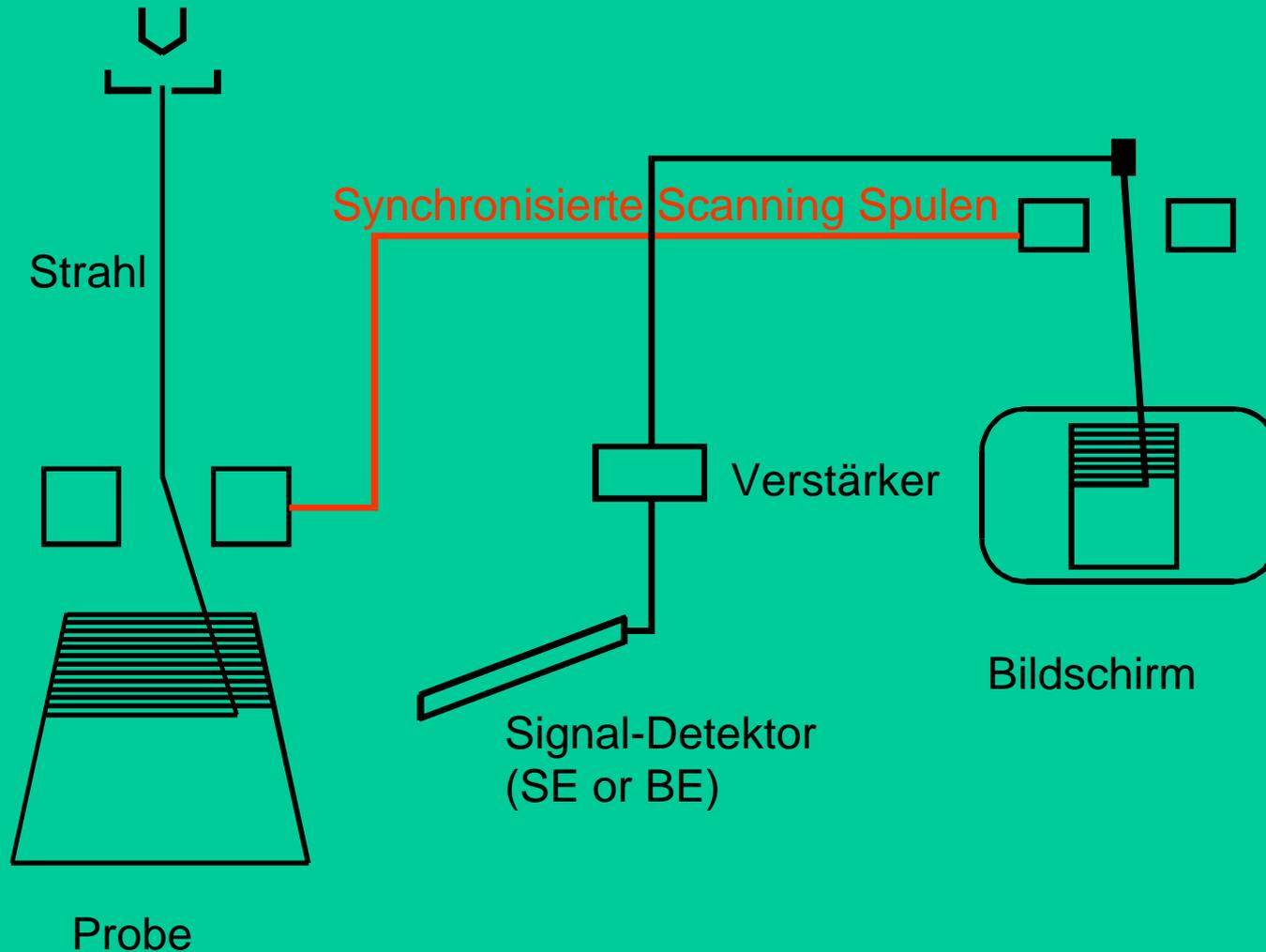
Elektronen Kanone (W-Kathode)



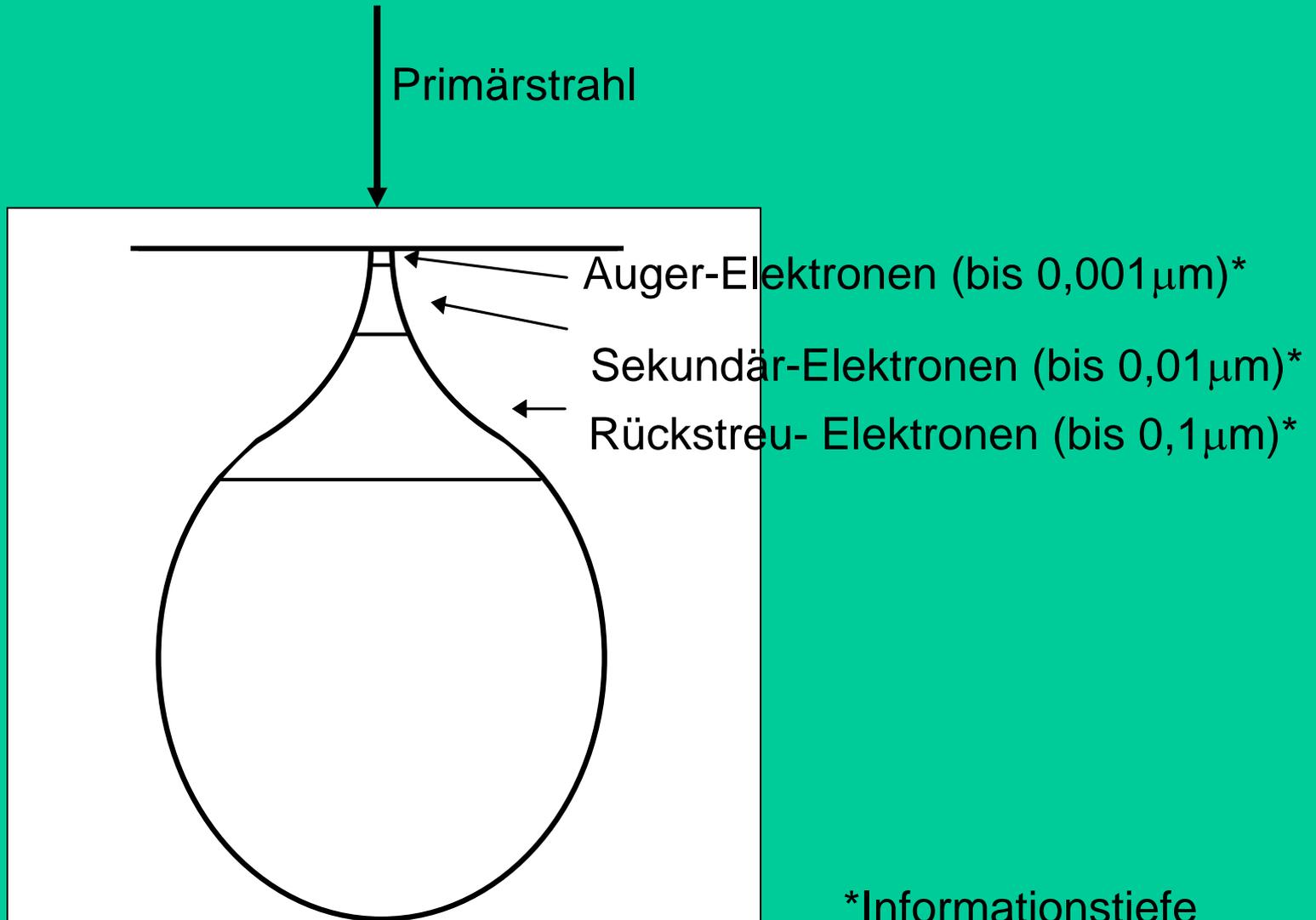
Wechselwirkungen eines hochenergetischen Elektronenstrahls mit Materie



Prinzip der Bilderzeugung



Wechselwirkungsvolumen (birnenförmig)



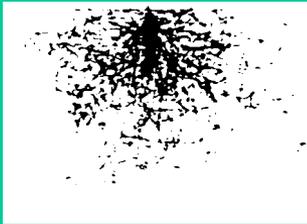
Wovon hängt das Wechselwirkungsvolumen ab?



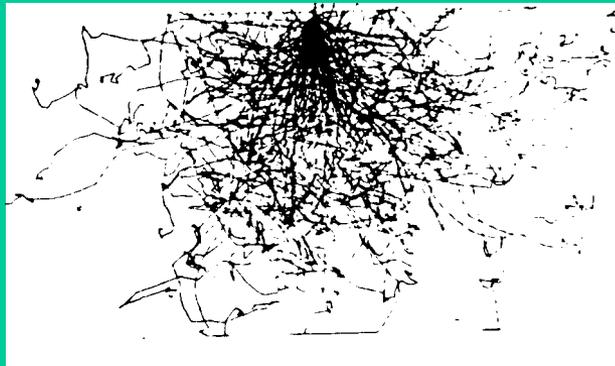
Fe (10 kV)



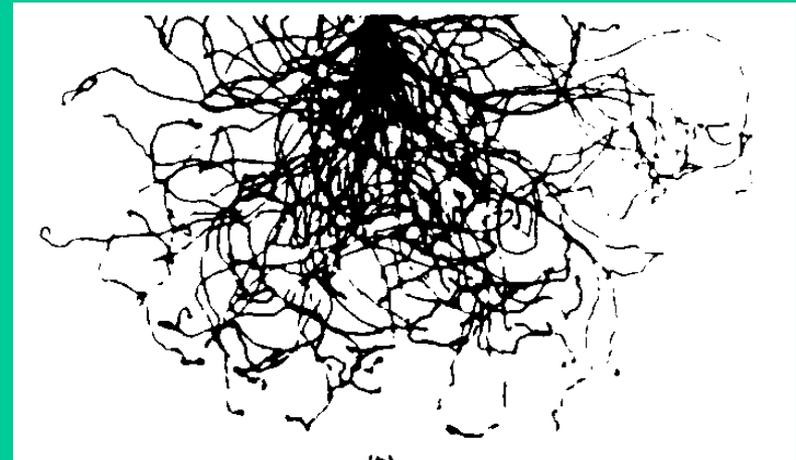
Au (20 kV)



Fe (20 kV)



Fe (30 kV)



Al (20 kV)

1 μm

Sekundär-Elektronen

- Inelastisch gestreute PE (Primär-Elektronen)
- Energie: **< 50 eV**
- maximale Emissionstiefe: **5-50 nm**

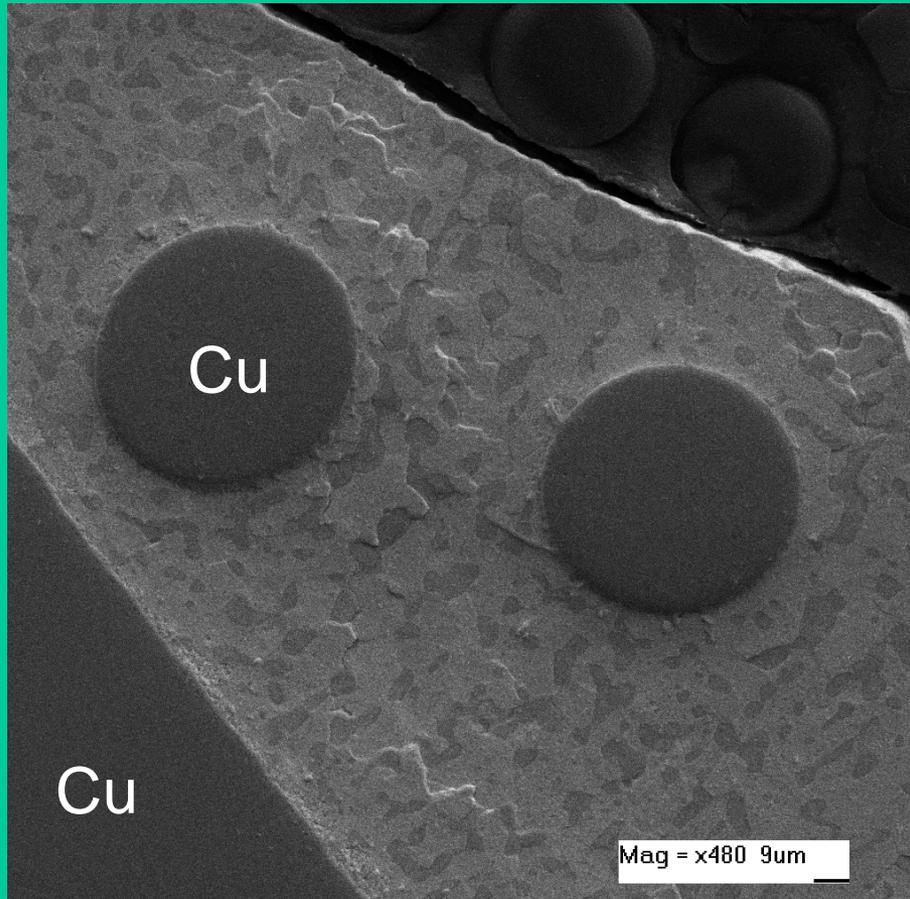
→ Hochauflösungsbilder

Rückstreu-Elektronen:

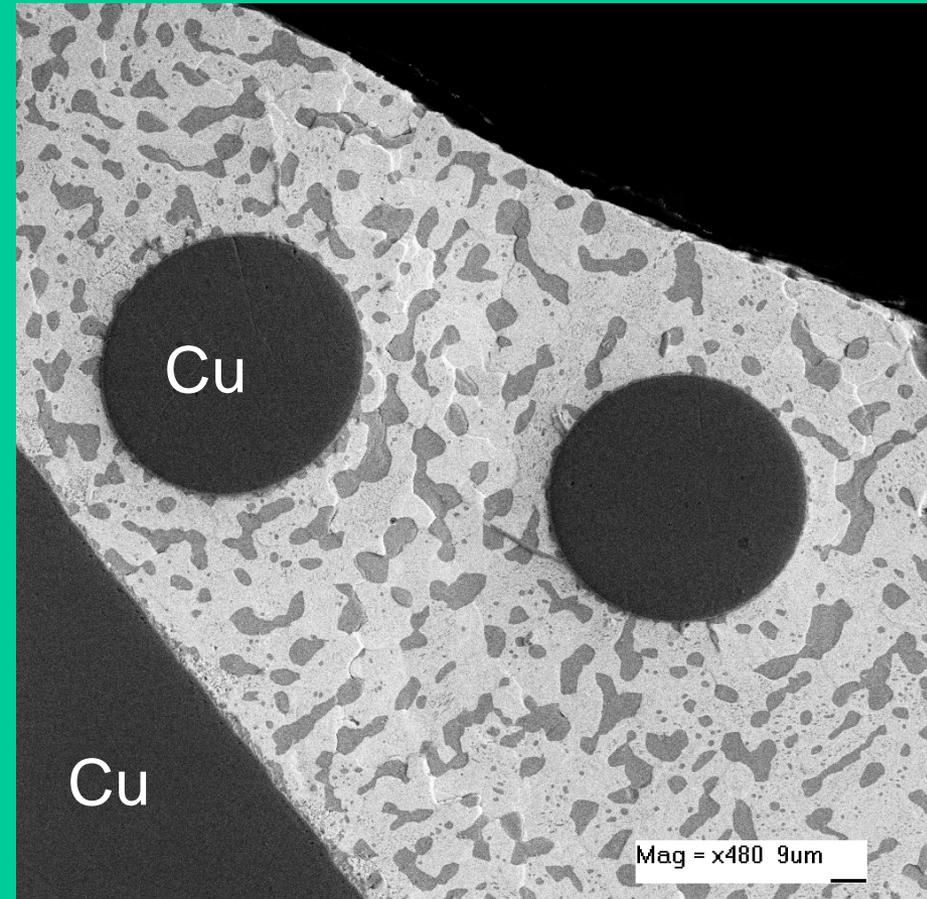
- Elastisch und inelastisch gestreute PE
- Energie: **50 eV – Energie der PE** (z.B. 20 keV)
- Maximale Emissionstiefe: **0.1 - 6 μ m** (abhängig von der Probe)
- Intensität hängt von der Ordnungszahl der Probe ab
(\rightarrow Materialkontrastbilder)
- Großes Wechselwirkungsvolumen
(\rightarrow gering aufgelöste Bilder)

Cu-Draht eingebettet in Lötzinn

SE-Bild
(hohe Auflösung)

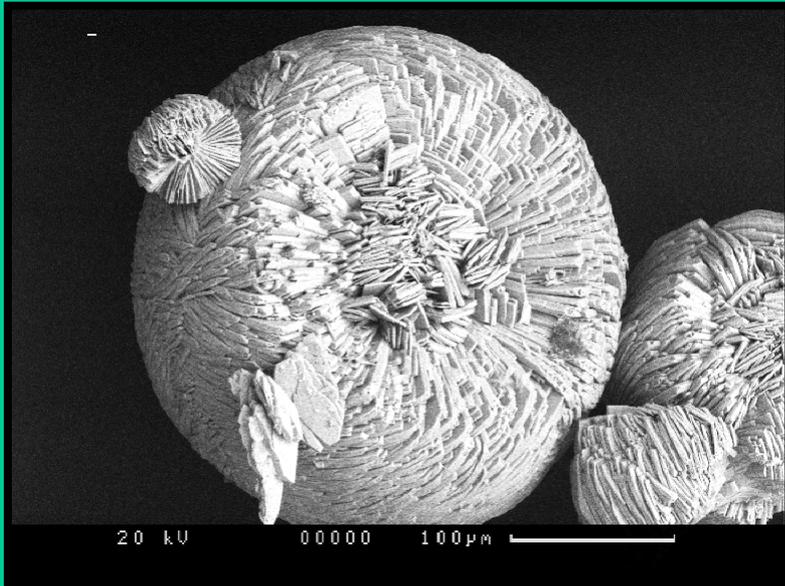


BE-Image
(hoher Z-Kontrast)

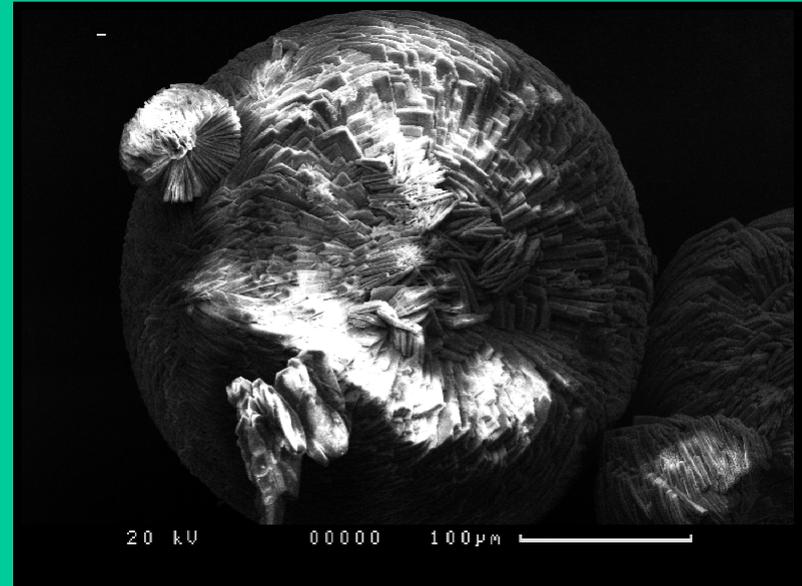


$$Z_{\text{Pb}} > Z_{\text{Sn}} > Z_{\text{Cu}}$$

BE sind weniger empfindlich bezüglich Aufladung

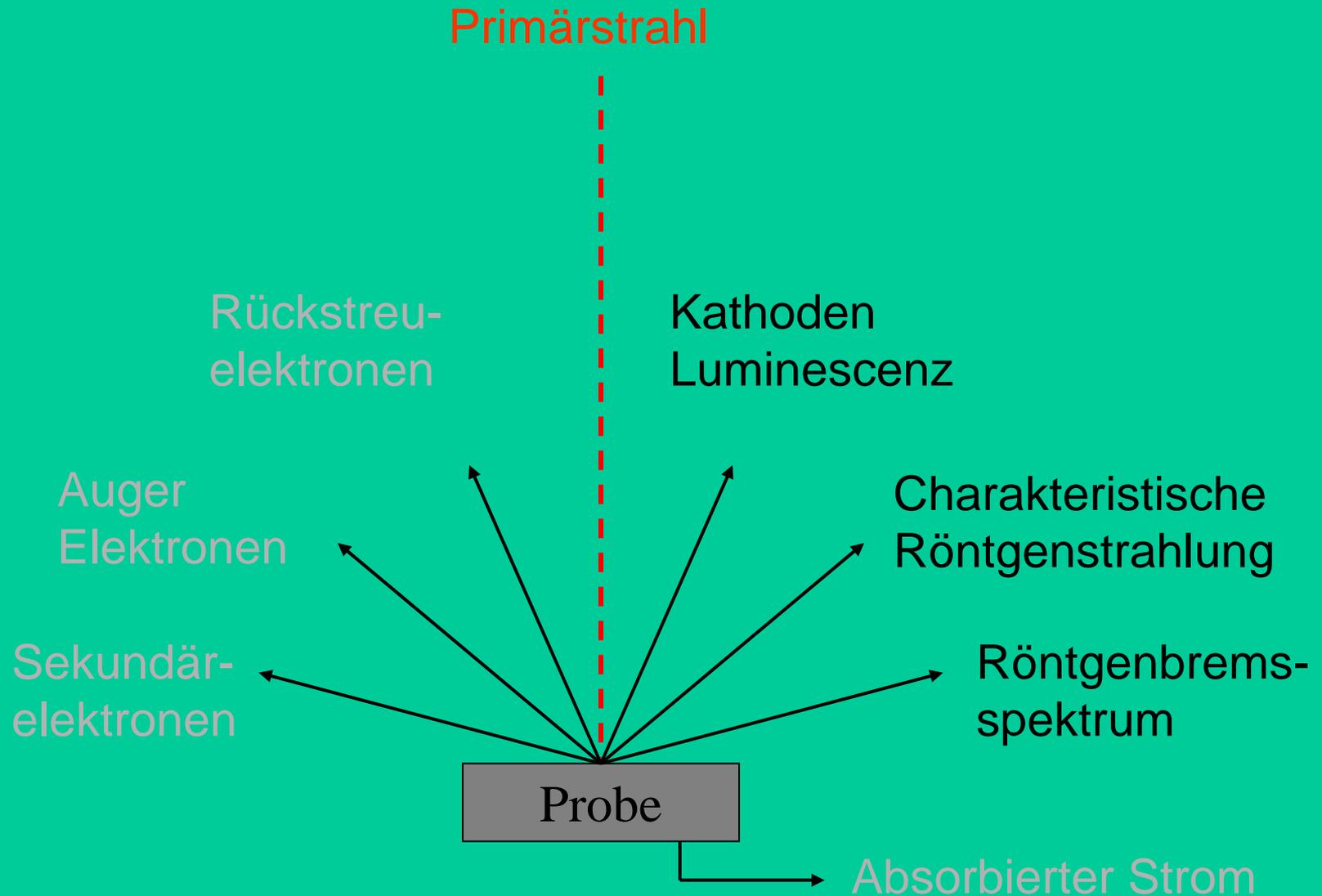


BE-Bild



SE-Bild

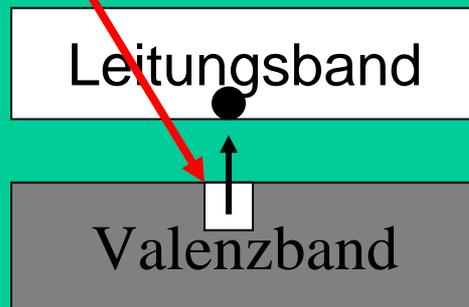
Wechselwirkungen eines hochenergetischen Elektronenstrahls mit Materie



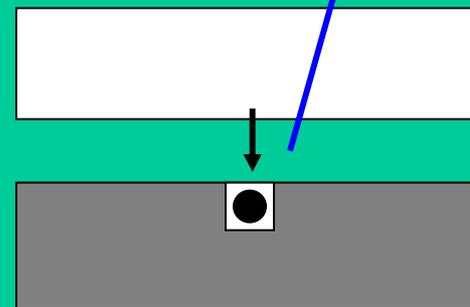
Kathoden Lumineszenz

- UV oder sichtbares Licht
- spezieller Detektor notwendig

PE

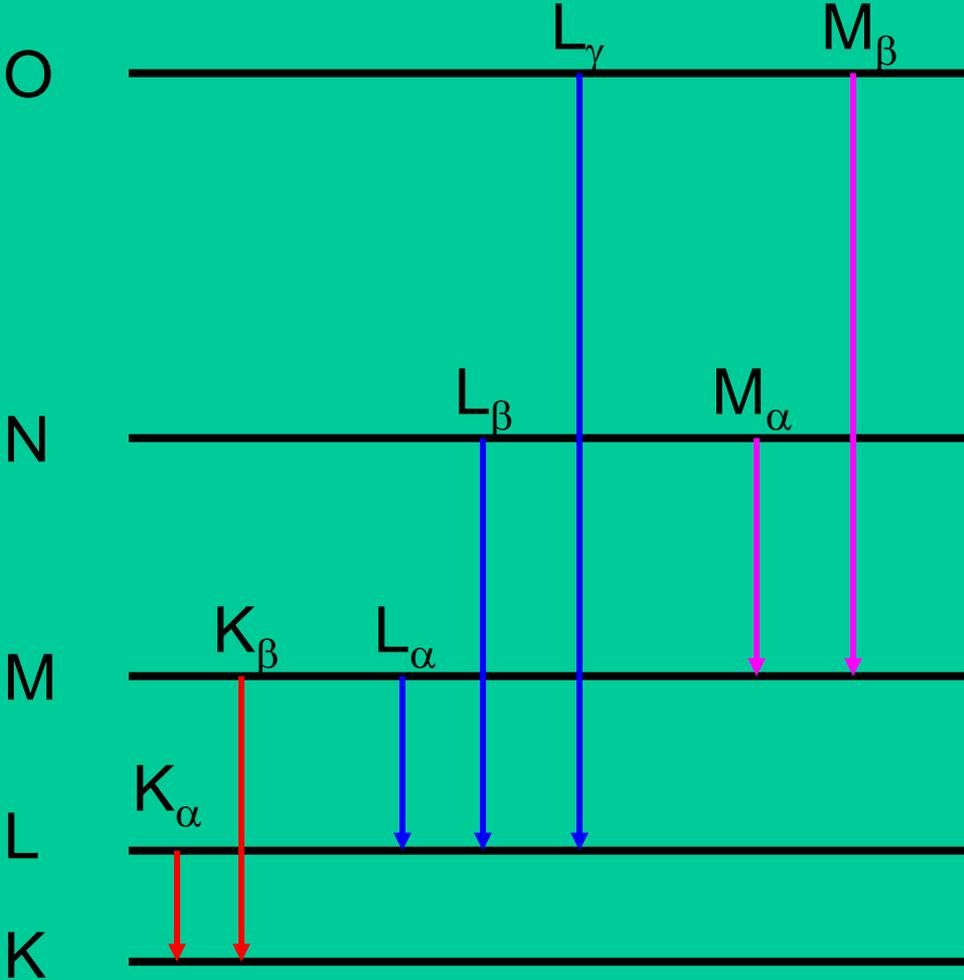


$h\nu$

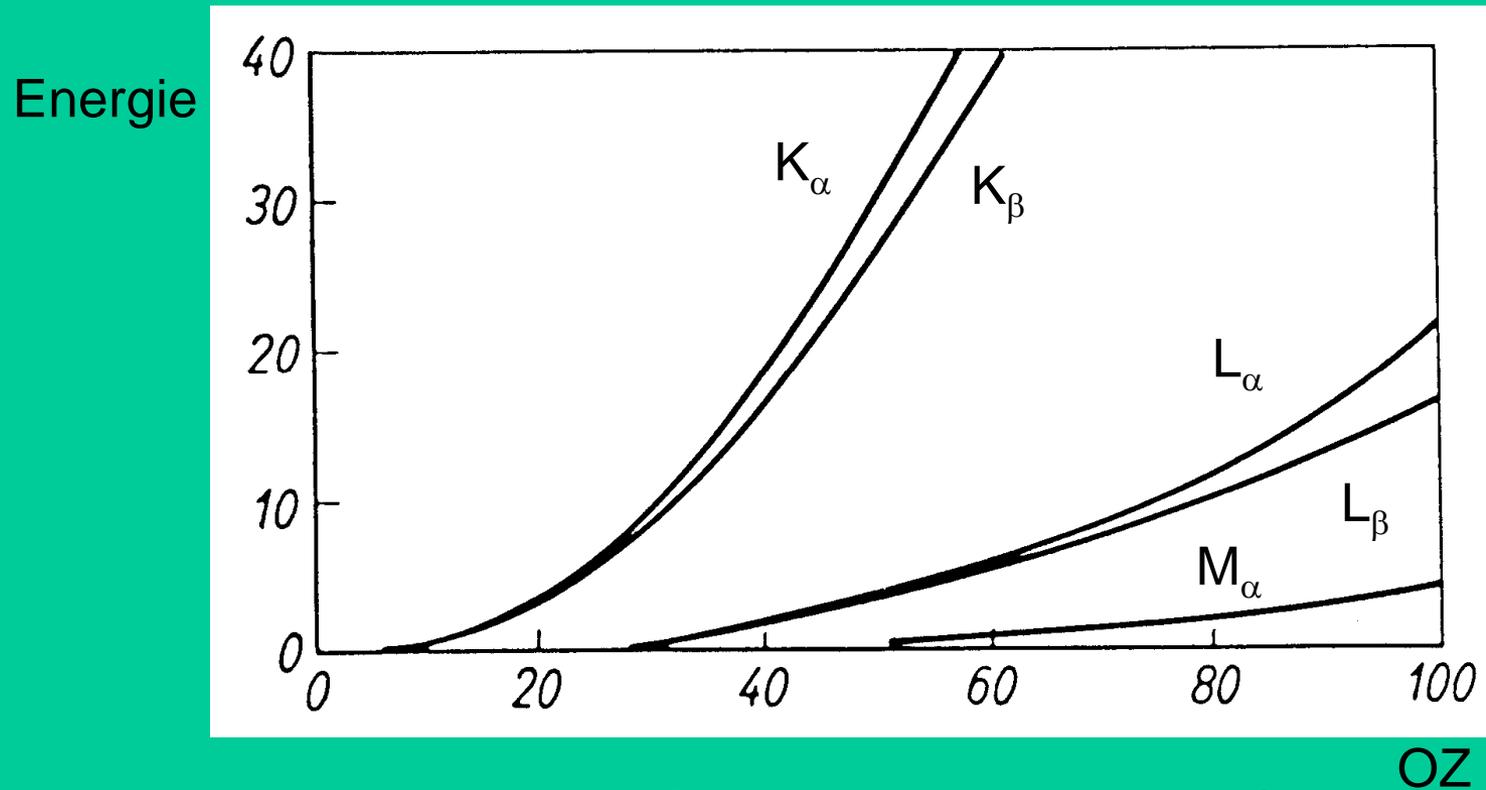


Charakteristisches Röntgen-Spektrum

(ohne Feinstruktur)



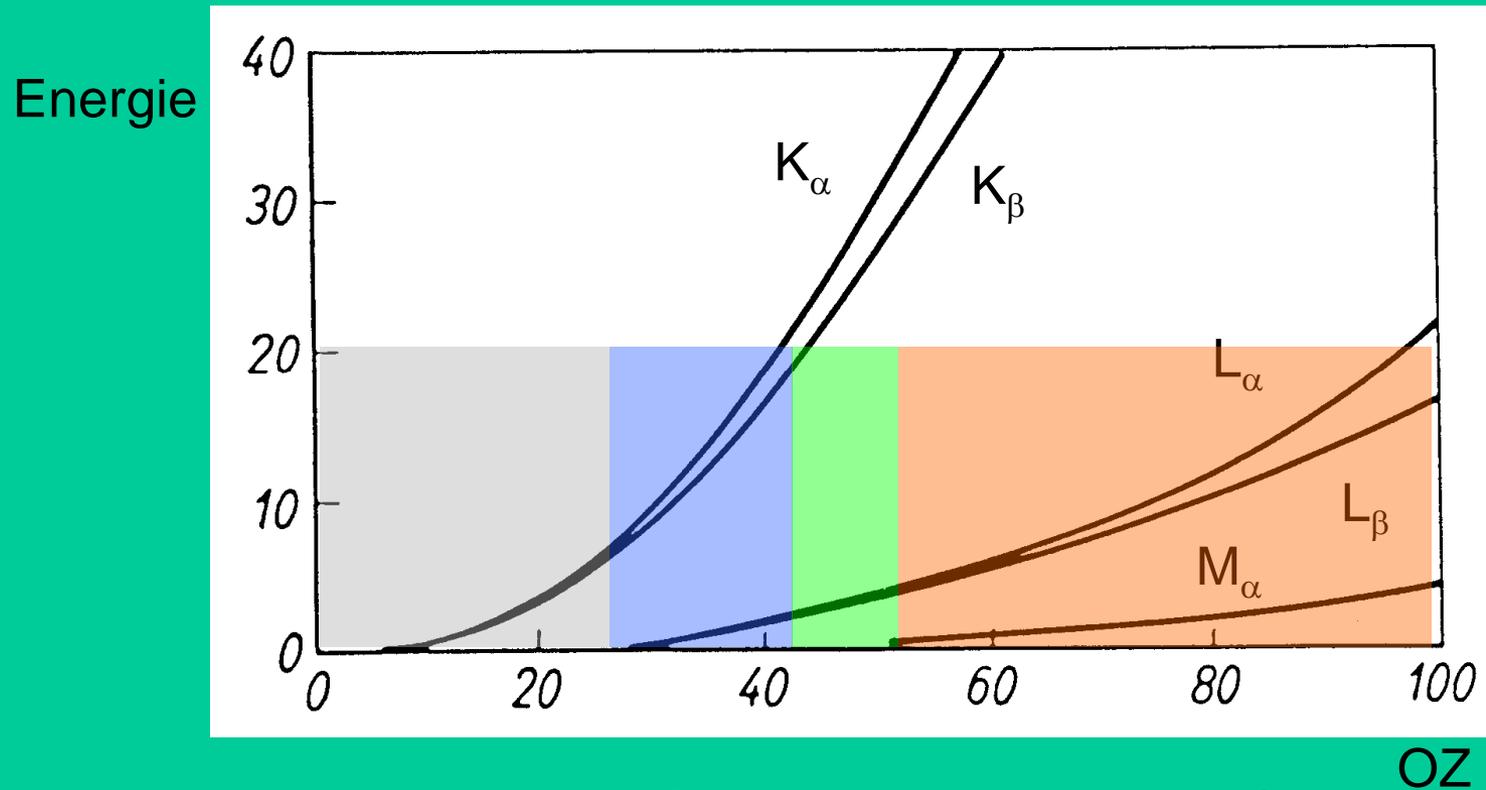
Energiebereich der Hauptserien als Funktion der OZ



Mosley's Gesetz: $1/\lambda = K (Z-1)^2$

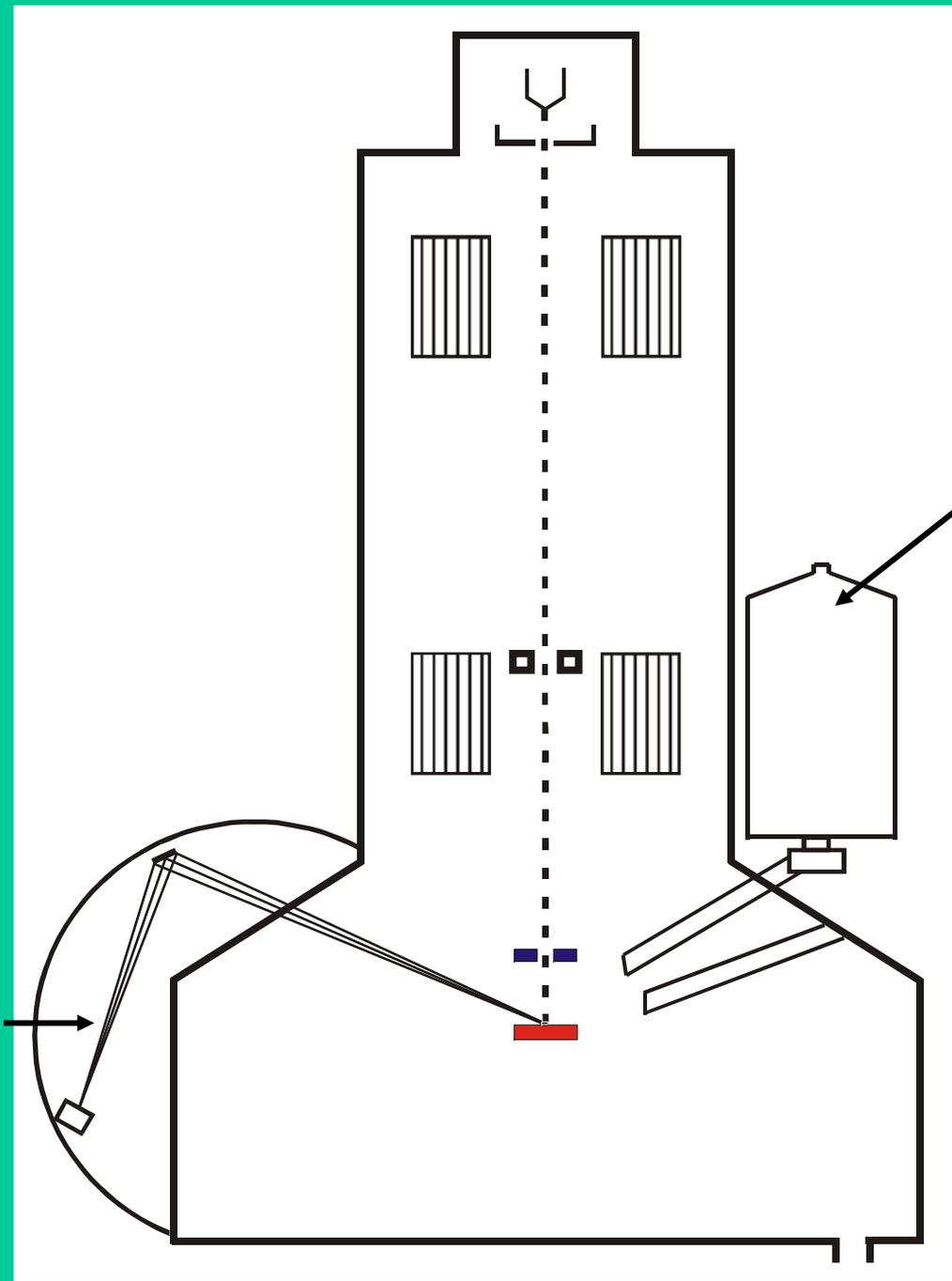
(K: Konstante, Z = Ordnungszahl)

Energiebereich der Hauptserien als Funktion der OZ



Mosley's Gesetz: $1/\lambda = K (Z-1)^2$

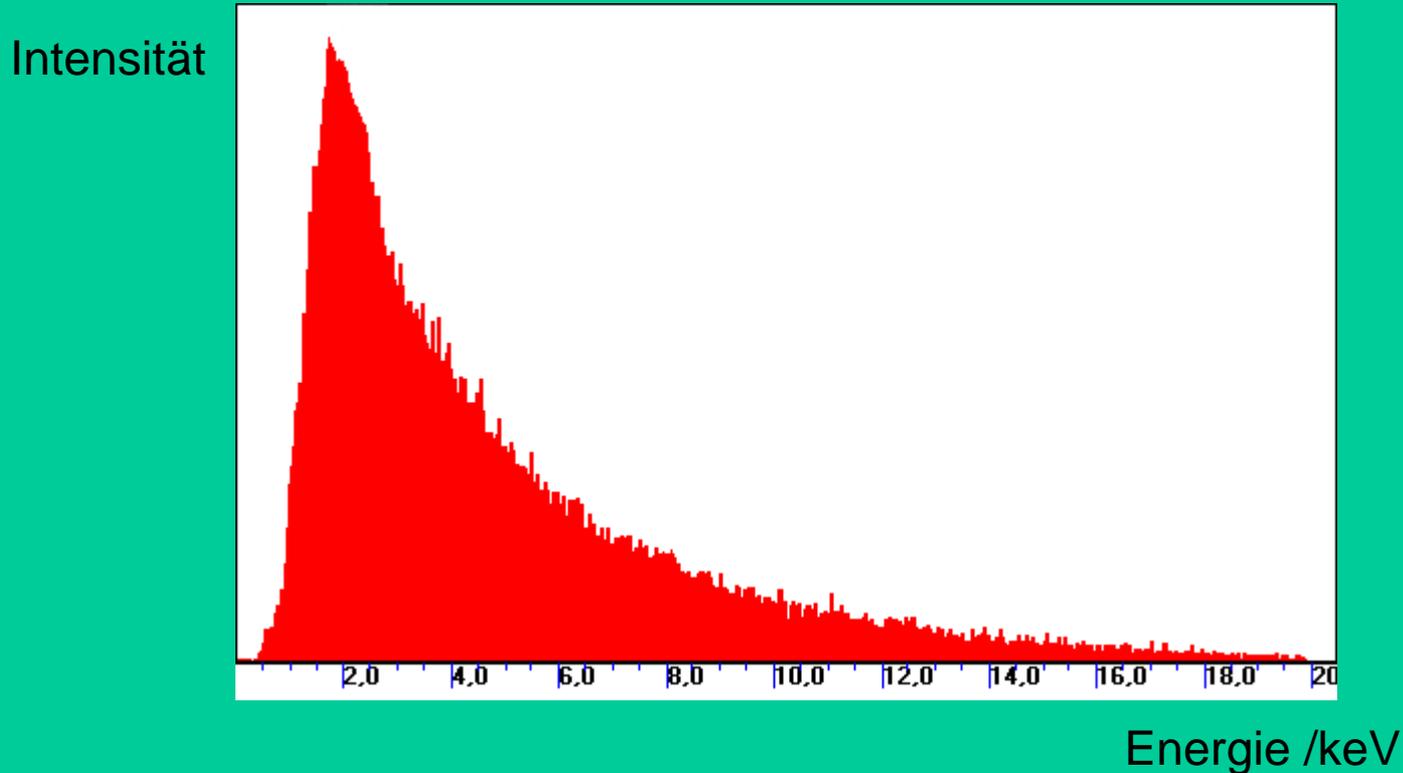
(K: Konstante, Z = Ordnungszahl)



Energy Dispersive X-Ray Detector

Wave length Dispersive X-Ray Detector

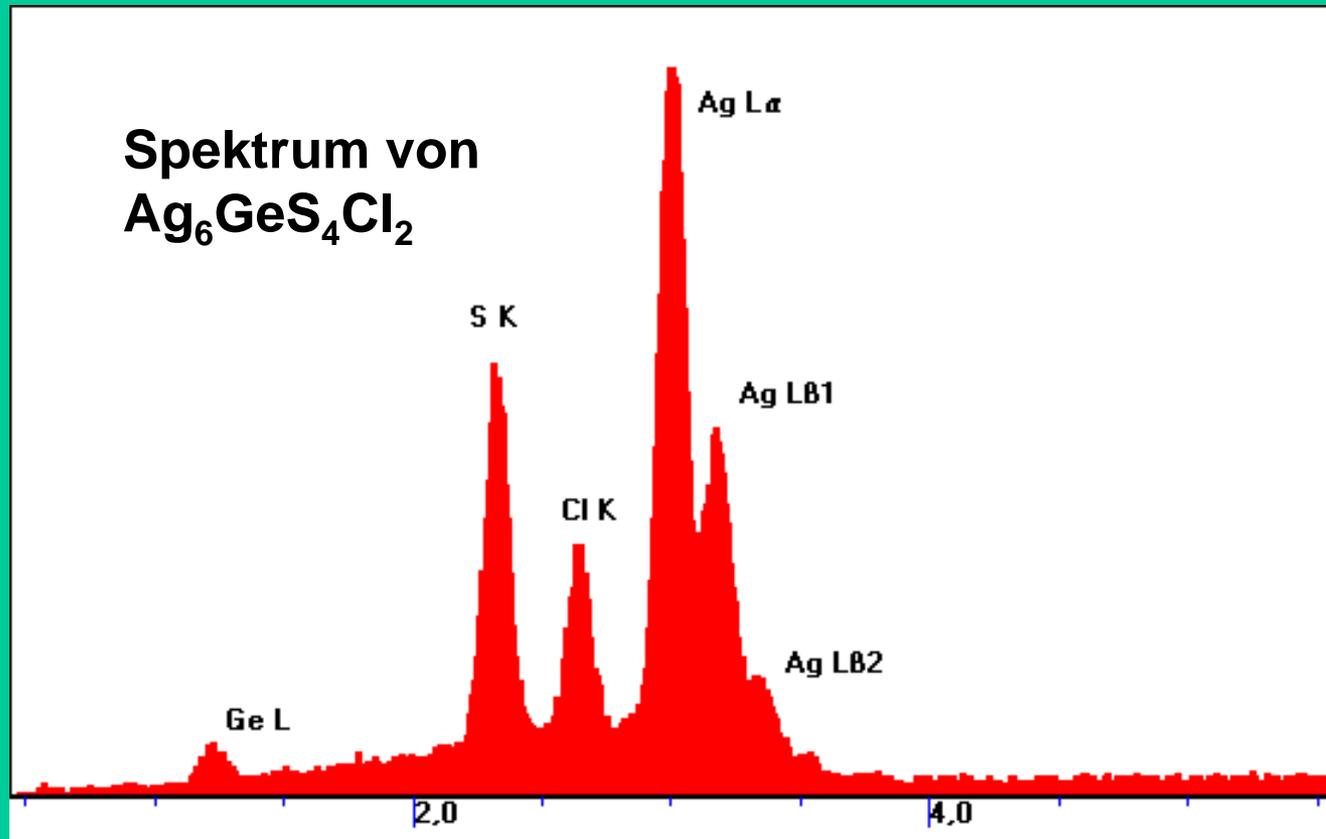
Röntgenbremsspektrum



- PE werden abgebremst und geben Energie als $h\nu$ ab
- E_{\max} der Röntgenstrahlung: $e \times U_{\text{Beschl}}$

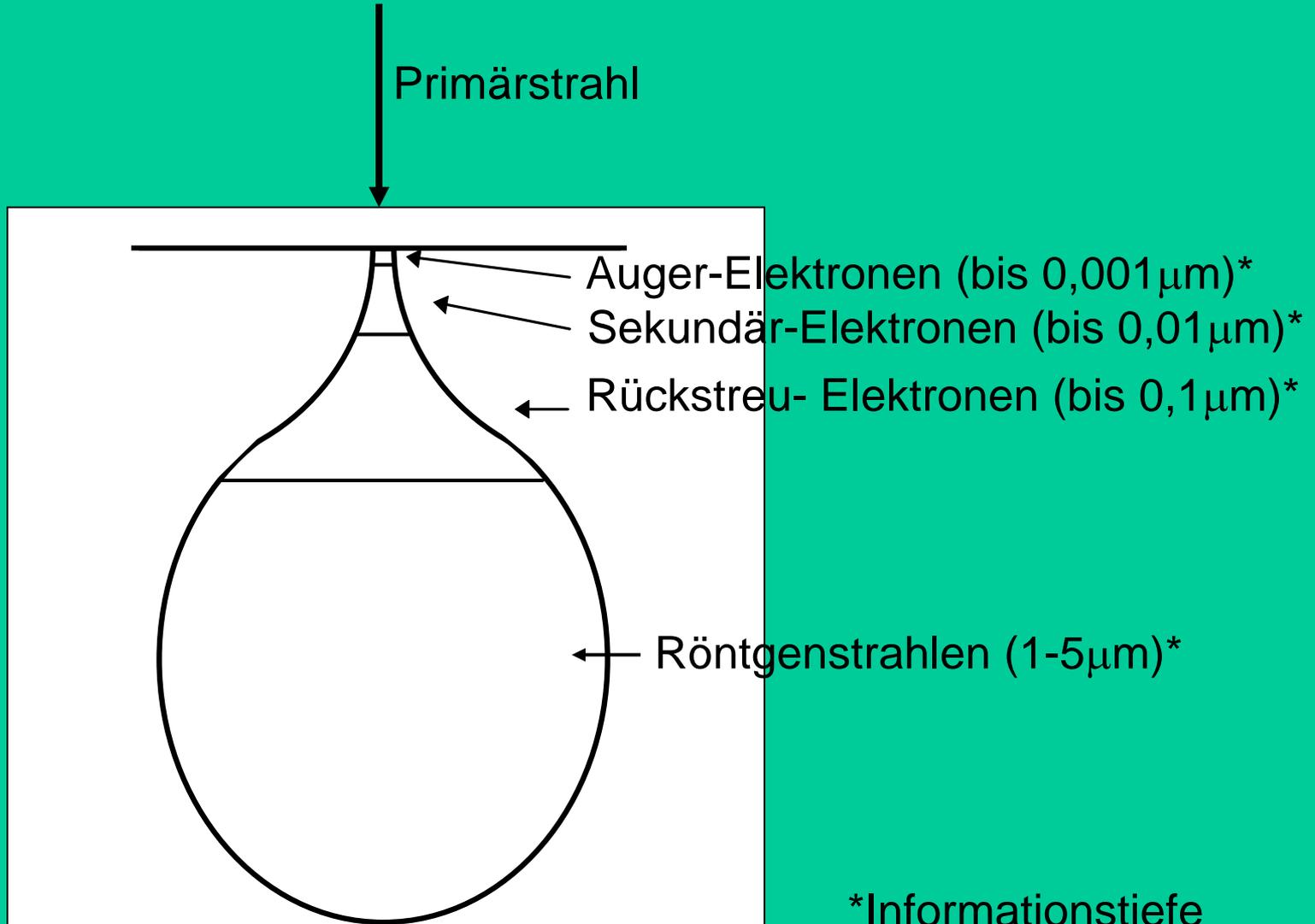
Typisches Röntgen Spektrum (EDX)

Intensität

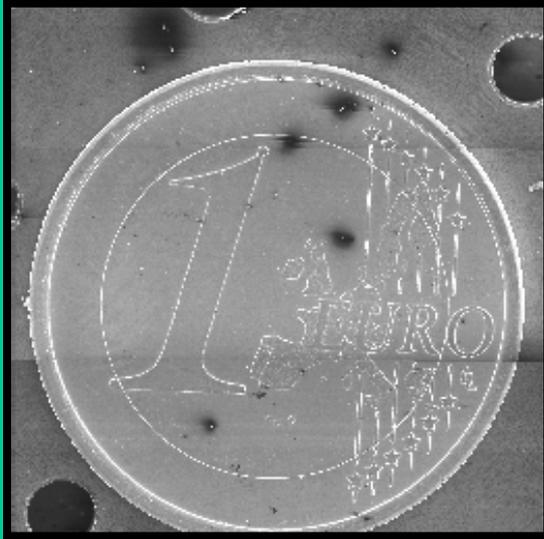


Energie /keV

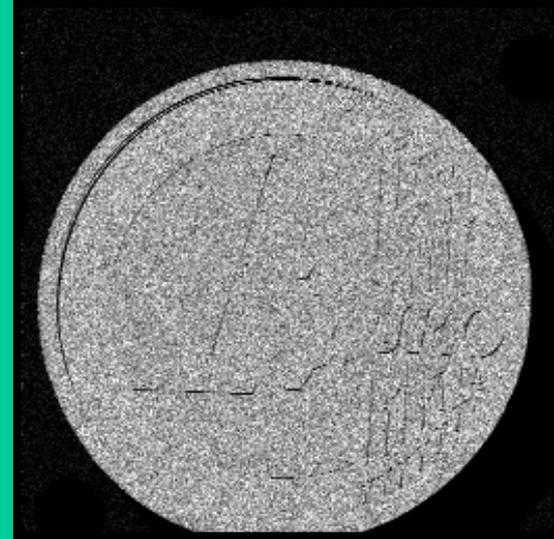
Wechselwirkungsvolumen (birnenförmig)



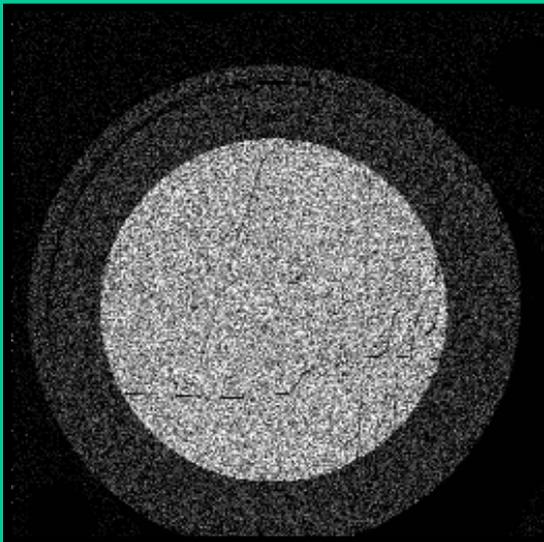
Large area mapping (Röntgenbilder)



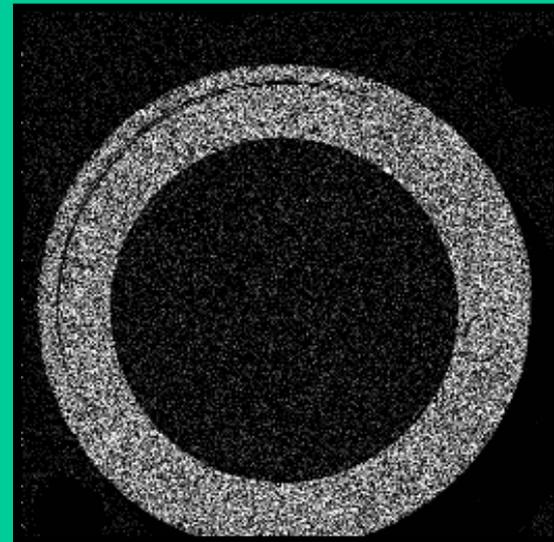
SE-Image



Cu-K α -
mapping



Ni-K α -
mapping

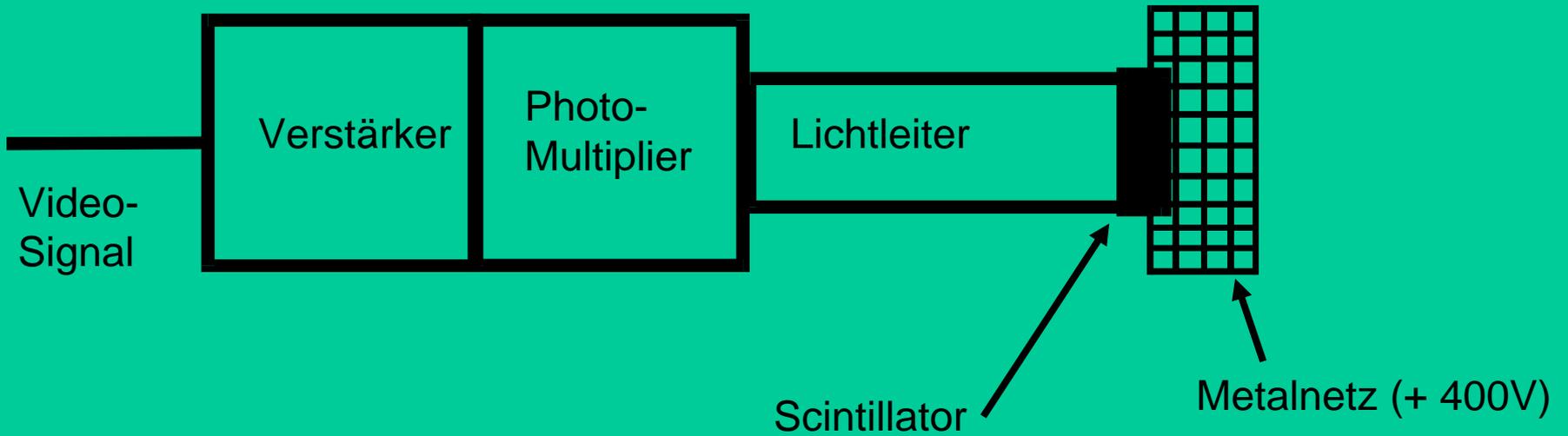


Zn-K α -
mapping

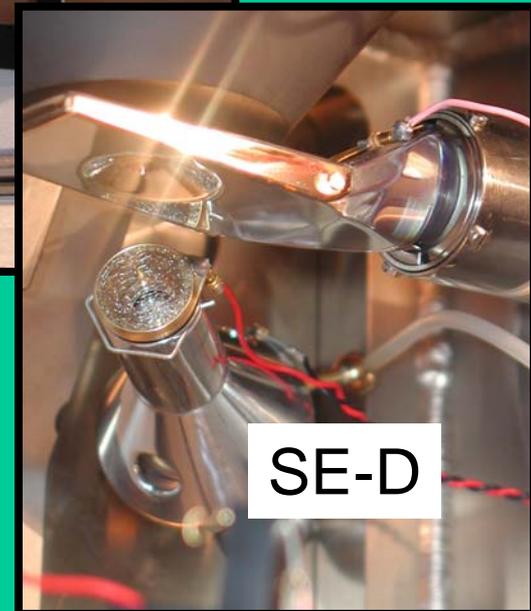
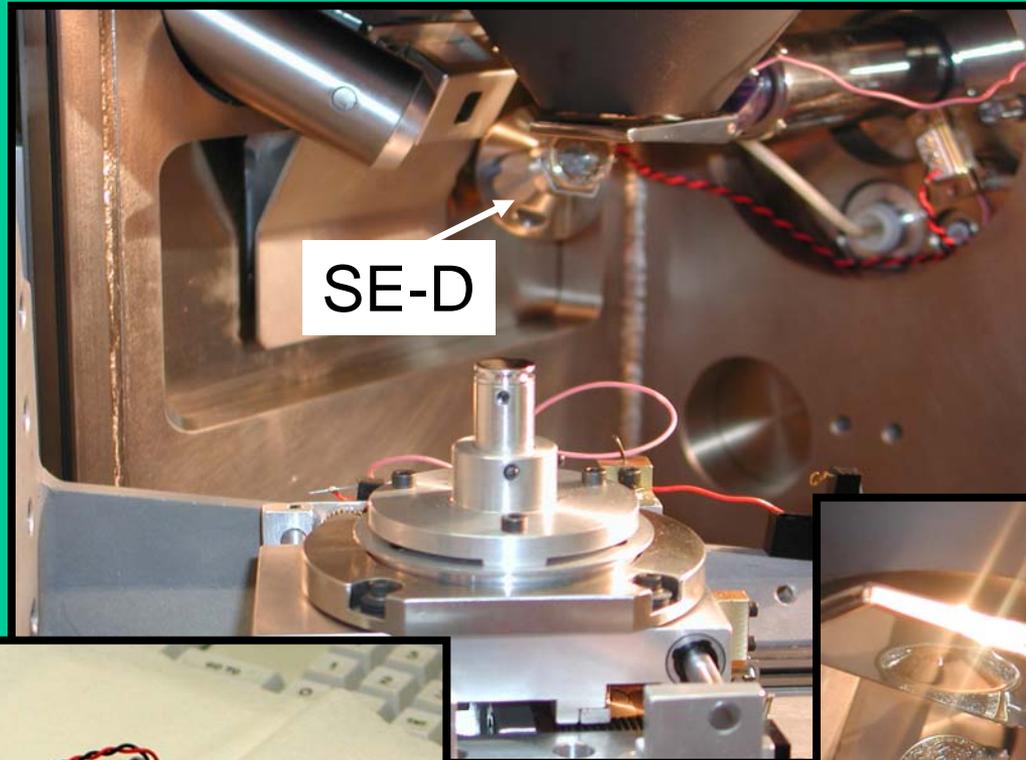
256x256 pixel

Sekundär-Elektronen-Detektor

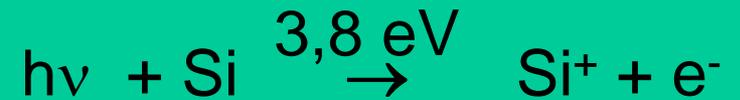
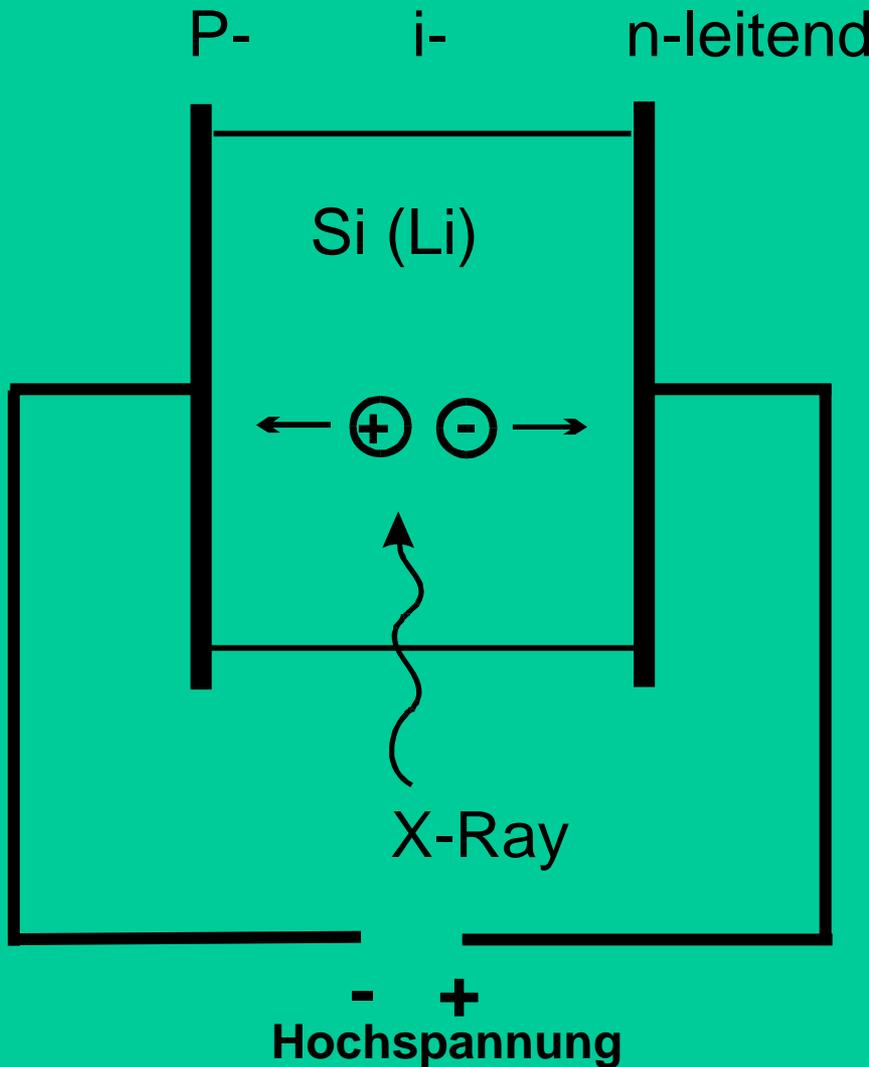
Szintillator-Photomultiplier-Detektor
(Everhart-Thornley-Detektor)



SE-Detektor:



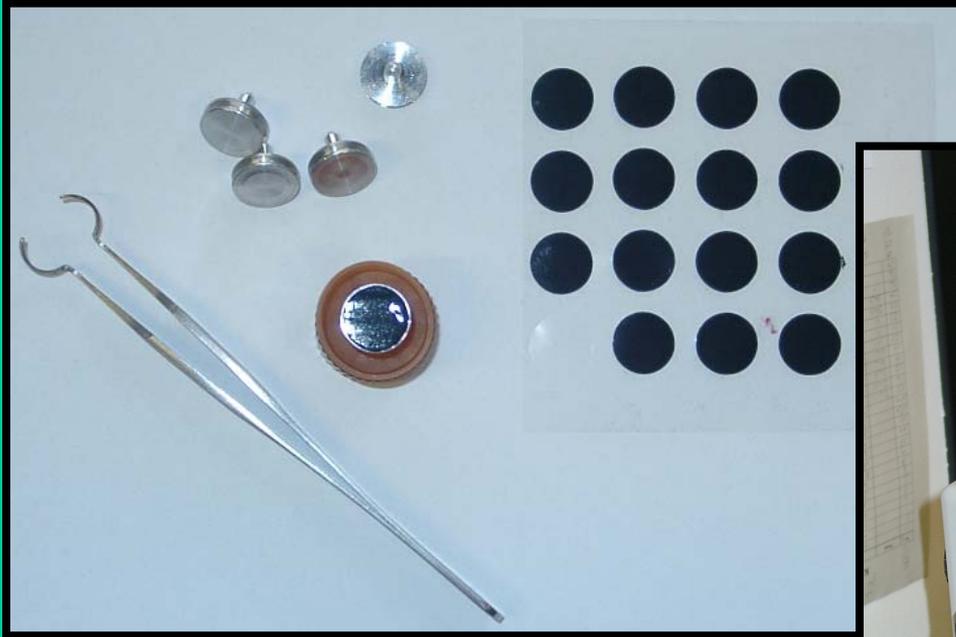
Prinzip eines EDX-Detektors



e.g. Mn K_{α} : 5894 eV

$5894/3.8 = 1550$
Elektron-Loch-Paare

Probenpräparation



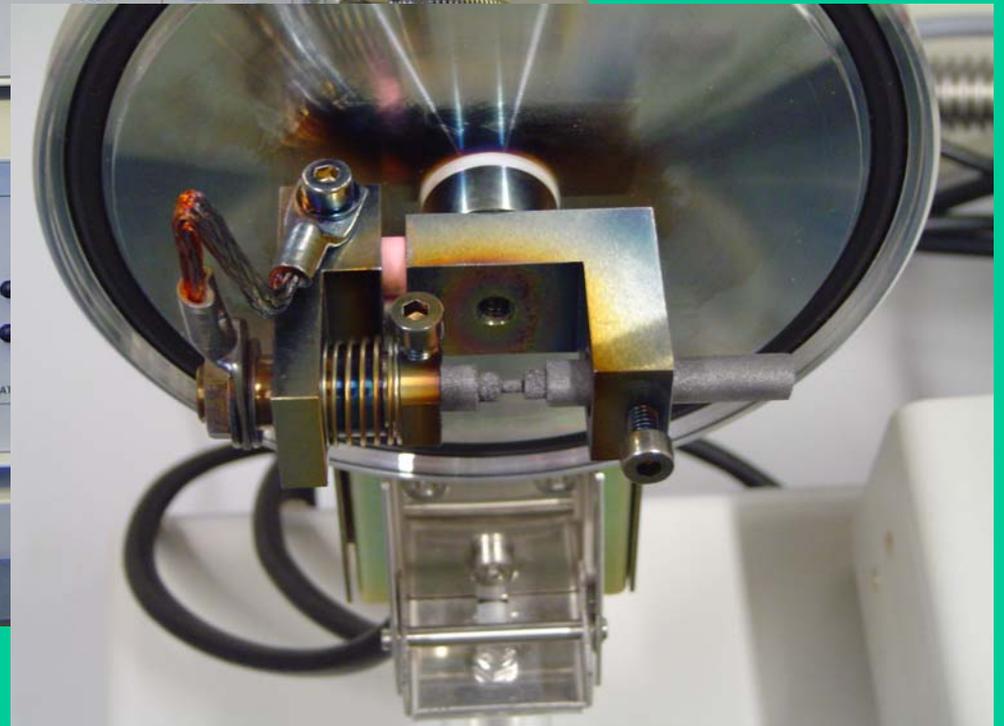
Spezielle Präparation für nichtleitende Proben:

- Aufbringen einer Metallschicht (sputtering Prozess)
- Aufbringen einer Kohlenstoffschicht (evaporation Prozess)

Goldbeschichtungsgerät



Kohlebeschichtungsgerät

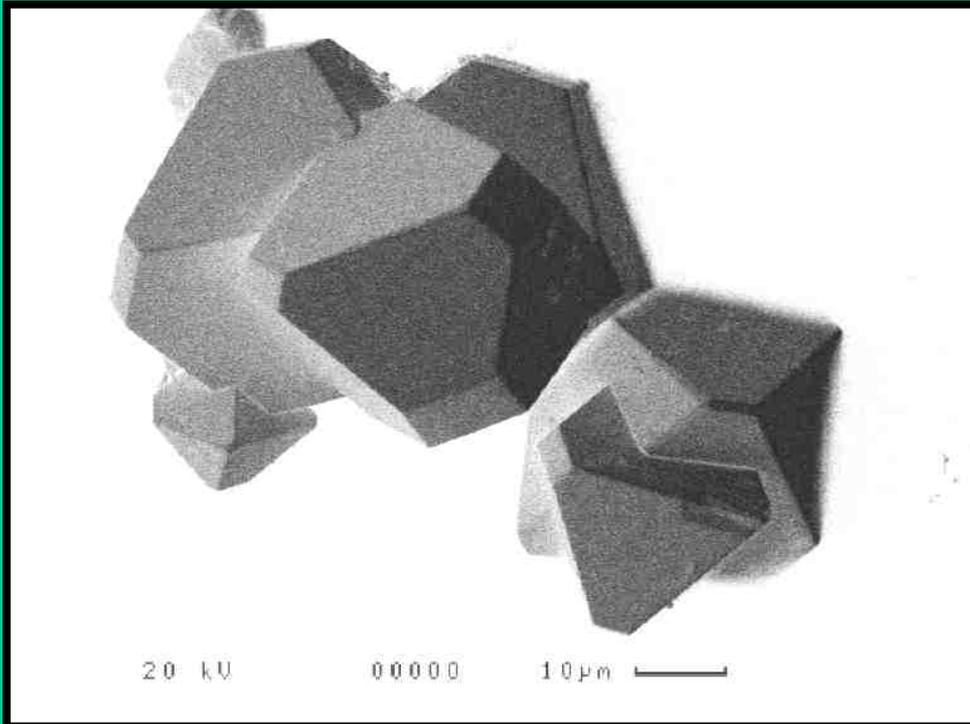


Anwendungen des REM:

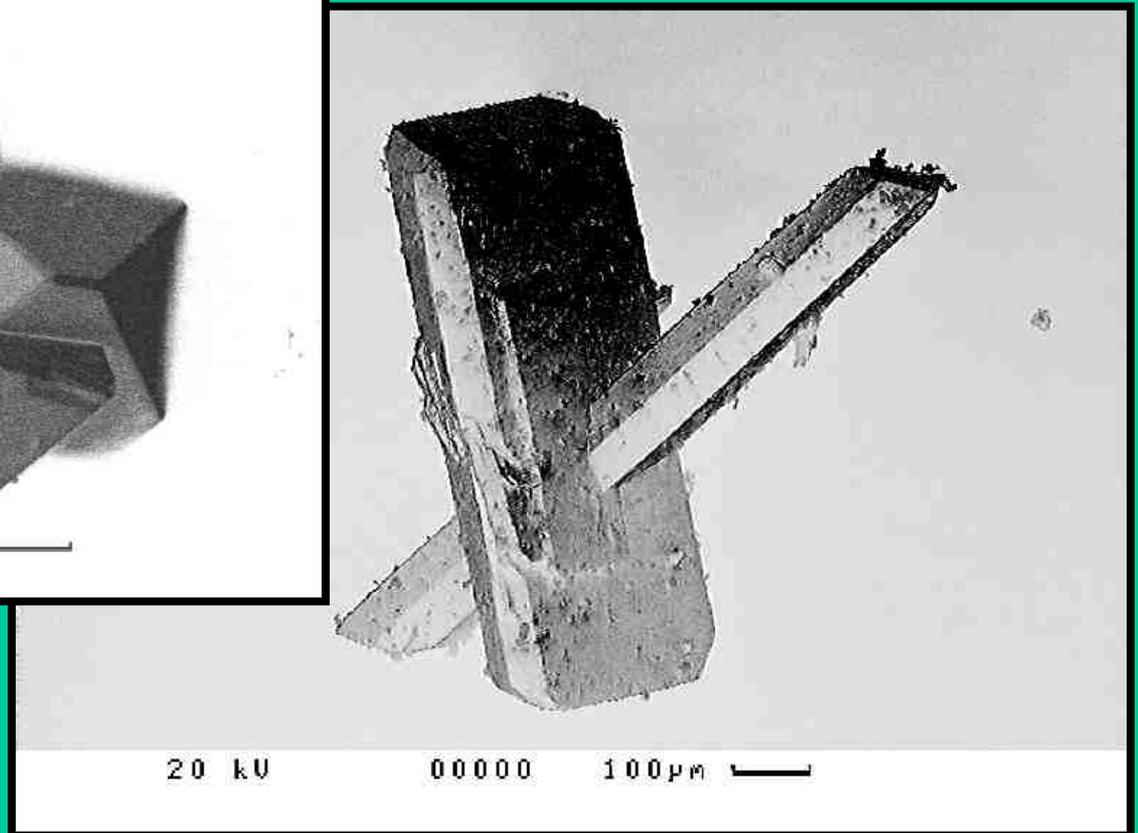
I) Hochauflösungsbilder

II) Qualitative und quantitative Analysen

Verzwilligung von Kristallen

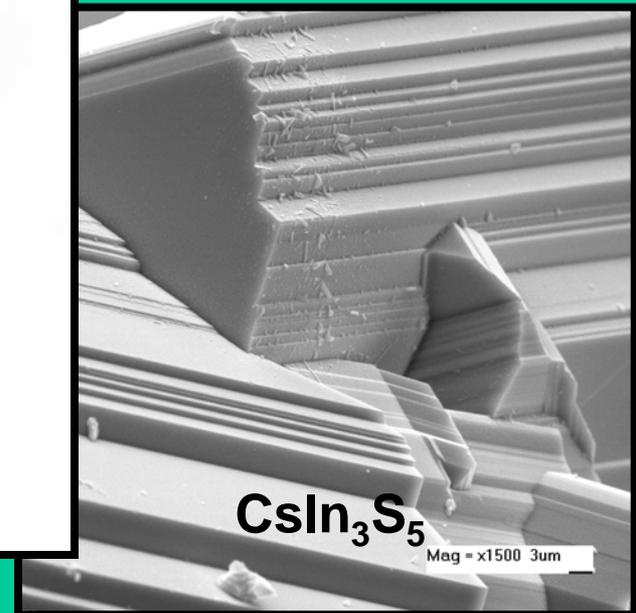
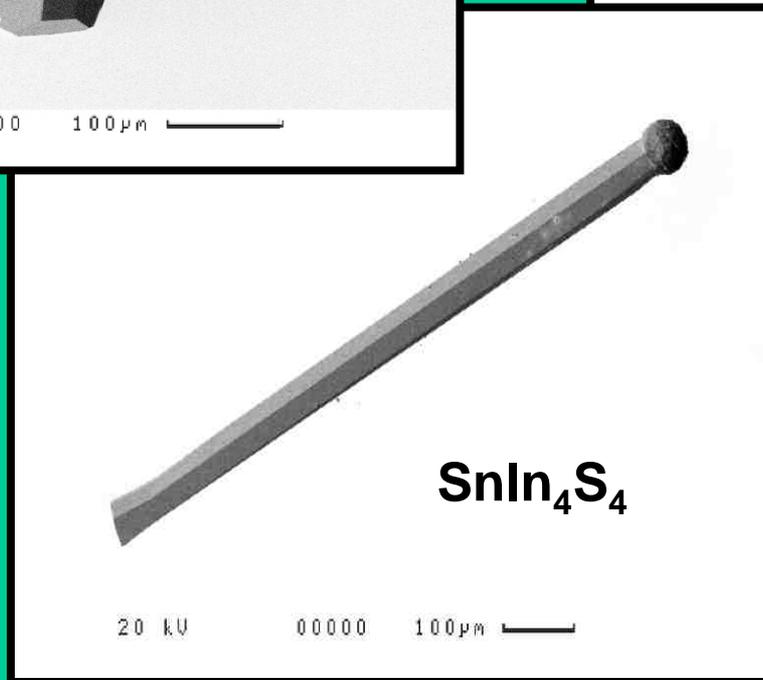
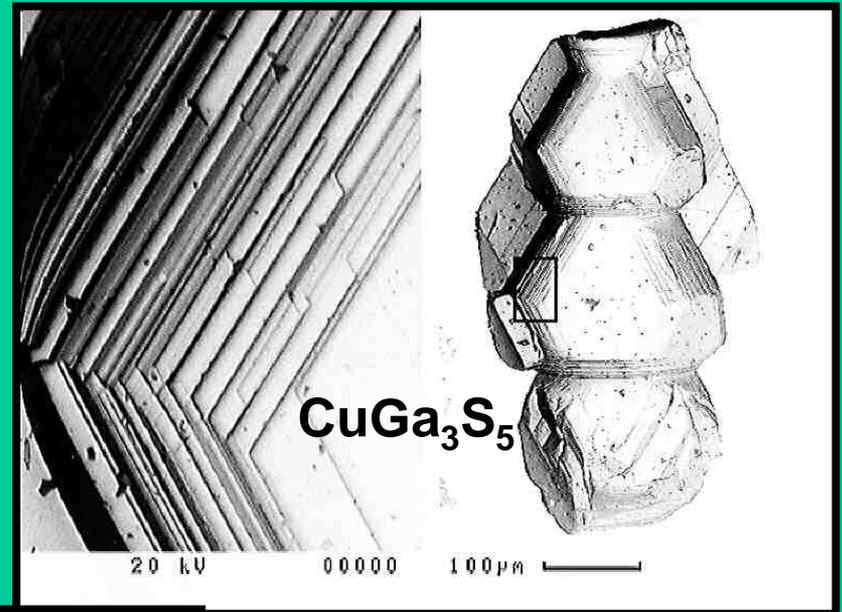
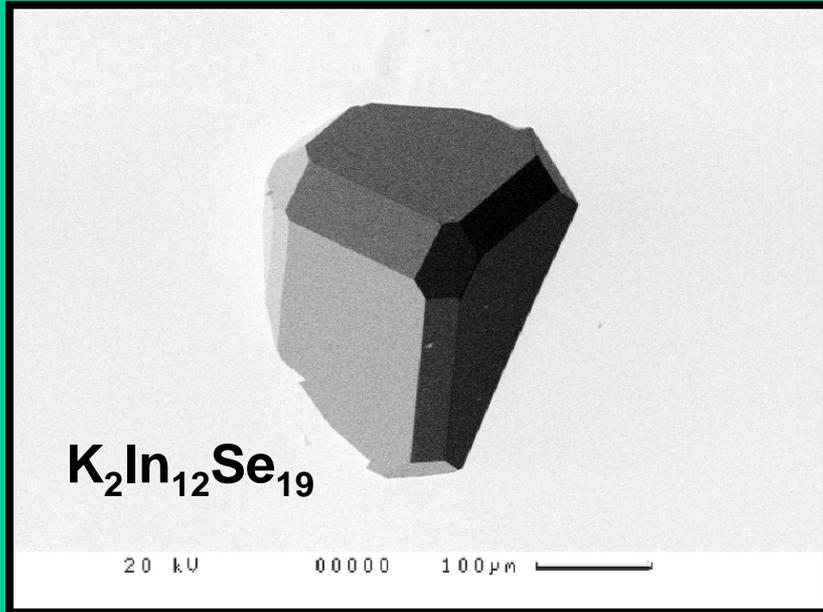


PbS

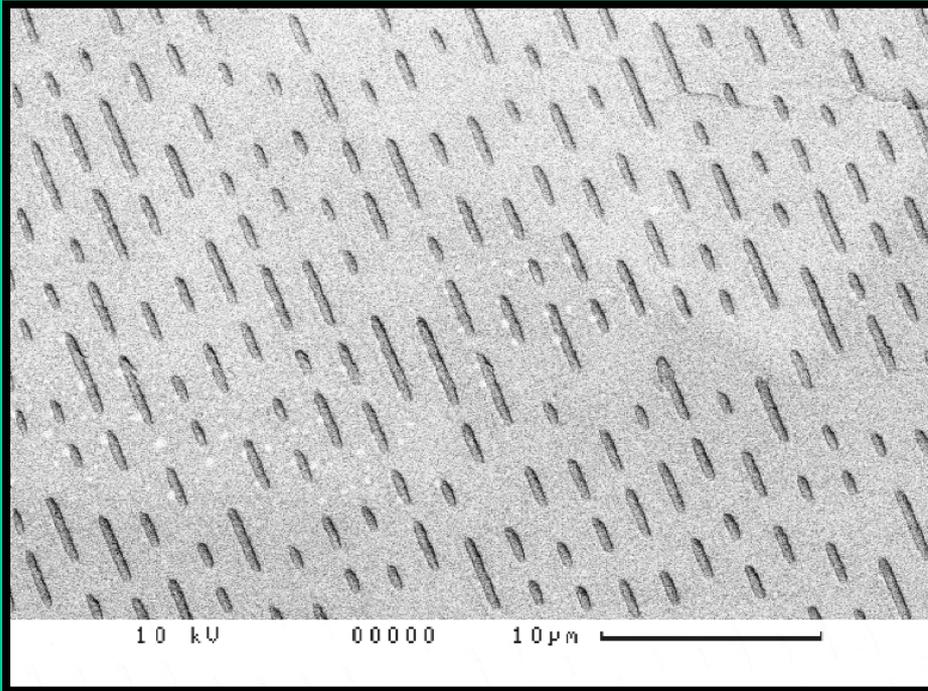


$\text{Na}_2\text{Zn}_2(\text{SeO}_3)_3 \cdot 3\text{H}_2\text{O}$

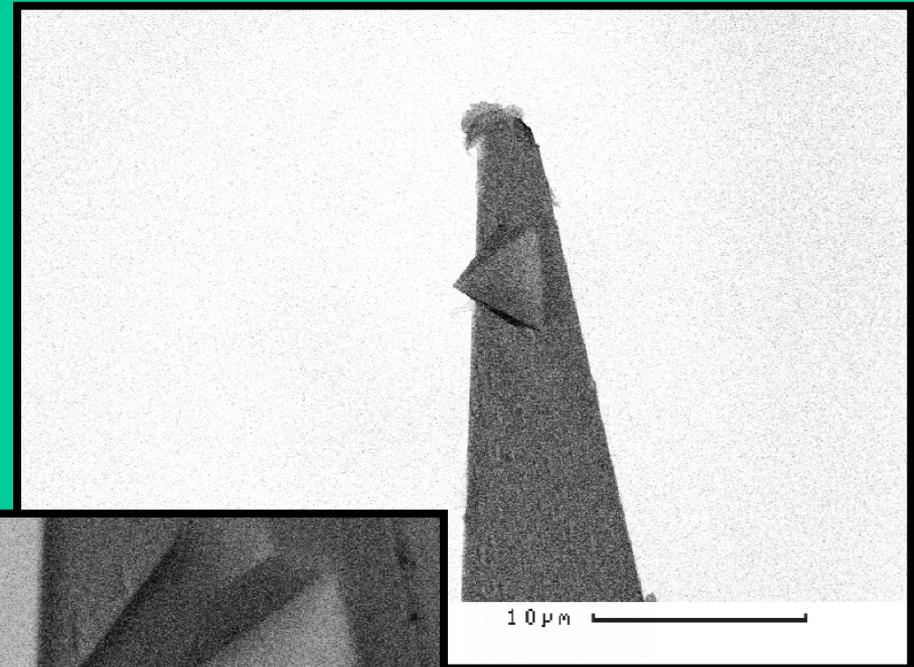
Morphologie von Kristallen



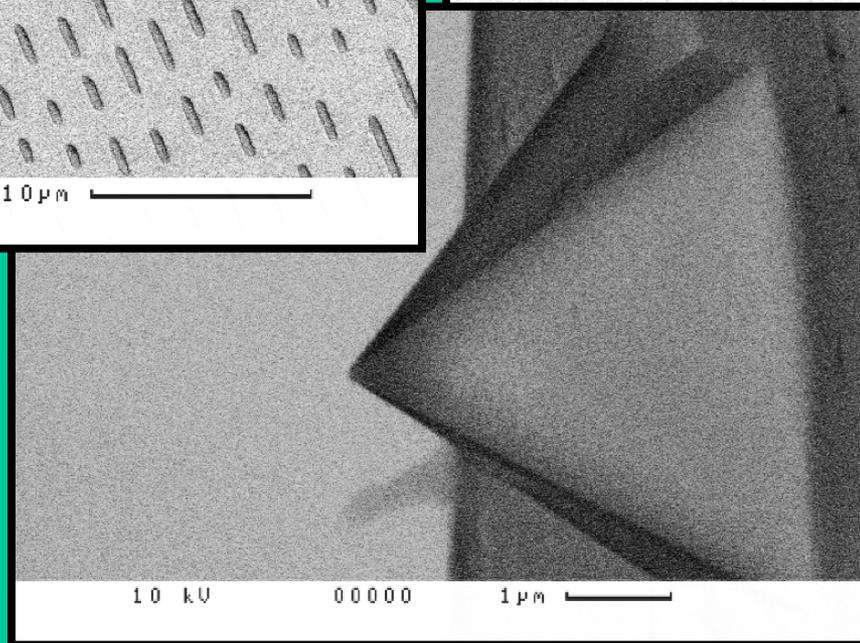
Kontrolle kleiner Objekte



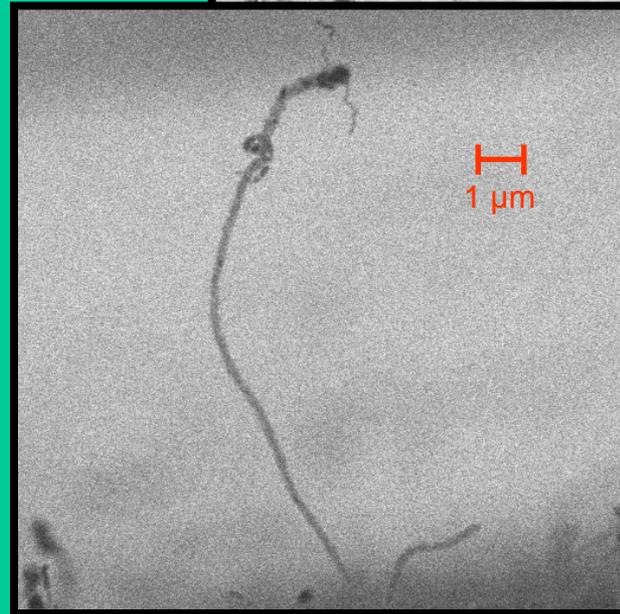
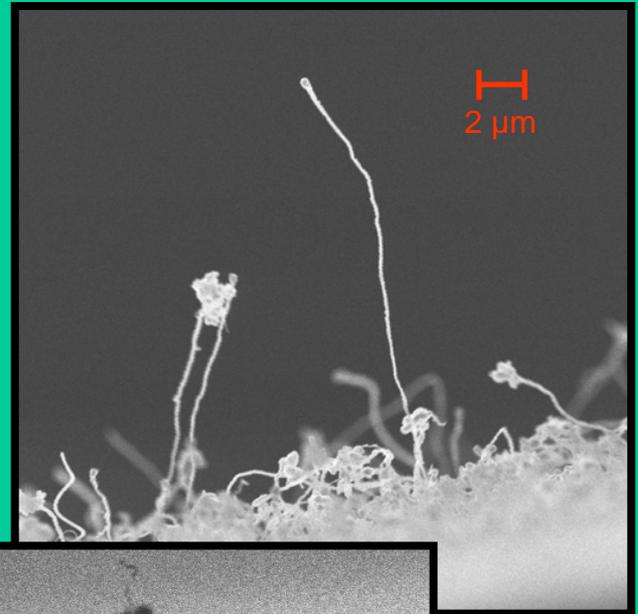
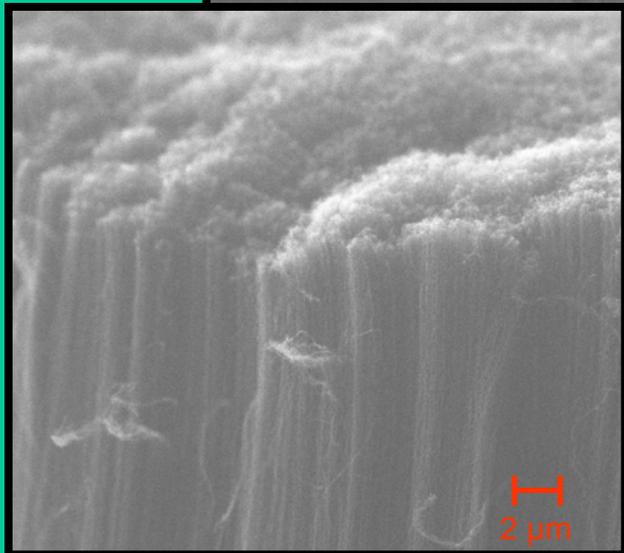
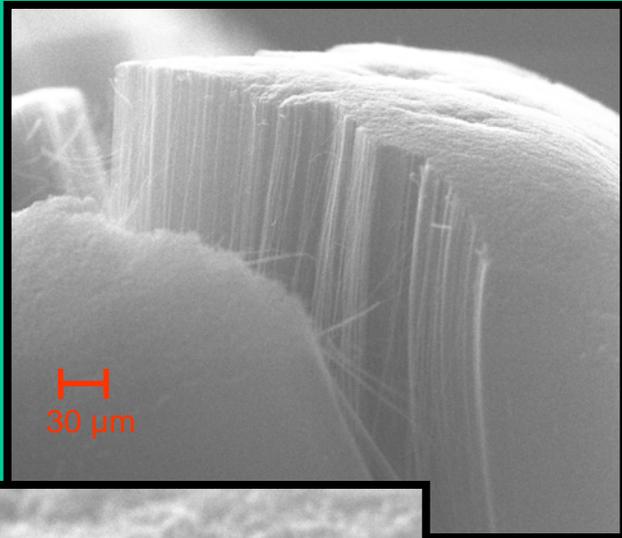
Compact disc

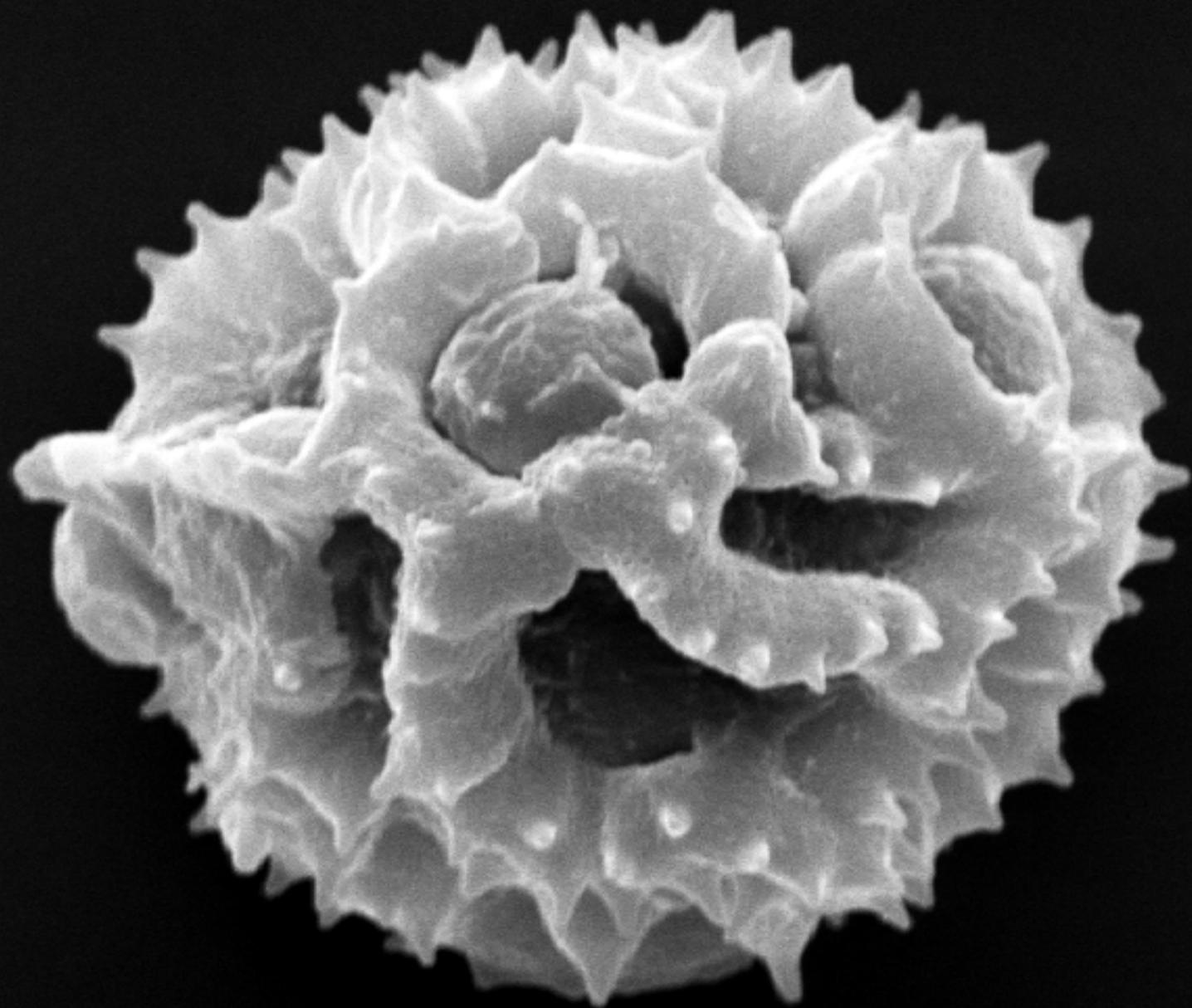


**Cantilever
of an AFM**



Carbo Nanotubes



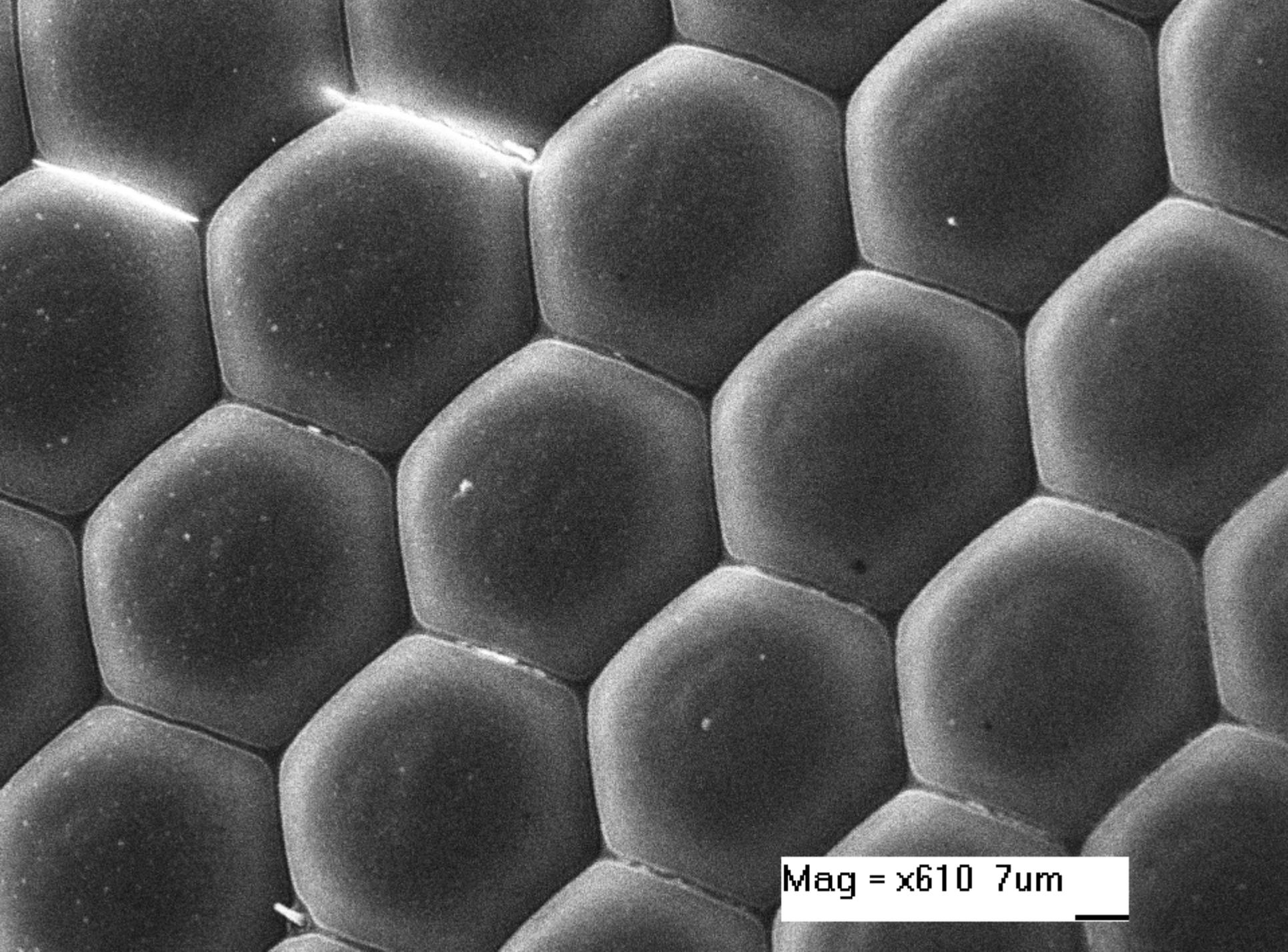


20 kV

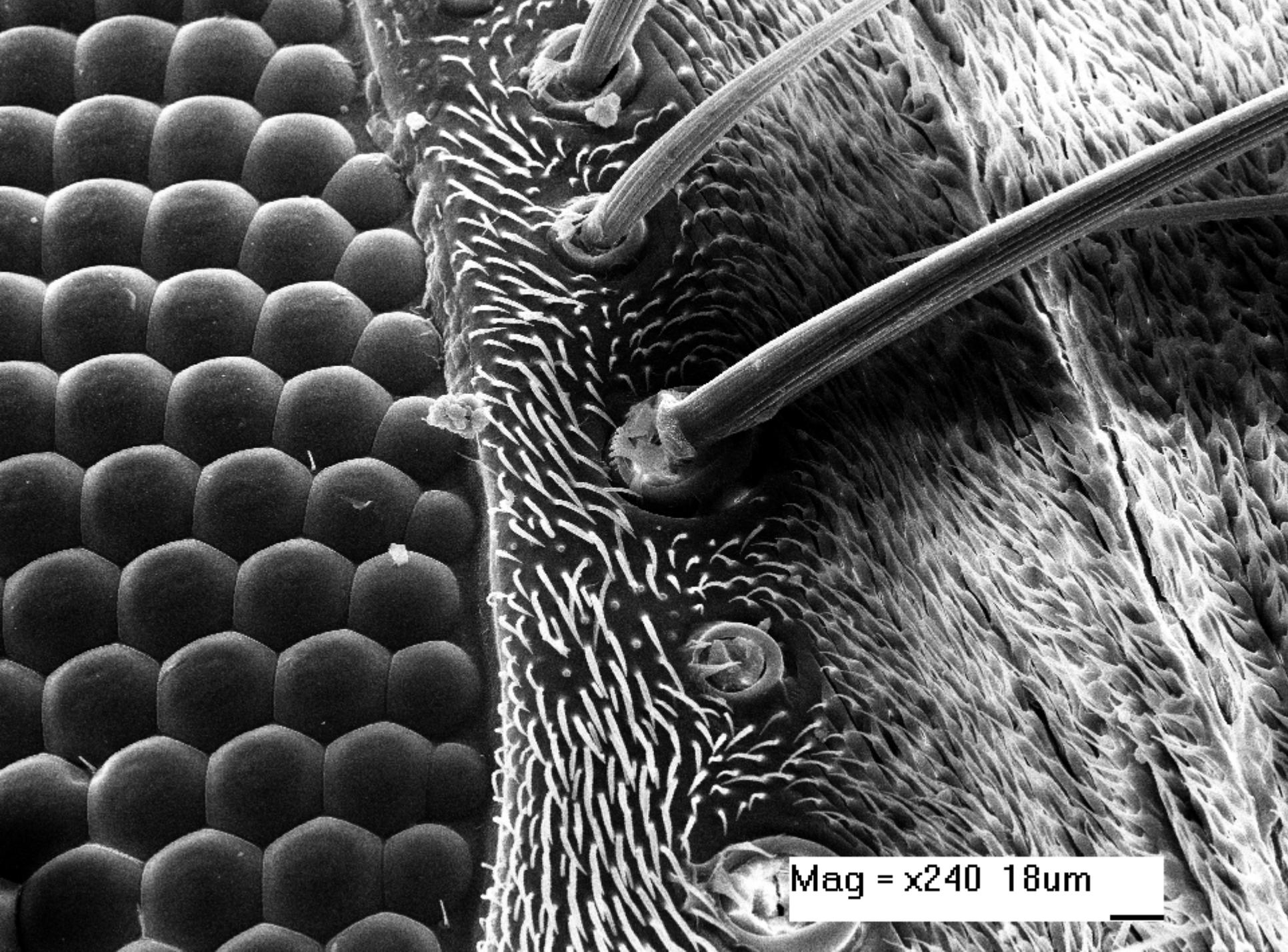
00000

10 μ m





Mag = x610 7um



Mag = x240 18um



