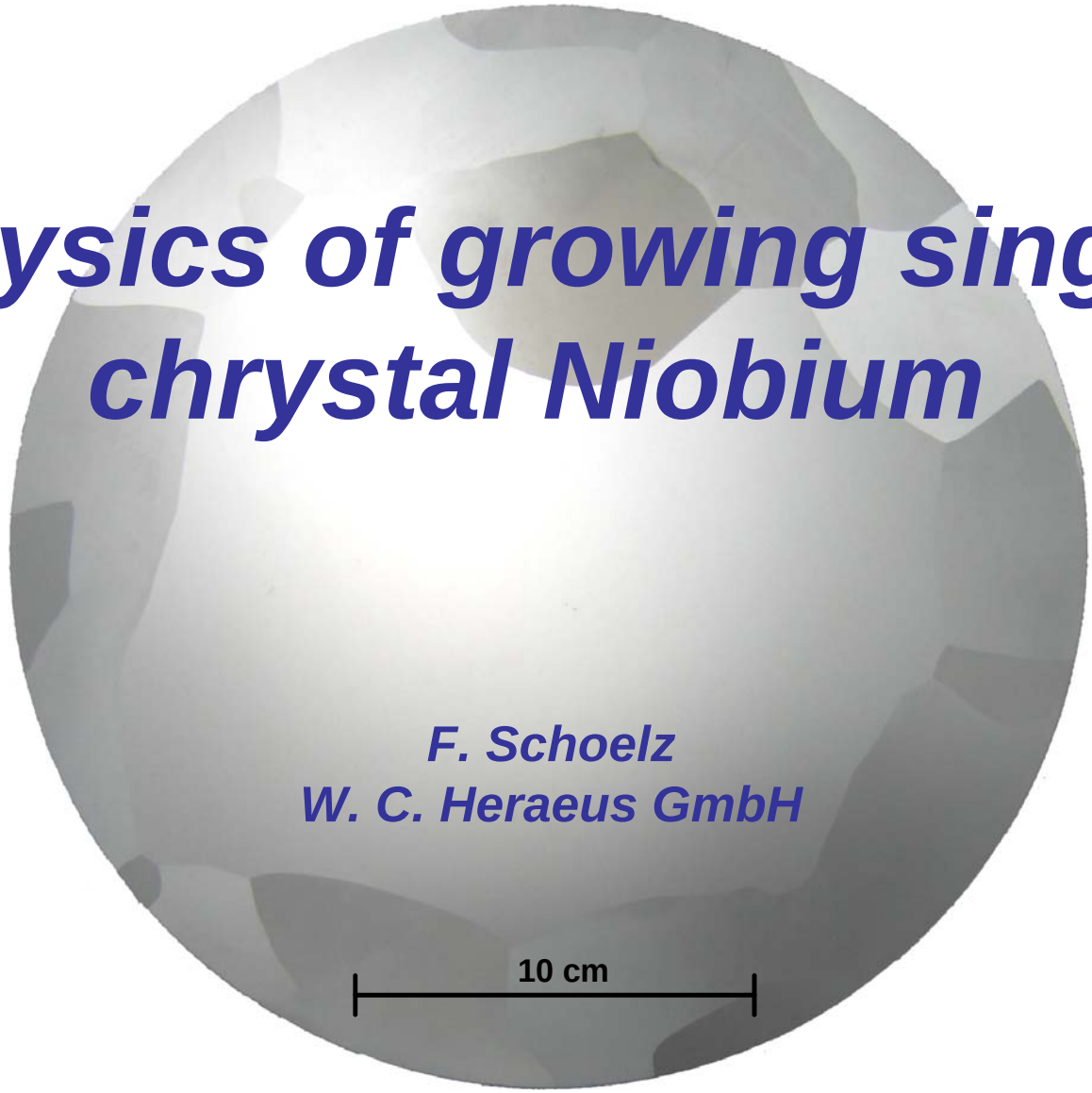
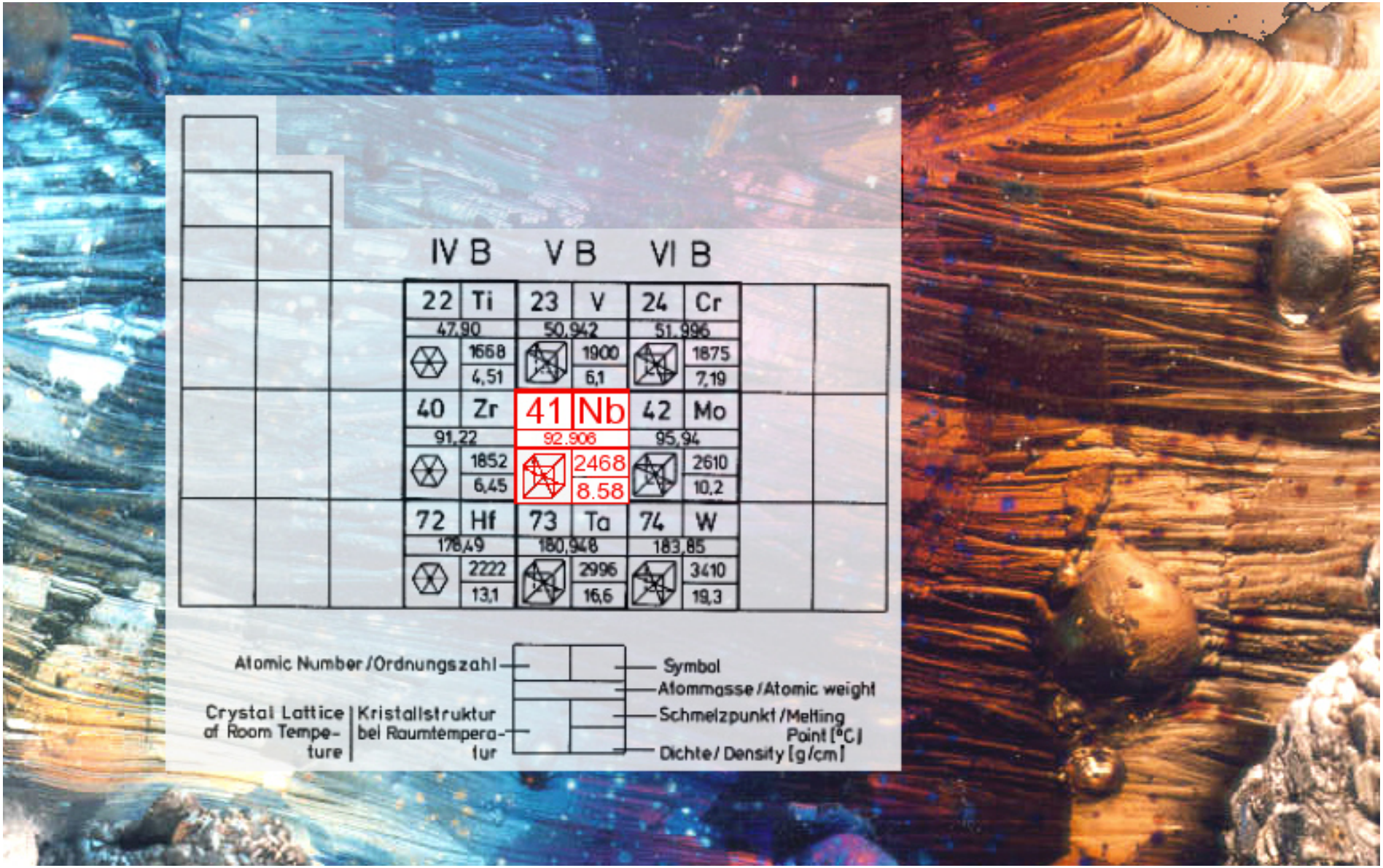
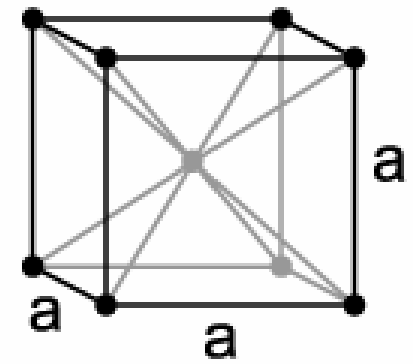
Physics of growing single chrystal Niobium

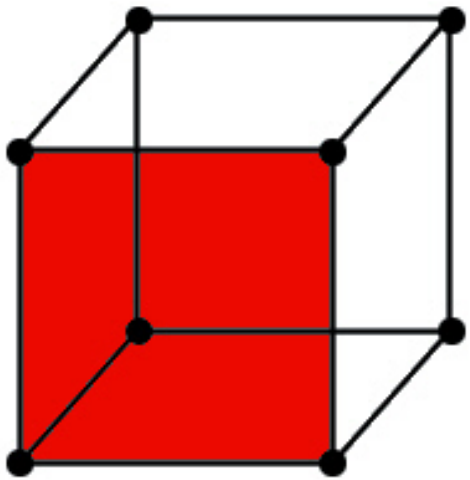


F. Schoelz
W. C. Heraeus GmbH


IV B
V B
VI B
22 Ti
47,90
1668
4,51
23 V
50,942
1900
6,1
24 Cr
51,996
1875
7,19
40 Zr
91,22
1852
6,45
41 Nb
92.906
2468
8.58
42 Mo
95,94
2610
10,2
72 Hf
178,49
2222
13,1
73 Ta
180,948
2996
16,6
74 W
183,85
3410
19,3
Atomic Number / Ordnungszahl
Symbol
Atommasse / Atomic weight
Crystal Lattice of Room Temperature
Kristallstruktur bei Raumtemperatur
Schmelzpunkt / Melting Point [°C]
Dichte / Density [g/cm]

Crystallographic classification of niobium and the most important miller indices





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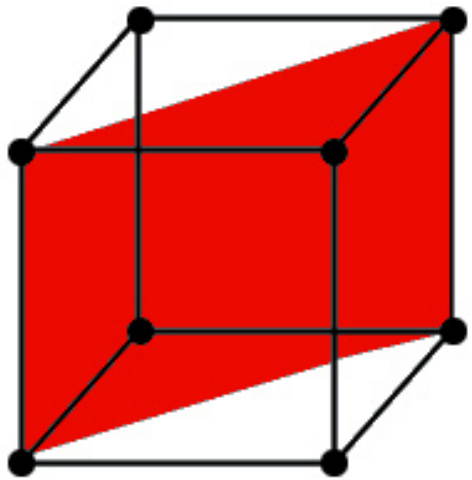

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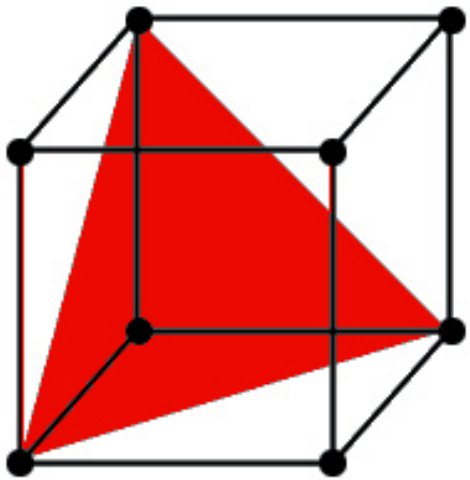

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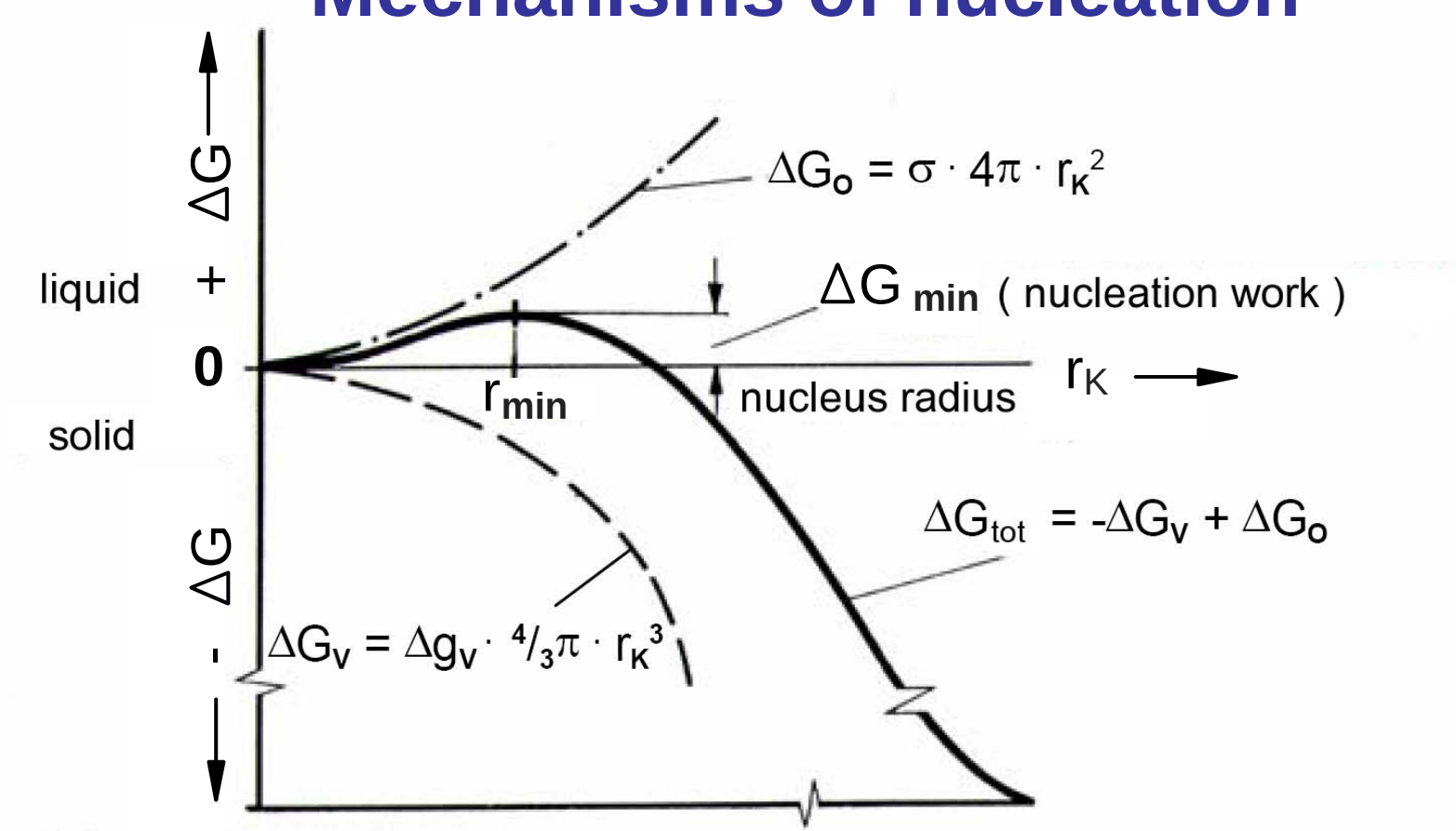
Mechanisms of nucleation



ΔG_O = surface energie

ΔG_V = volume energie

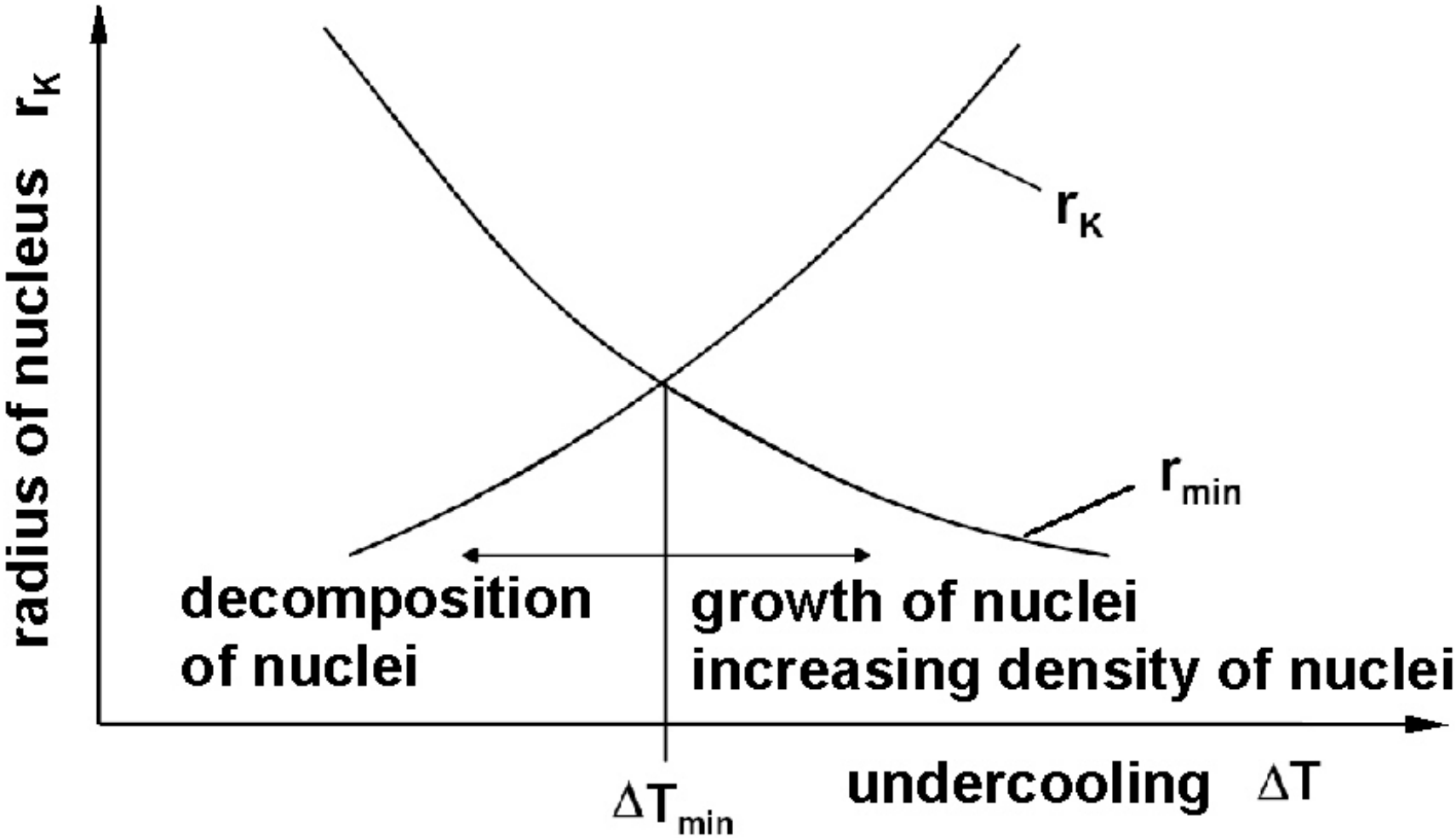
σ = free surface energie

$4\ \pi\ r^2$ = surface of a spherical nuclei

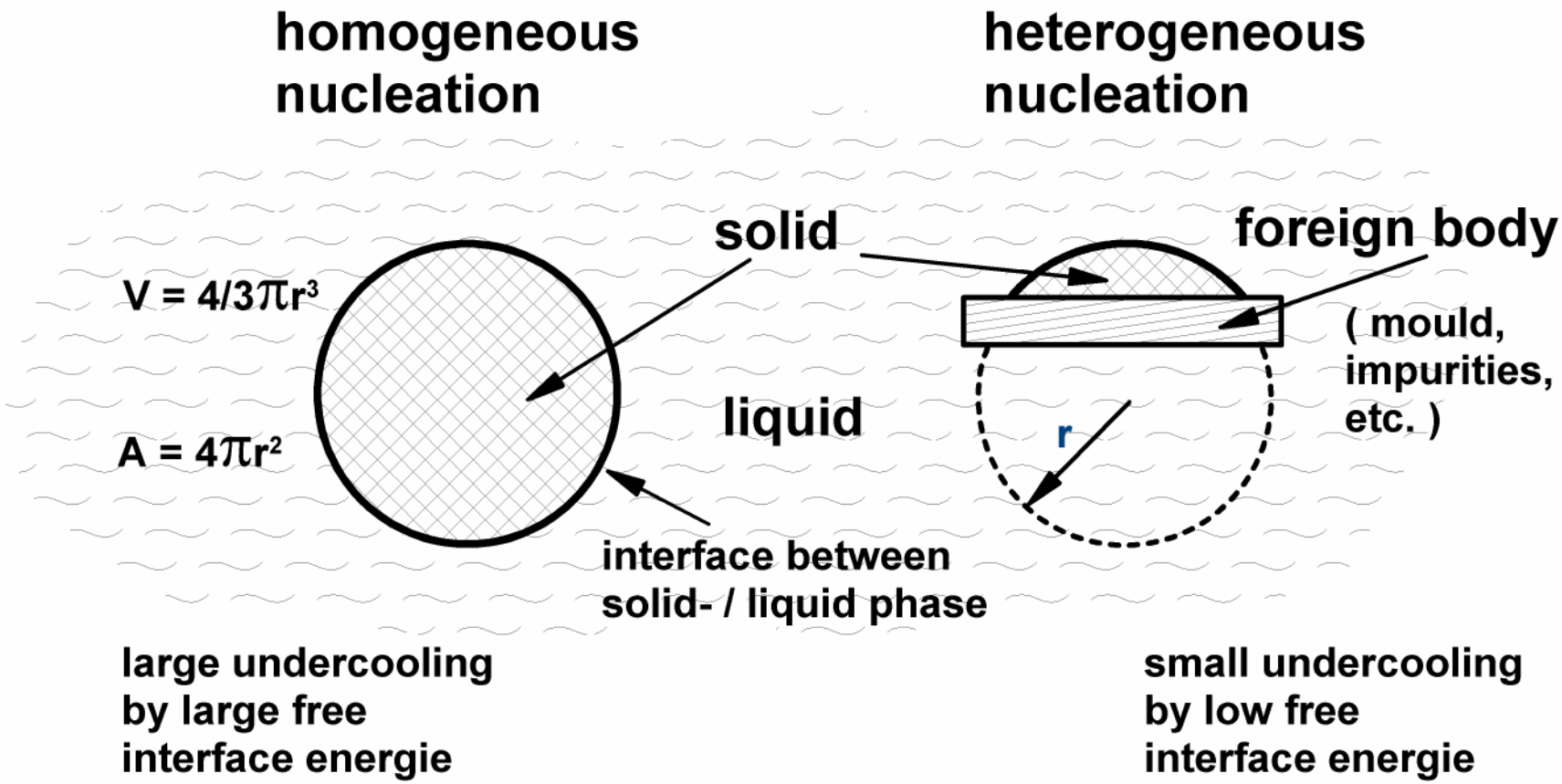
$4/3\ \pi\ r^3$ = volume of a spherical nuclei

g_V = volume energie

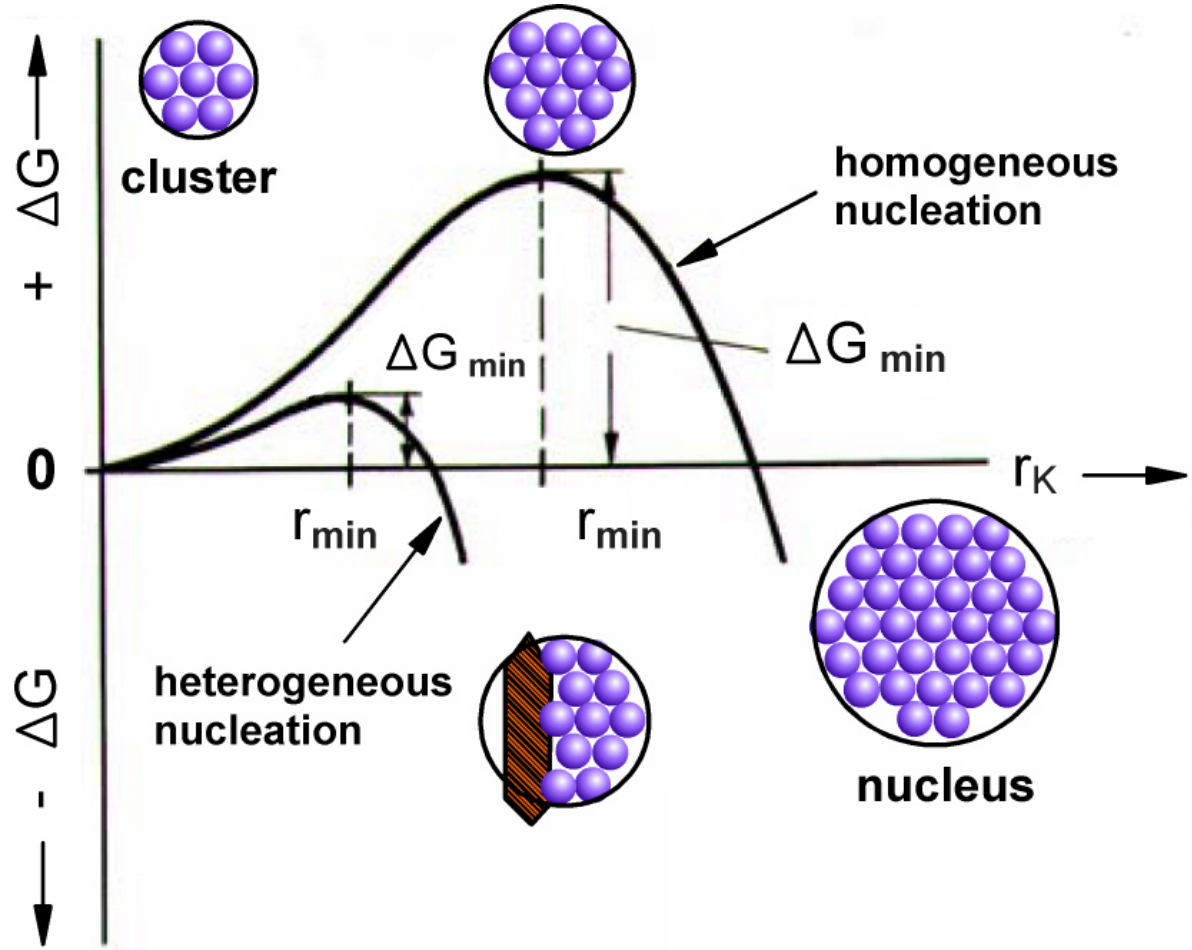
Influence of building nuclei by undercooling



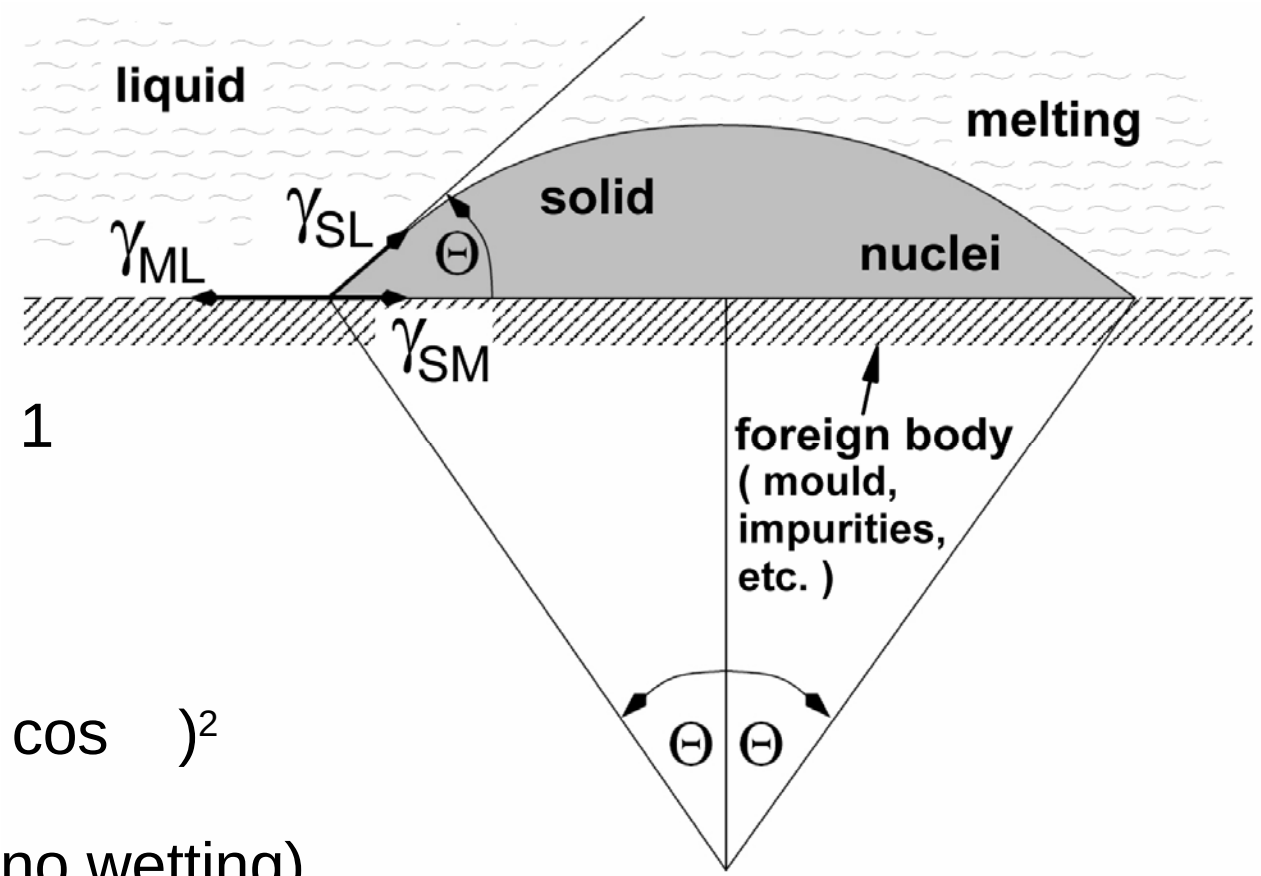
Nucleation by phase transition liquid-solid



Critical nucleus size for homogeneous / heterogeneous nucleation



Heterogeneous nucleation of spherical cap on a flat mould wall



$\Delta G_{het} = f\ \Delta G_{hom}$; f 1

= wetting angle

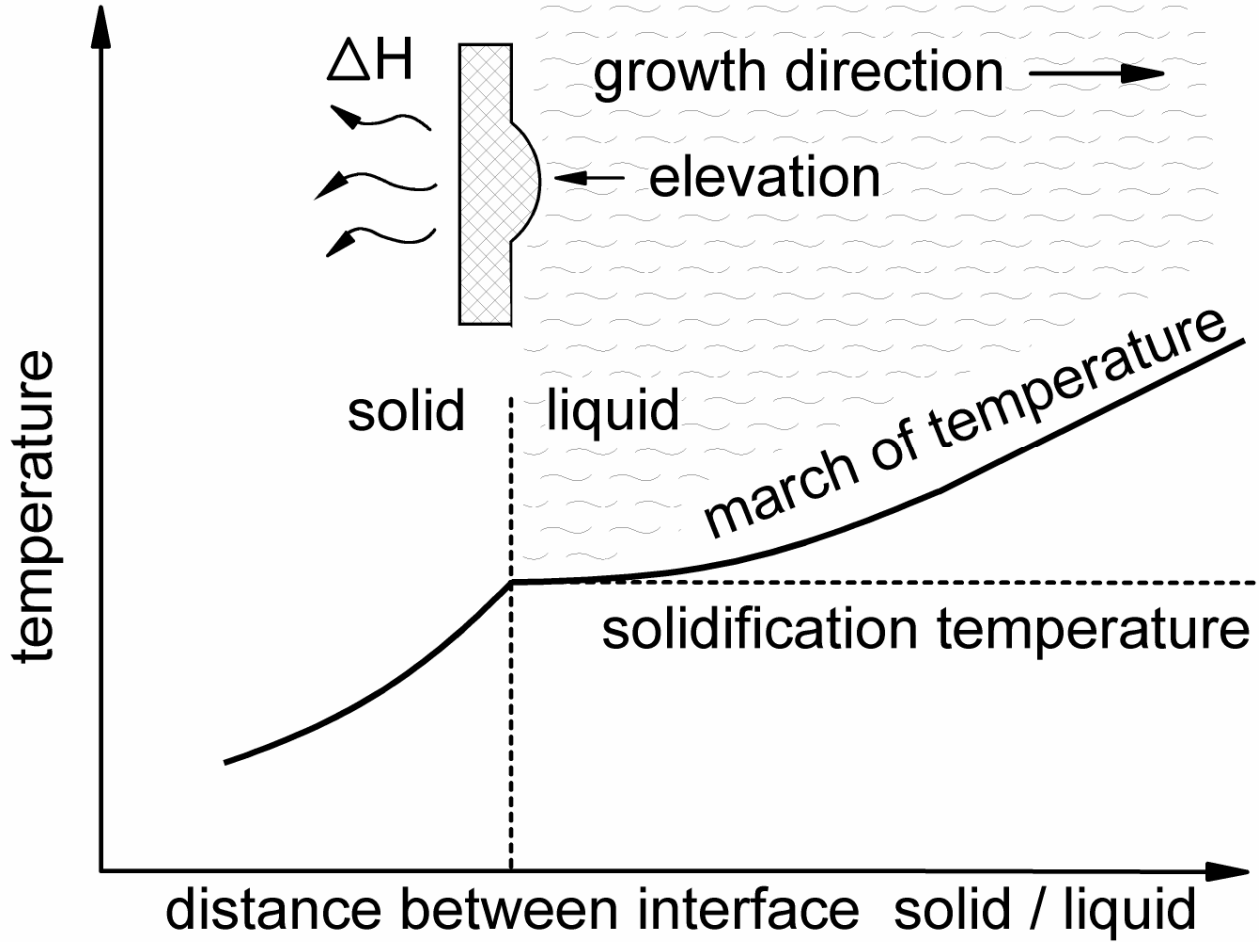
for a plain wall:

f = 1/4 (2 + cos)(1 - cos)^2

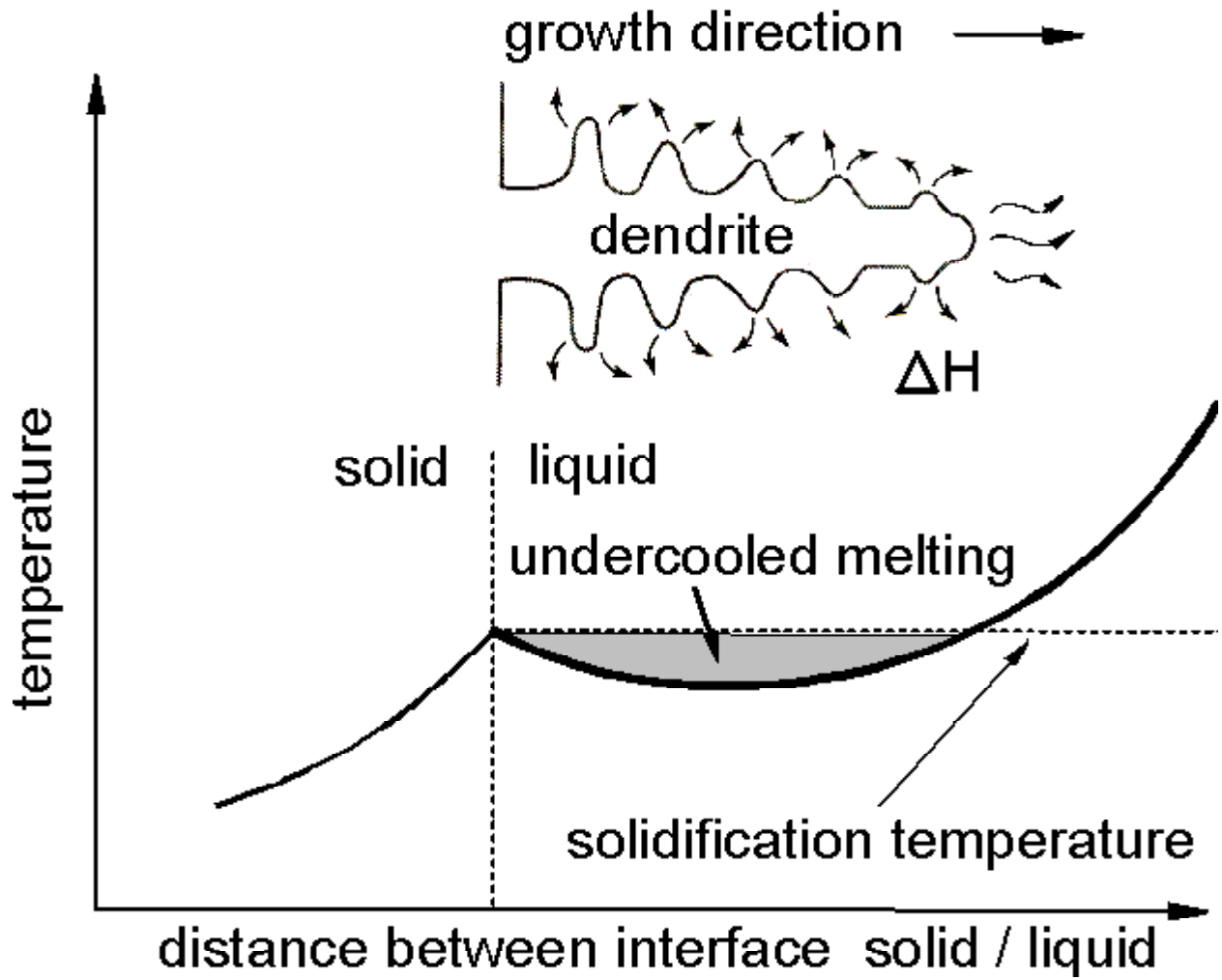
if very large, f→1 (no wetting)

$T_{liquid} > T_{solid}$

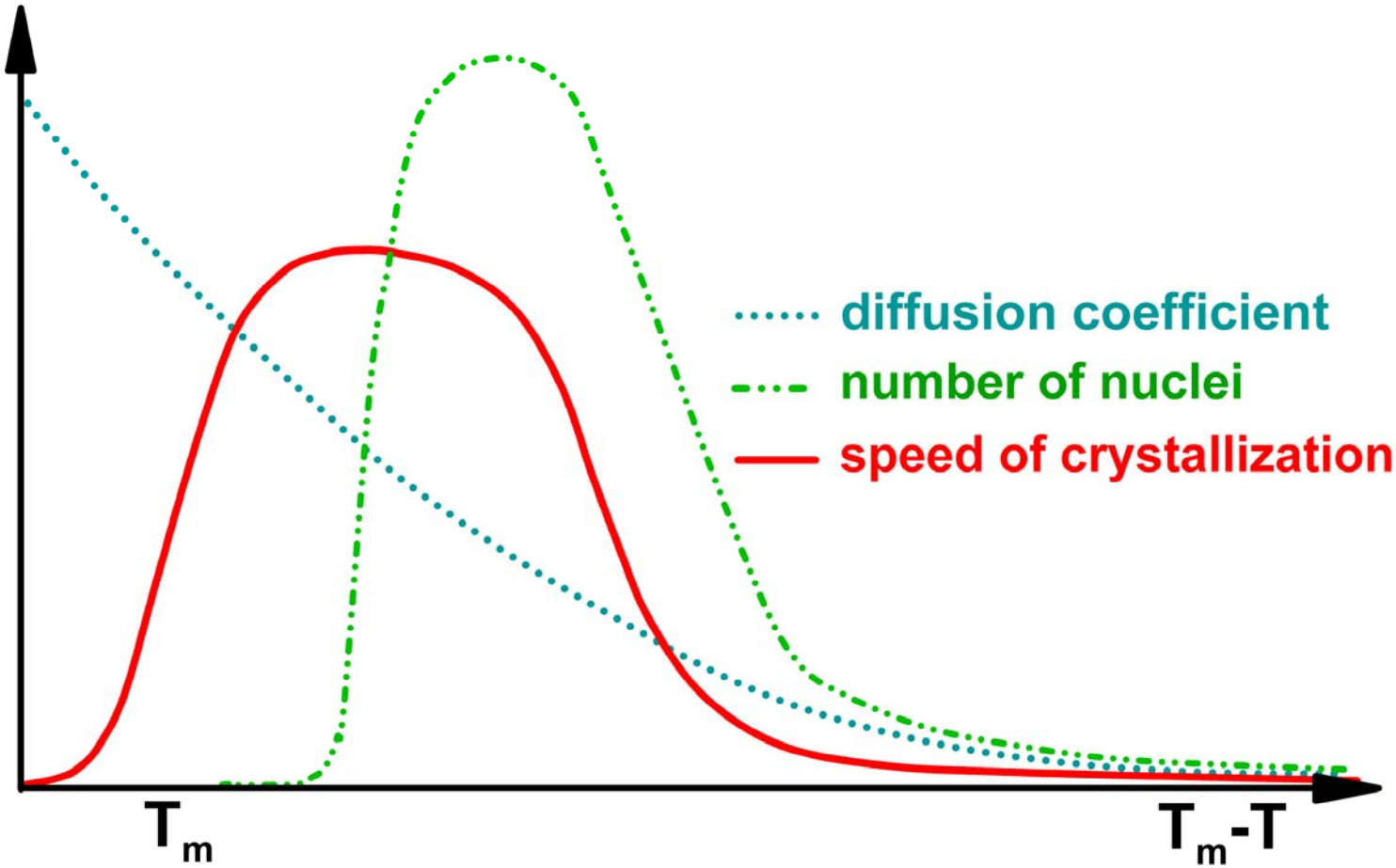
latent heat will be deduced by the solid state



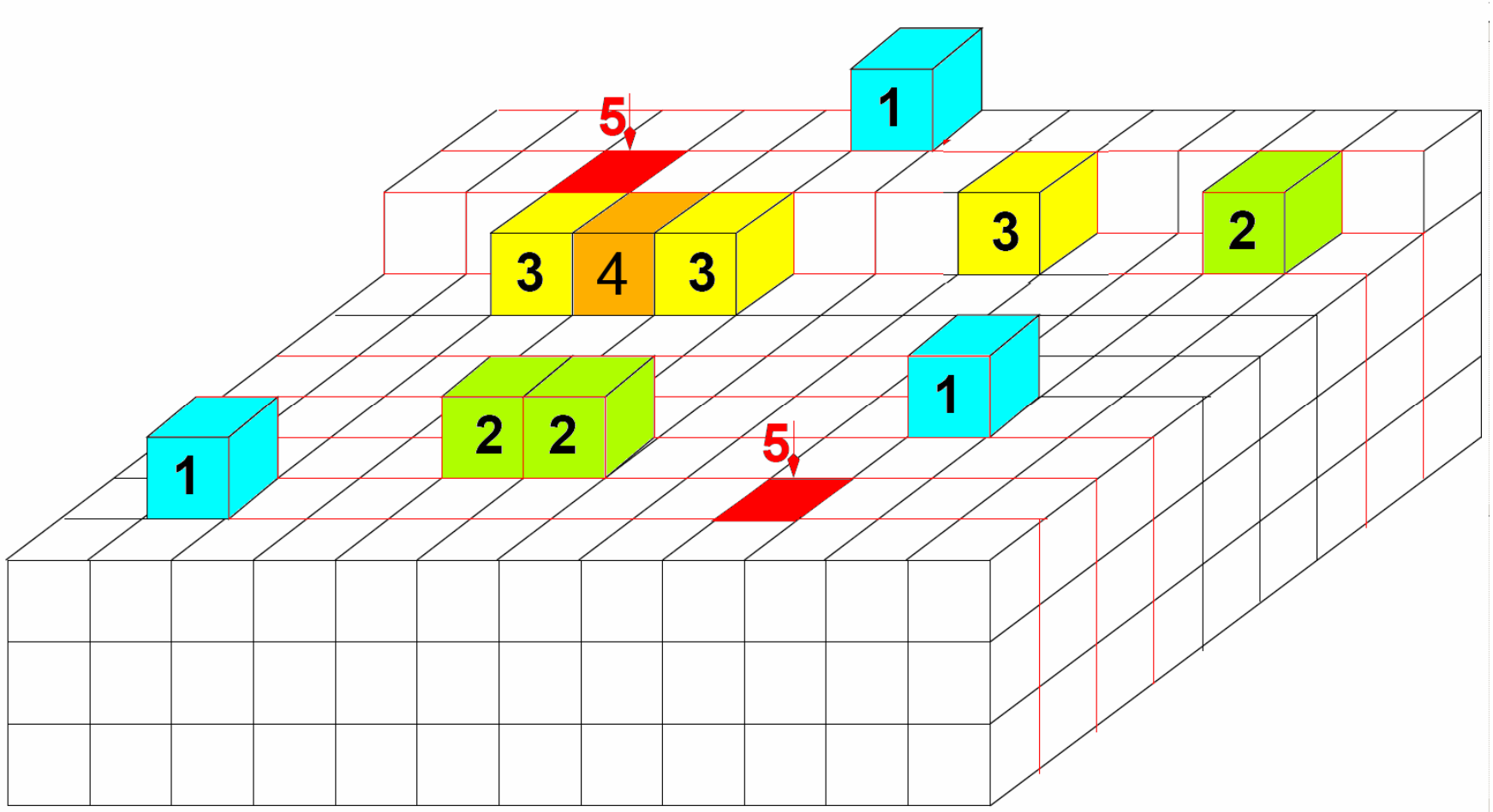
$T_{solid} > T_{liquid}$ latent heat will be deduced by the melting



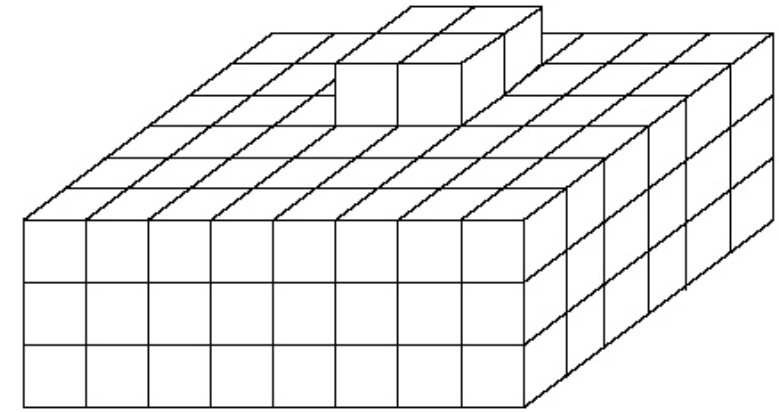
Speed of crystallisation

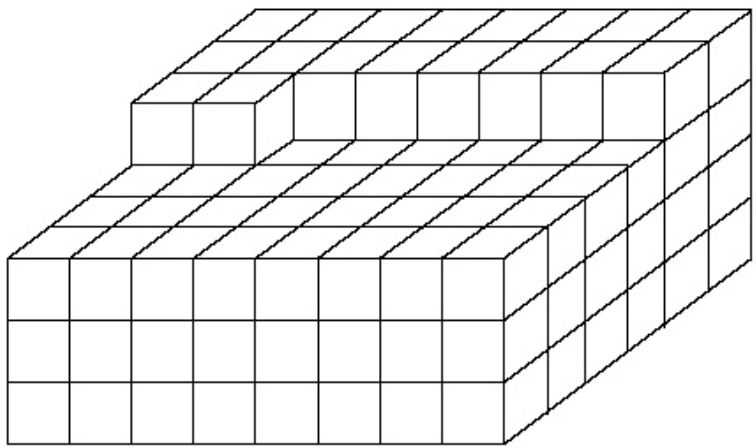


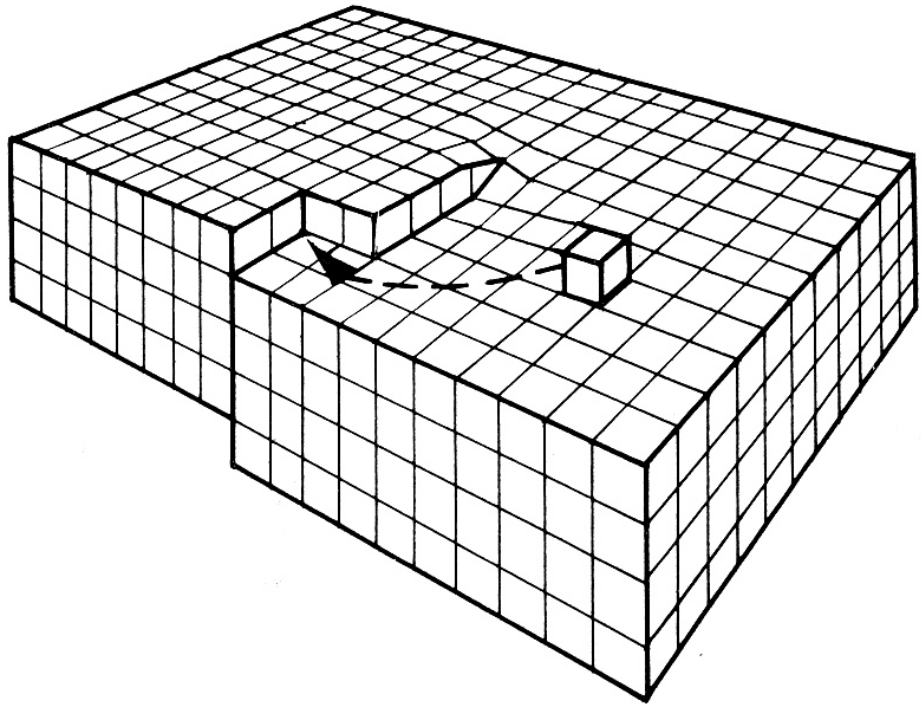
Preferred growing positions an the chrystal-surface characterized by the binding energy



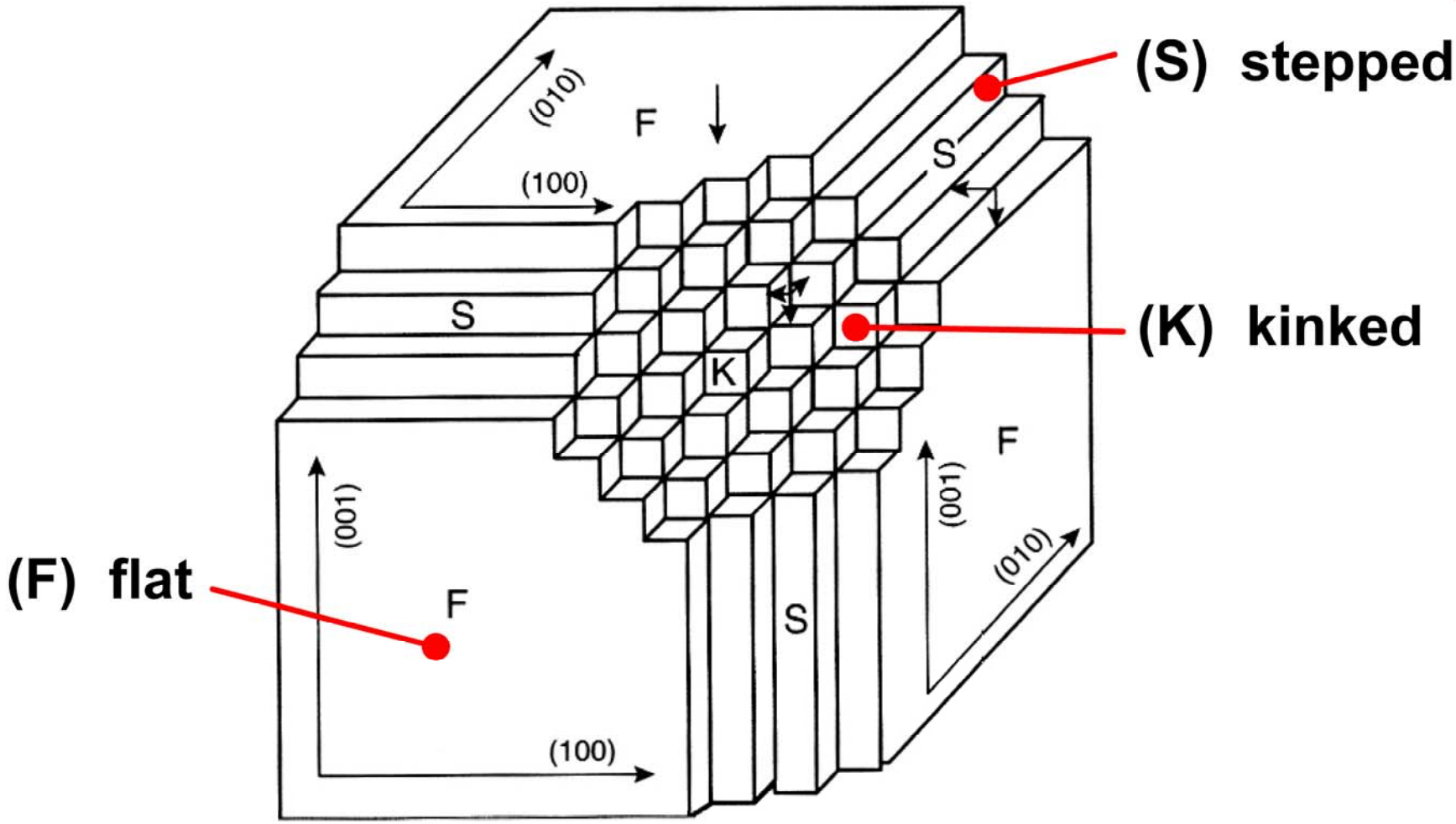
Different types of surface growth



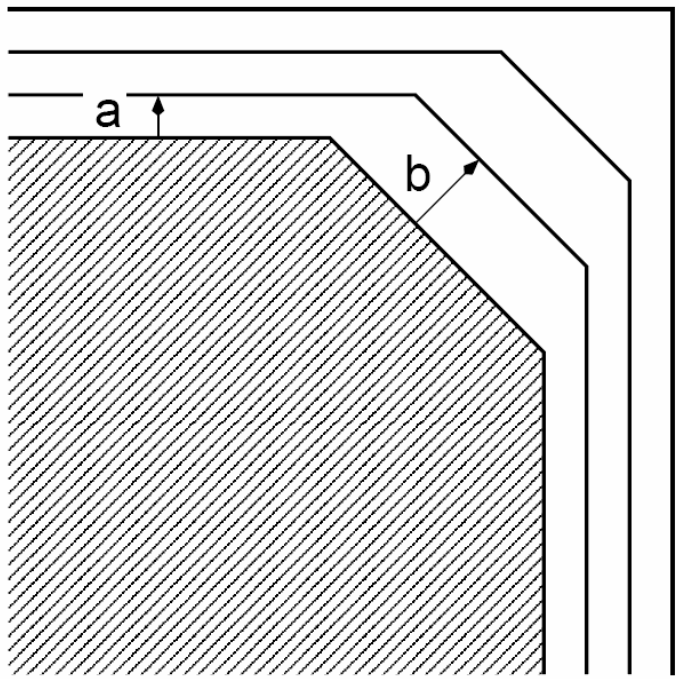


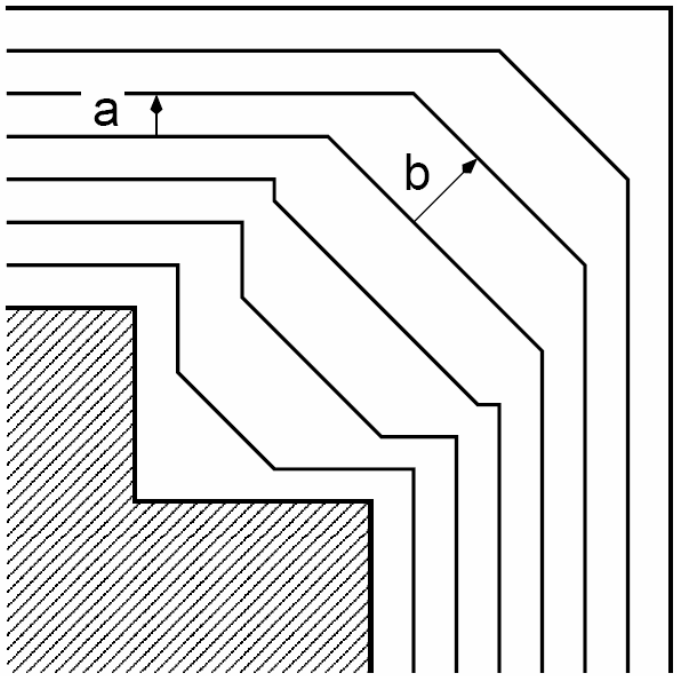


Schematic of a kossel crystal

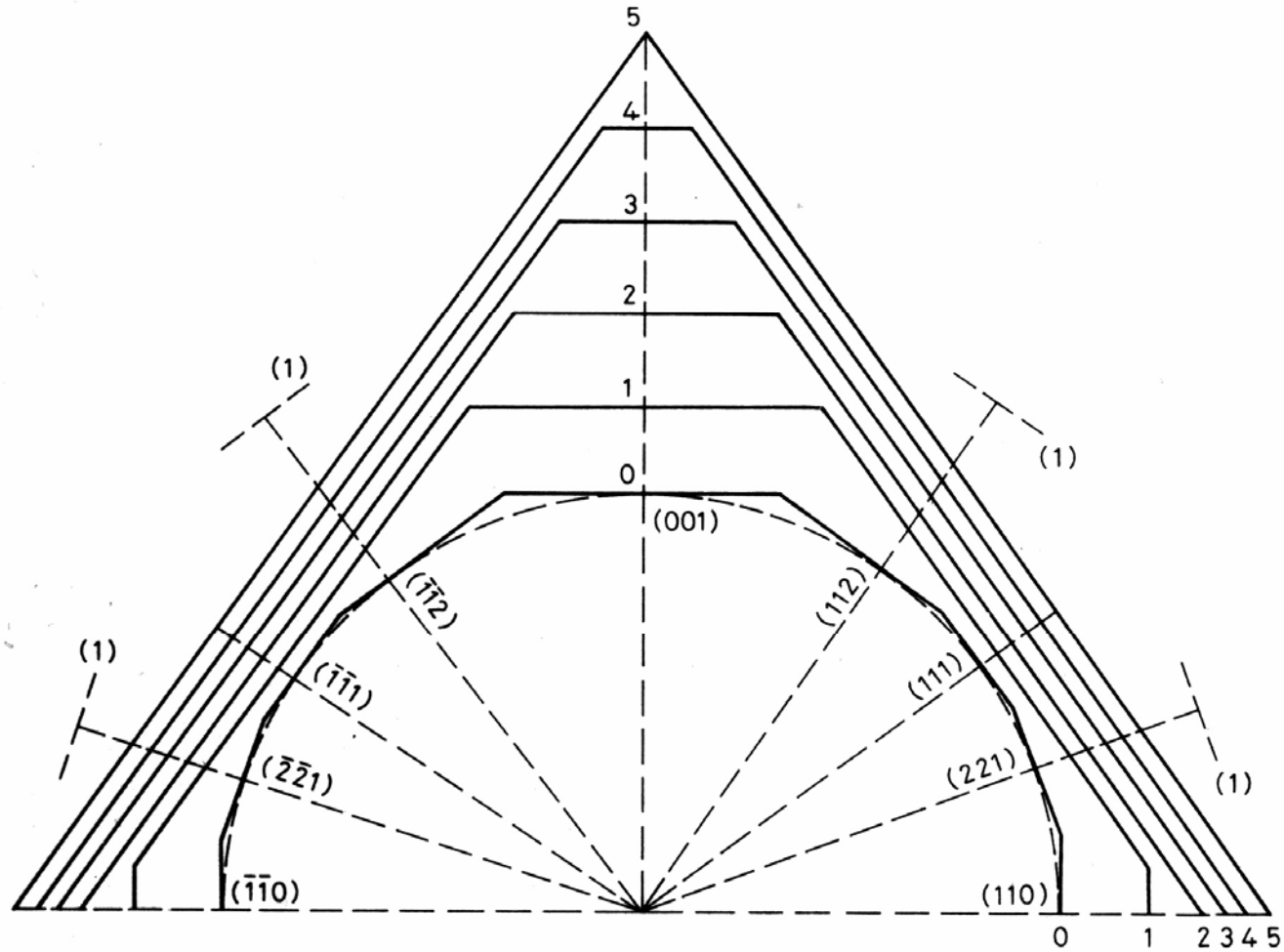


Displacement steps for a (a) slow and a (b) fast growing area

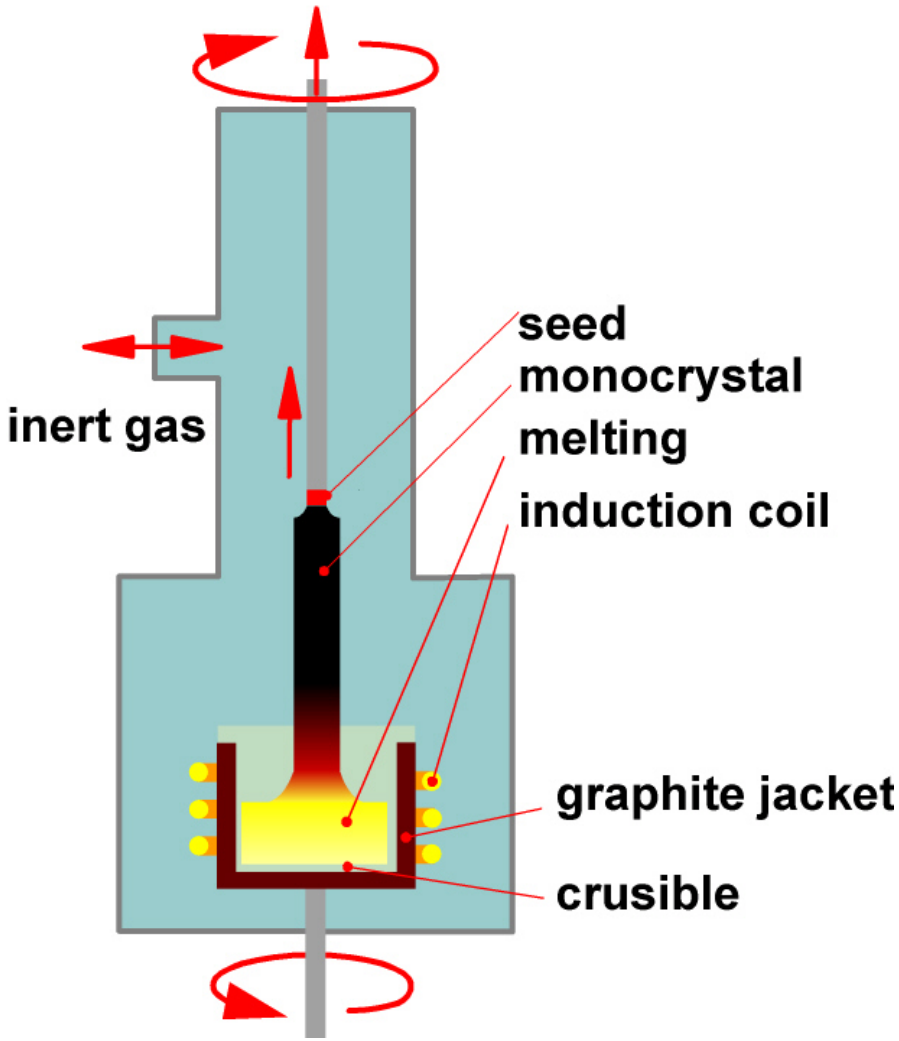


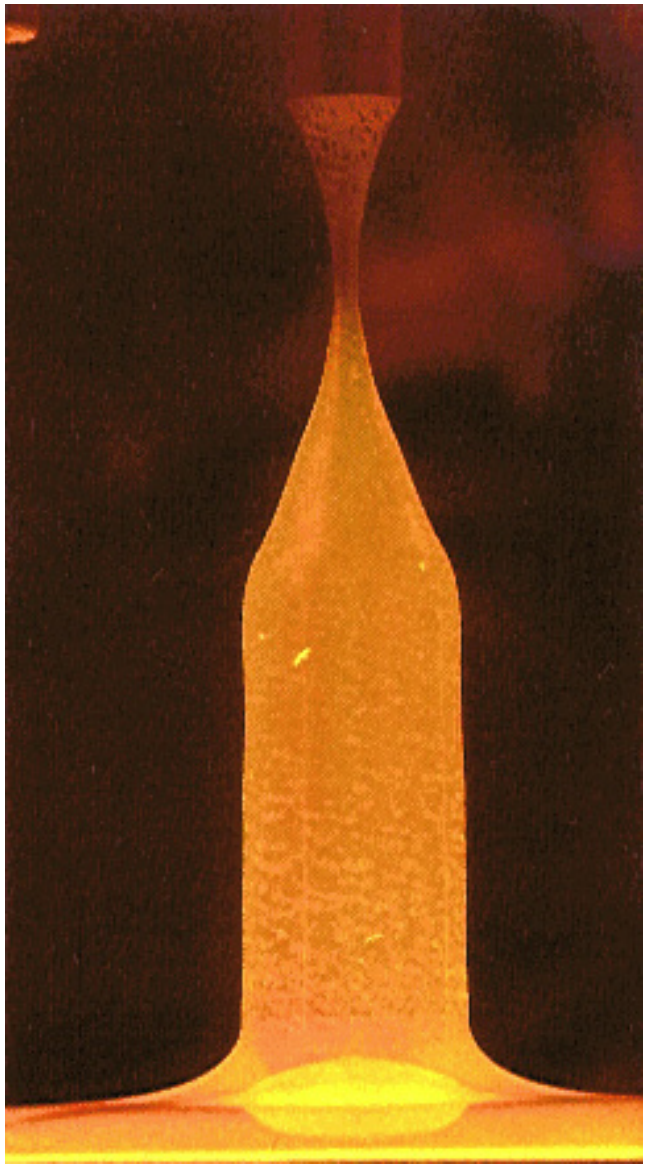


Kinematic expansion during crystal growth fast growing areas will be eliminated

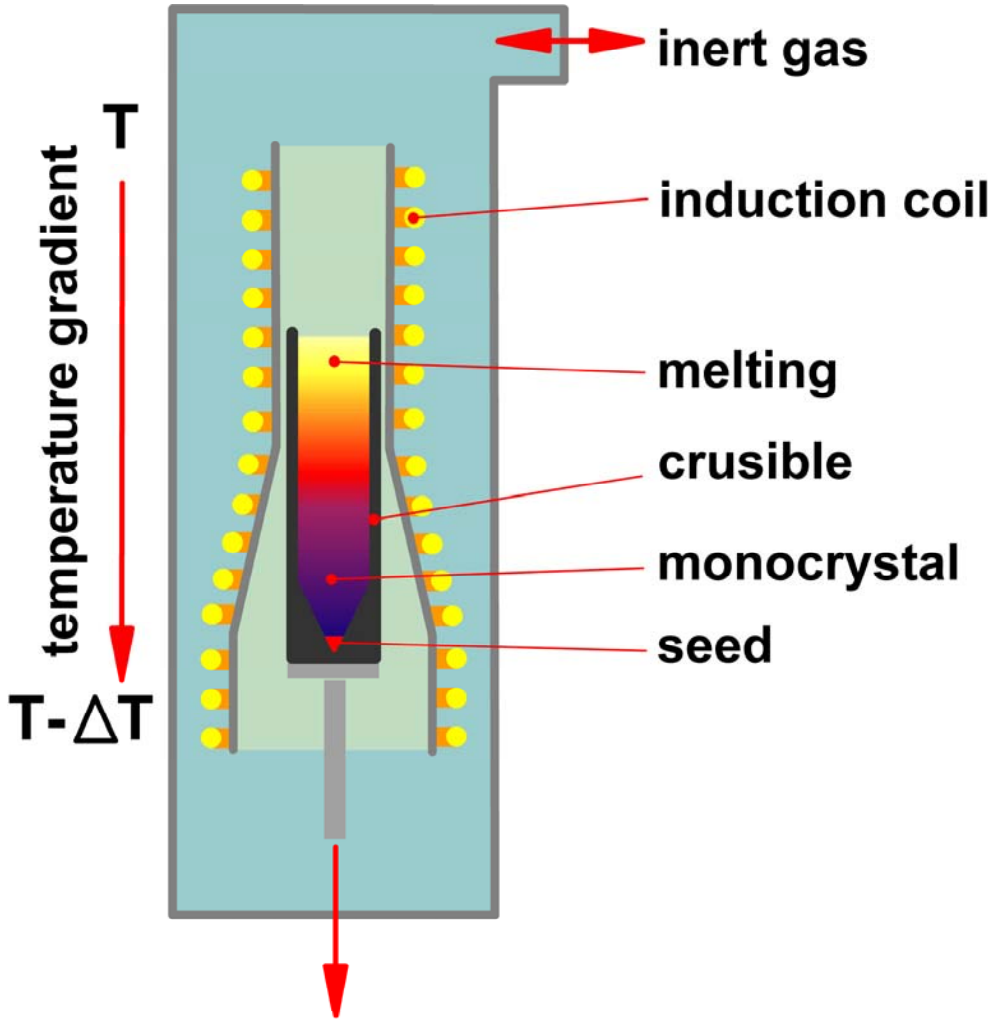


Czochralski-process

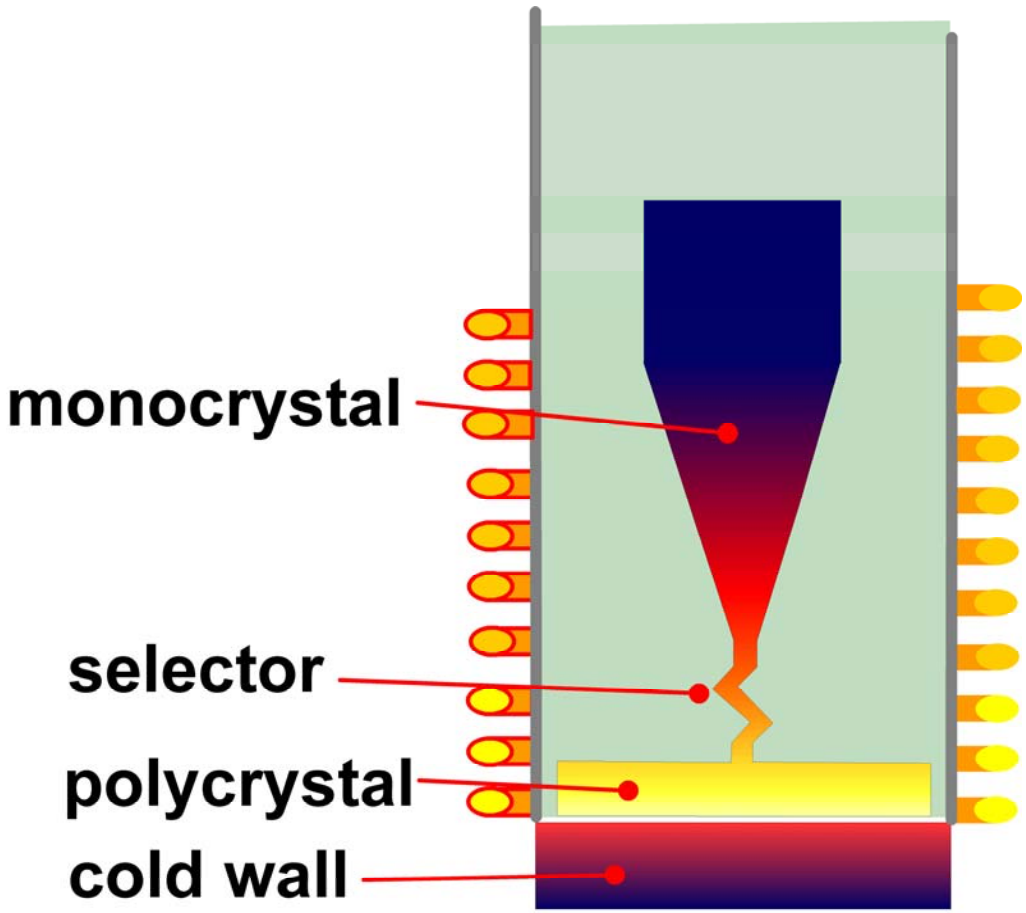




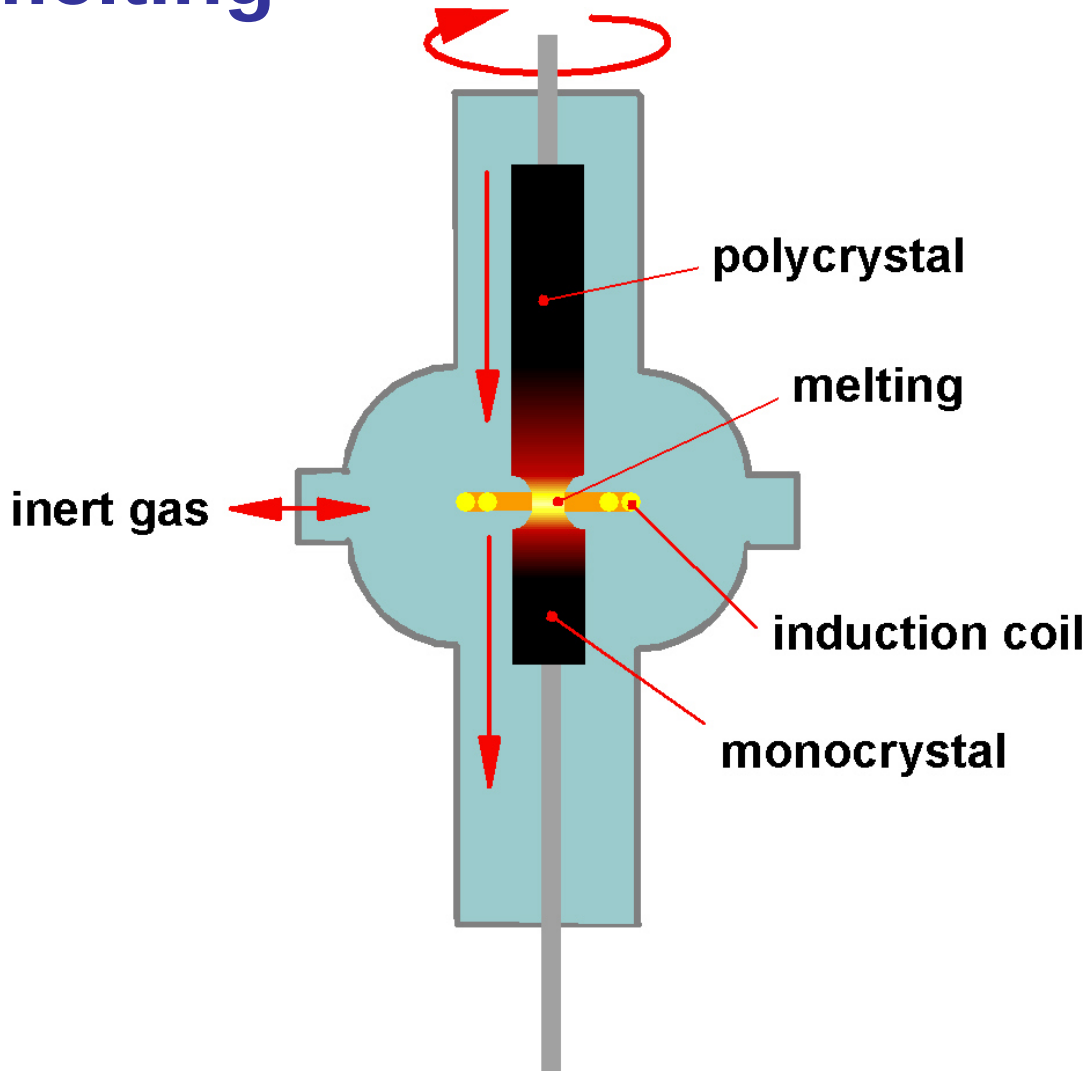
Bridgman-process



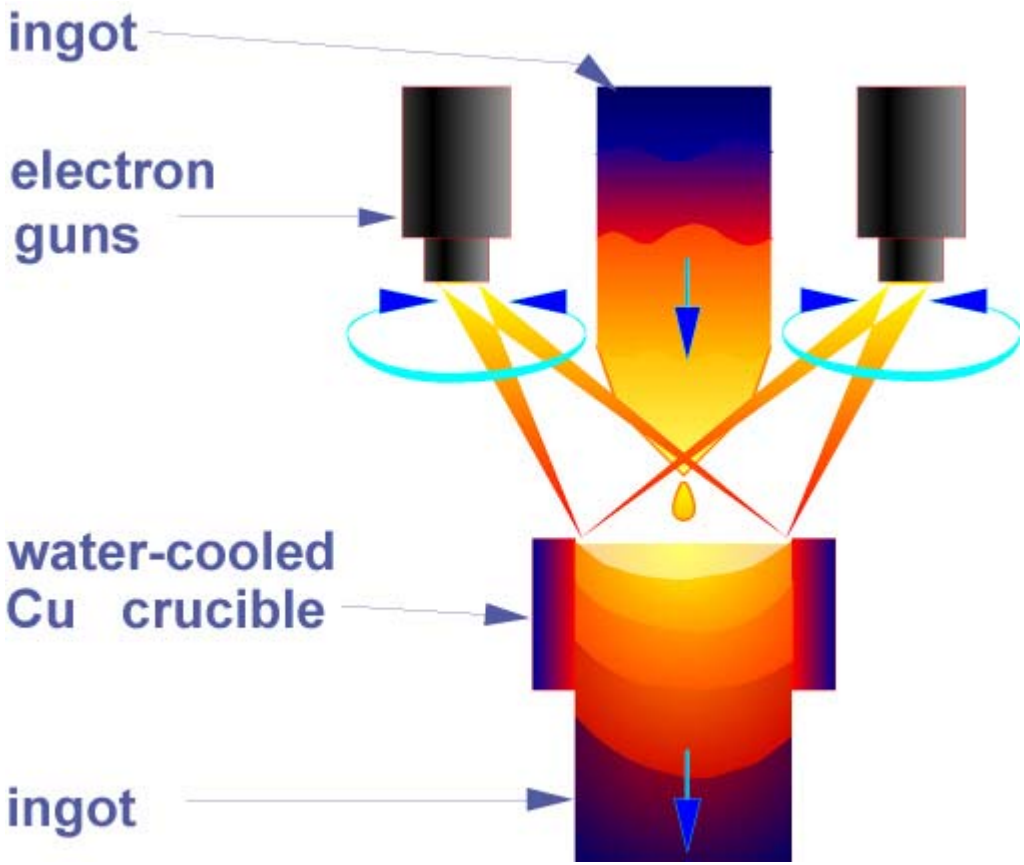
Bridgman-process with selector



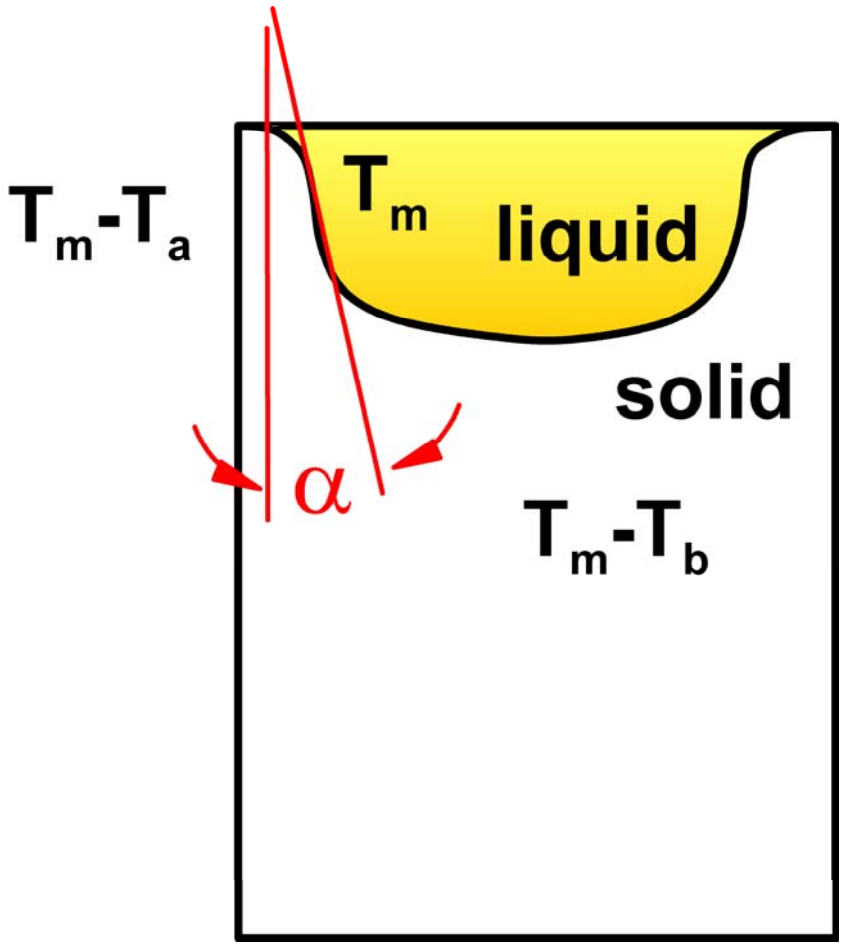
Zone melting



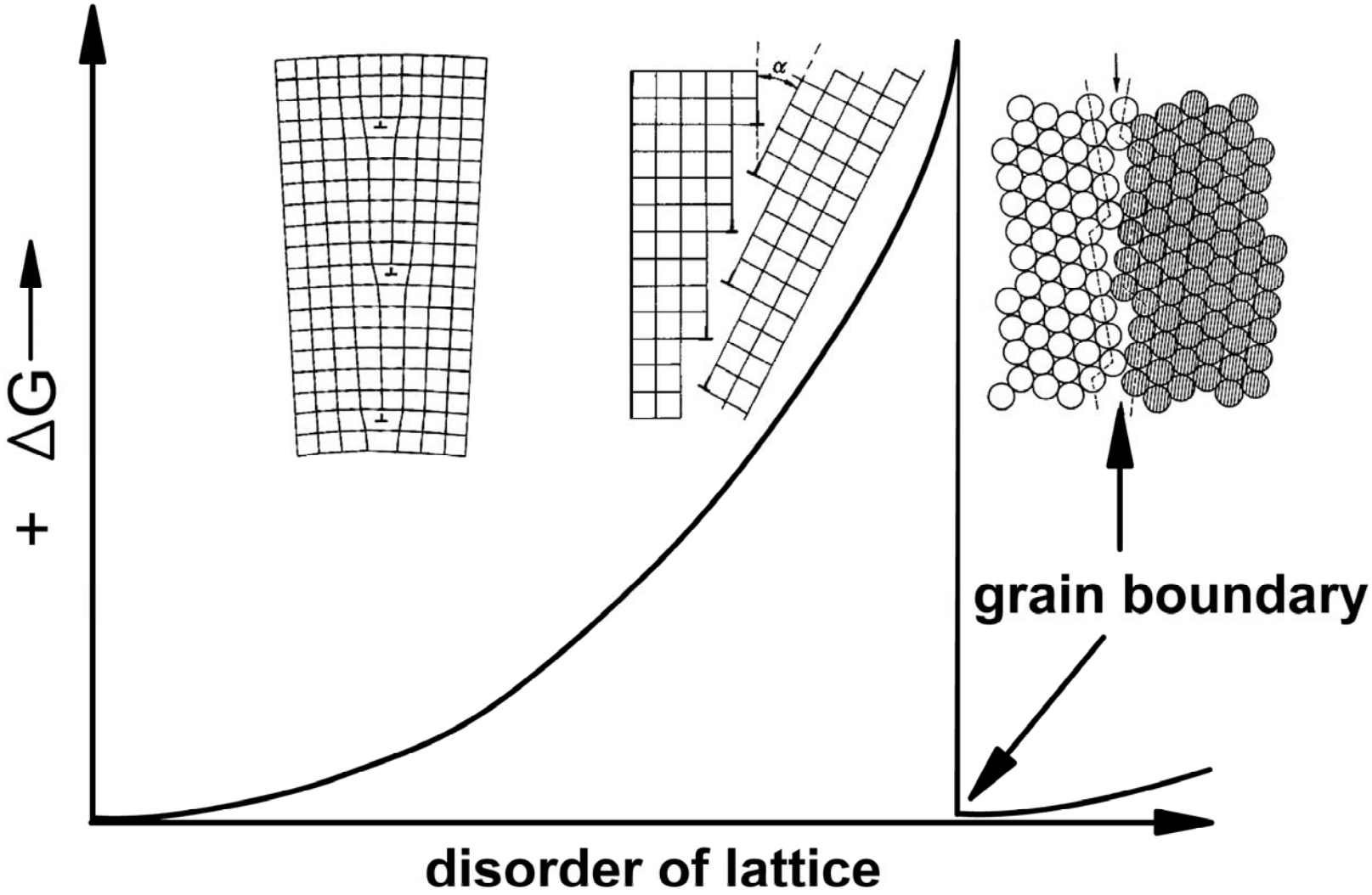
Electron Beam melting furnace



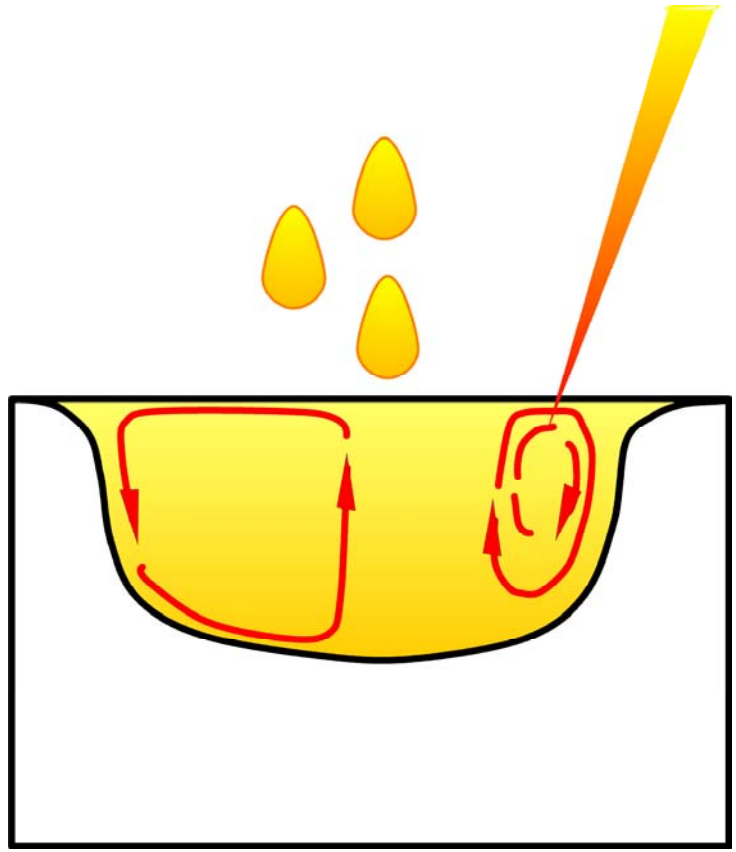
Crystal growing conditions in dependence of the angle between solid- and liquid surface

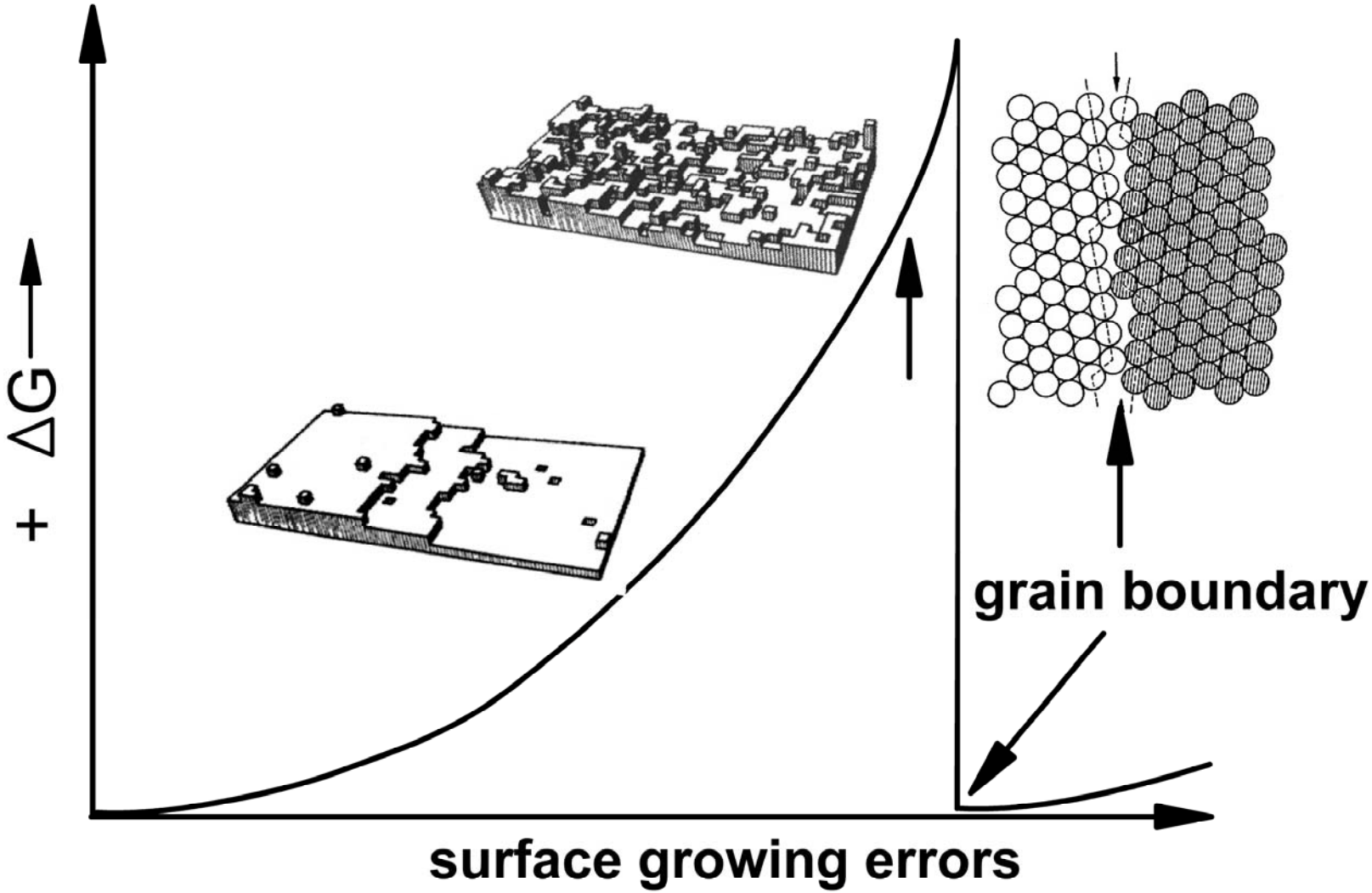


High disorder leads to grainboudaries

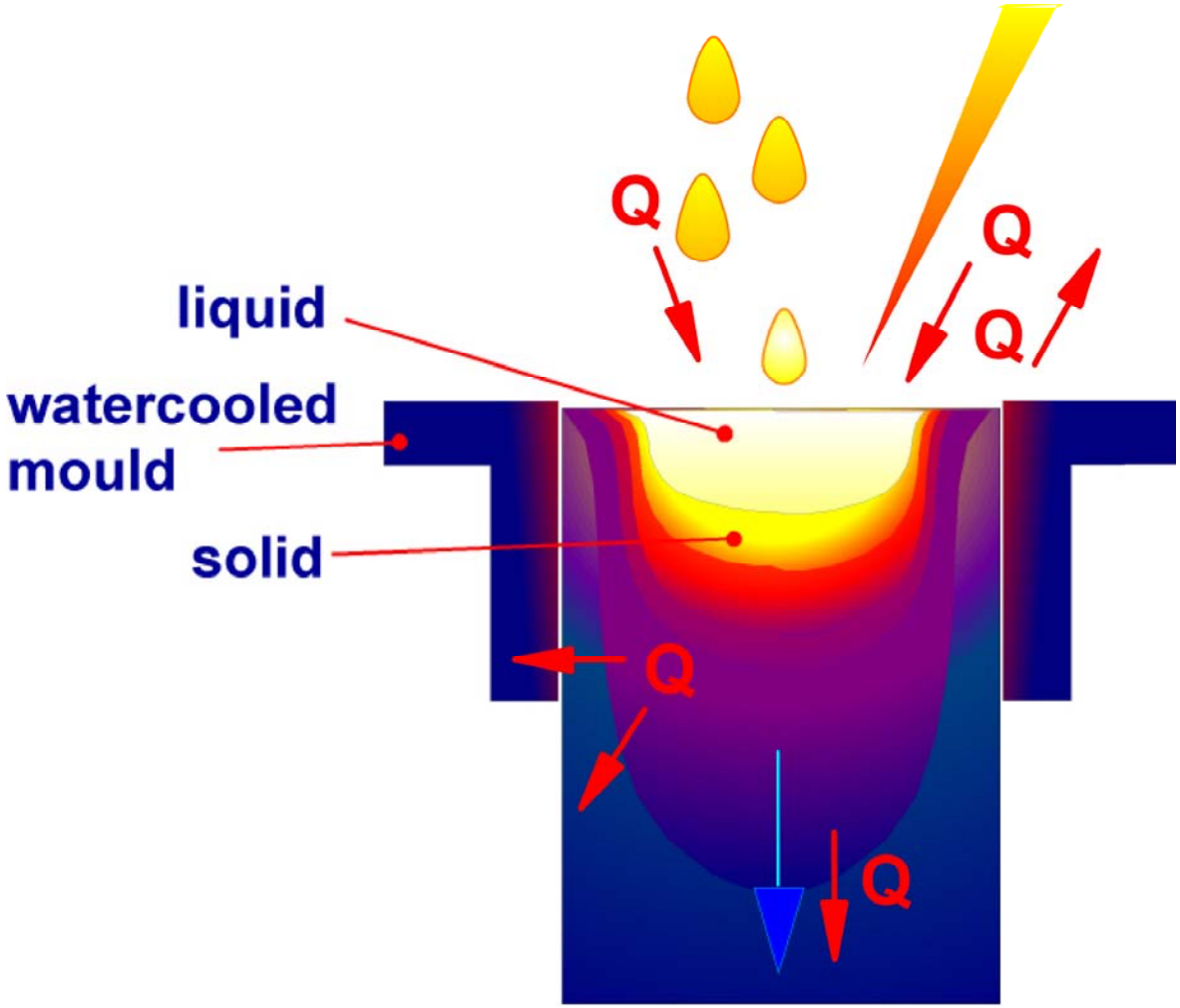


Convection in the melting in dependence of the viscosity, surface tension, density etc




+ ΔG
grain boundary
surface growing errors

Thermal economy of the EB-melting



Thank you for attention