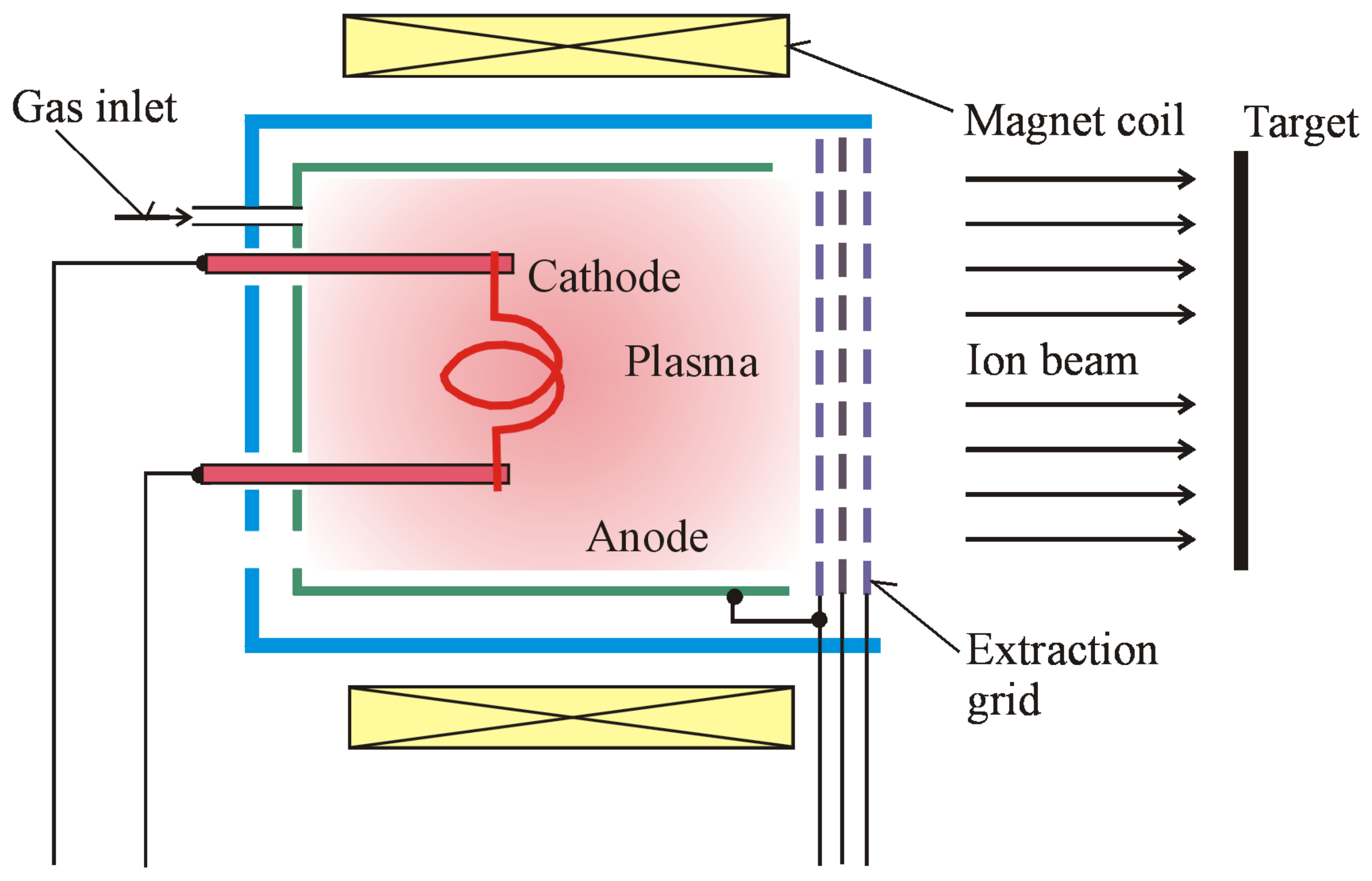
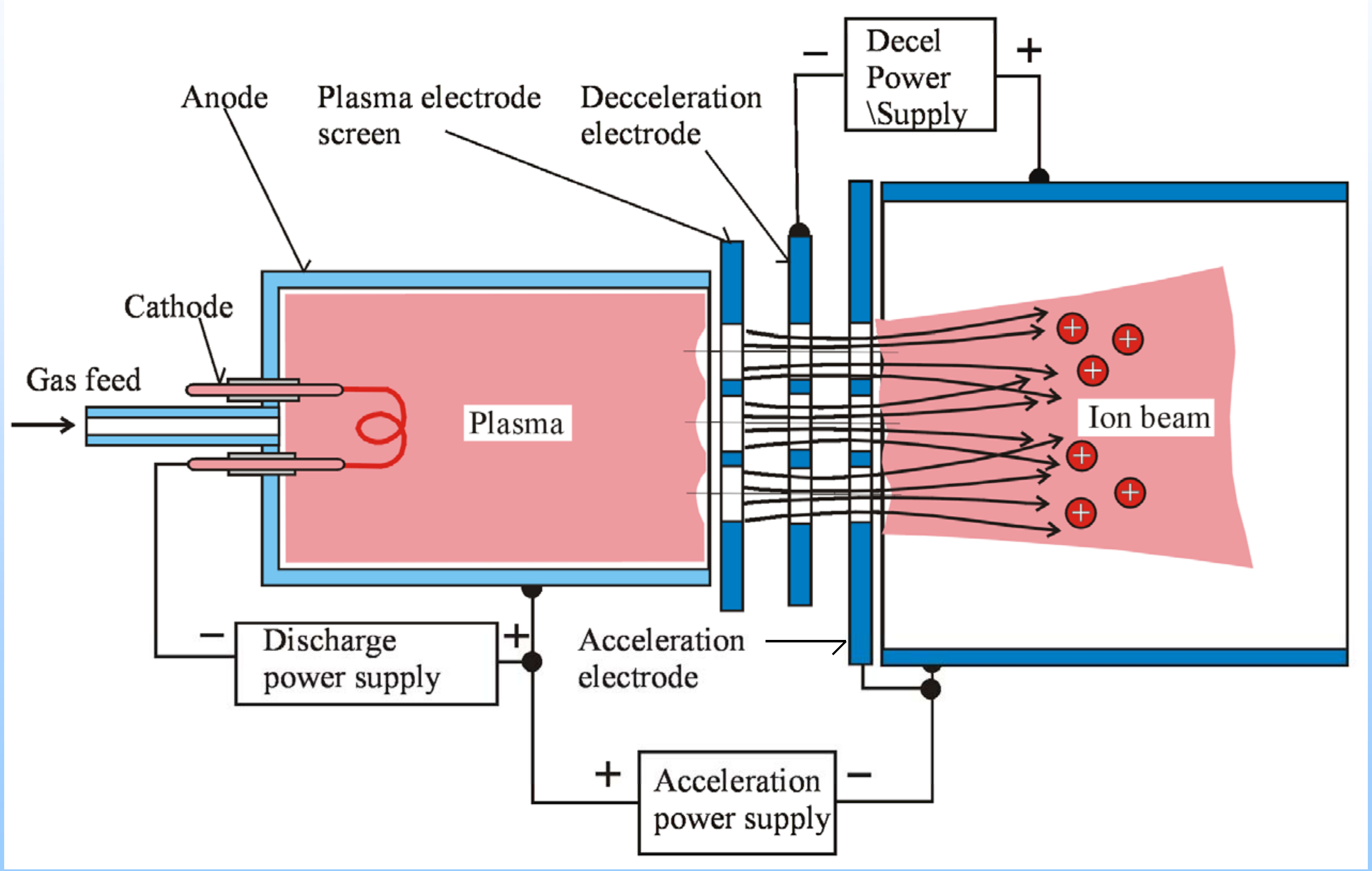
Contents

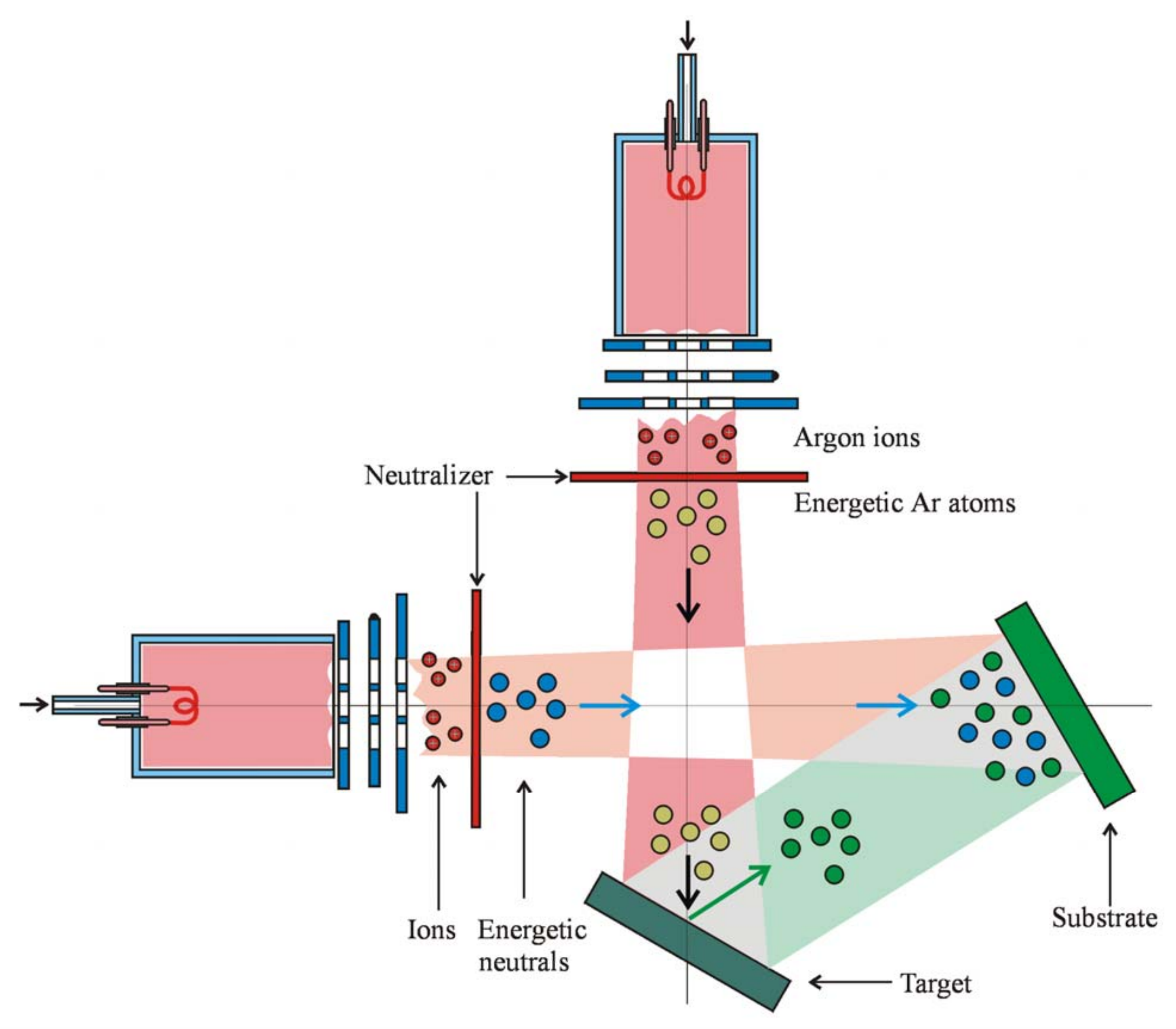
Broad Ion Beams - Kaufman Ion Source



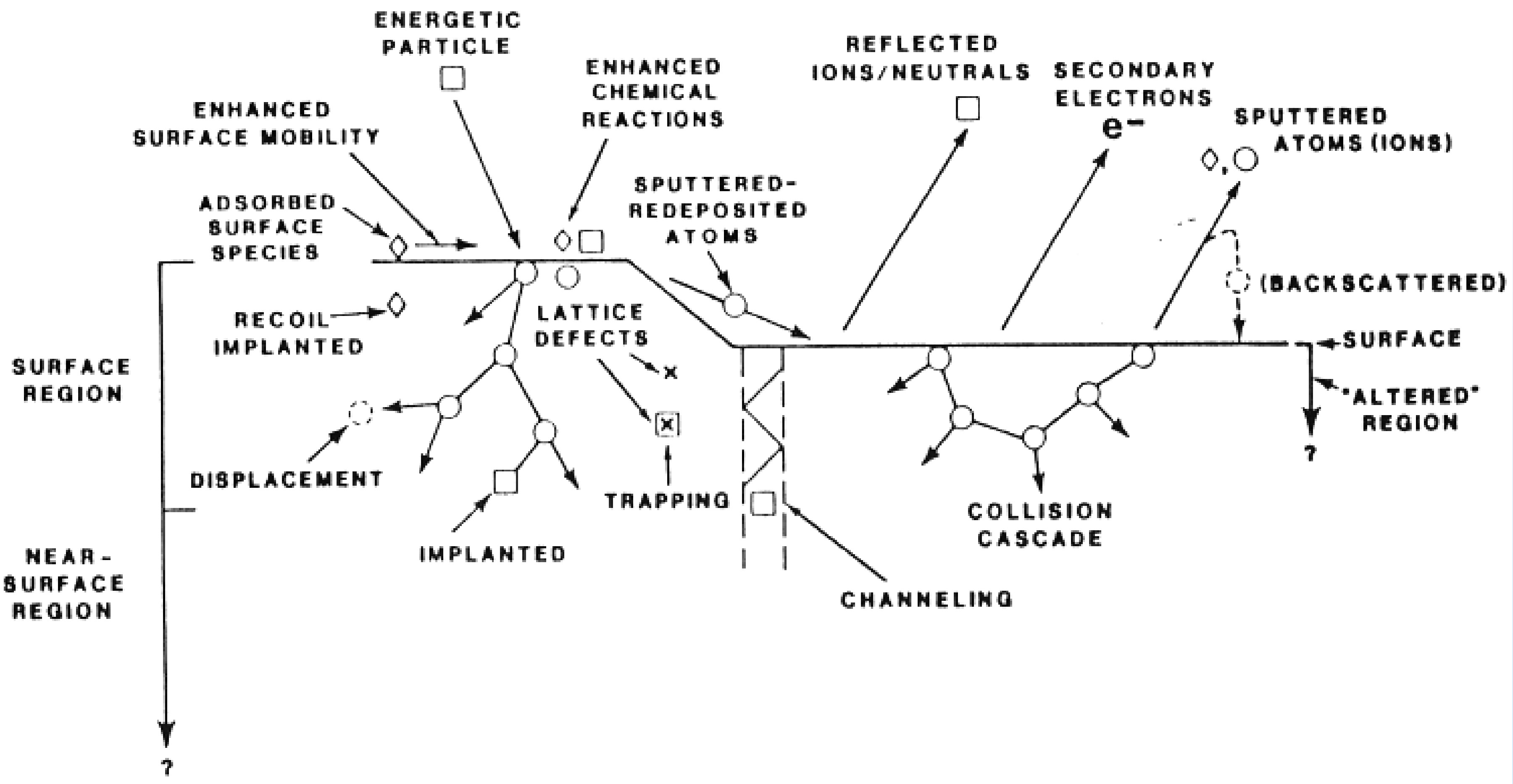
Wiring - Broad Beam Ion Source



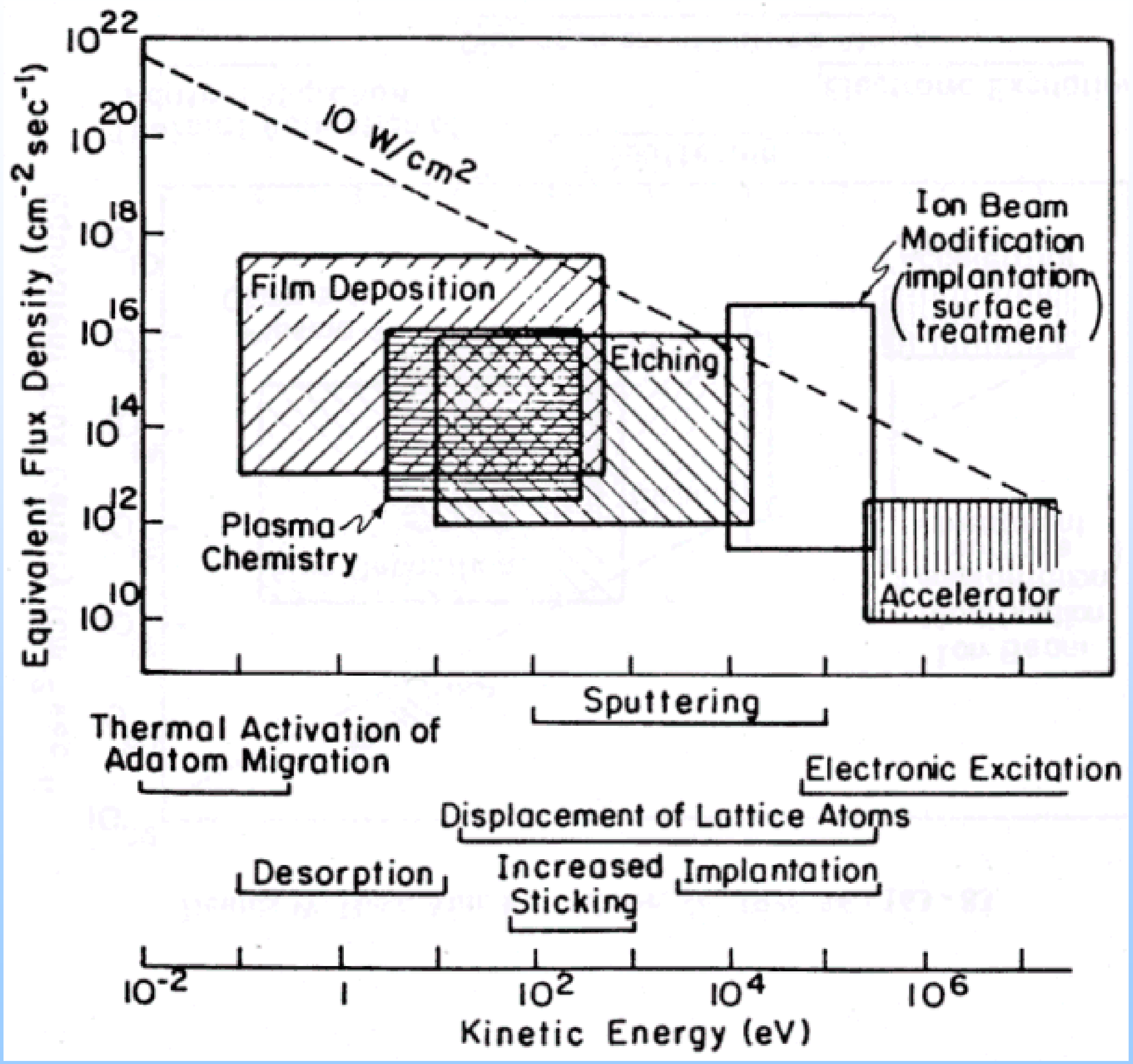
Dynamic Recoil Mixing



Influence of the kinetic energy

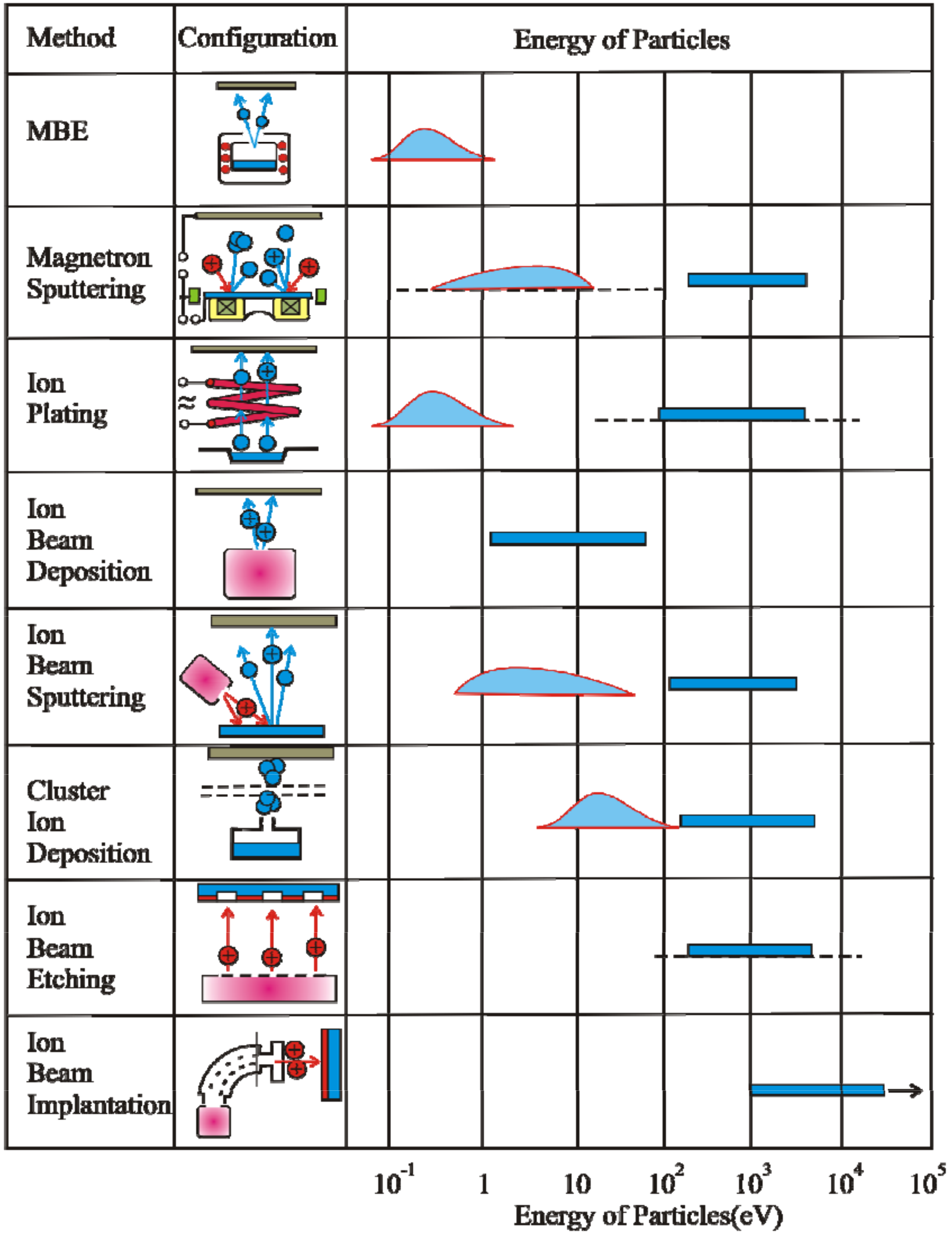


Schematic diagram showing the effect of bombardment of energetic particles on surface and grown films.



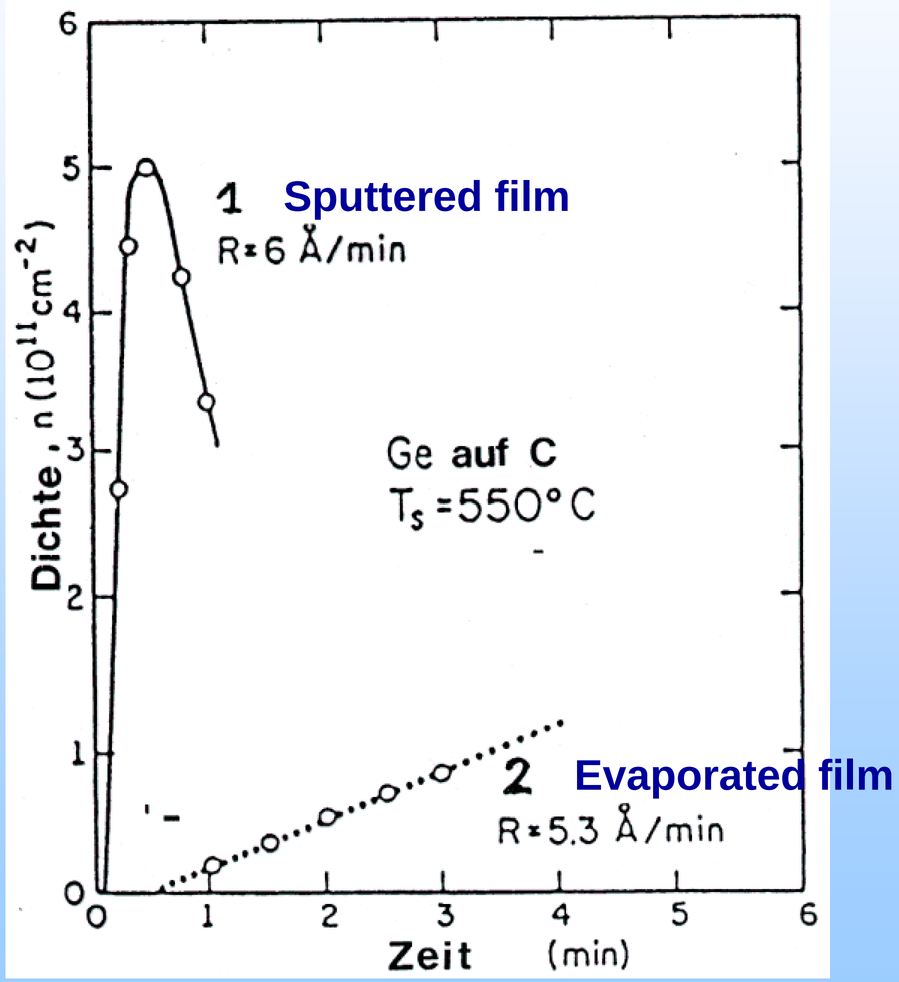
Range of kinetic Energy and equivalent flux density of incident particles

Particle Energy and Deposition Techniques

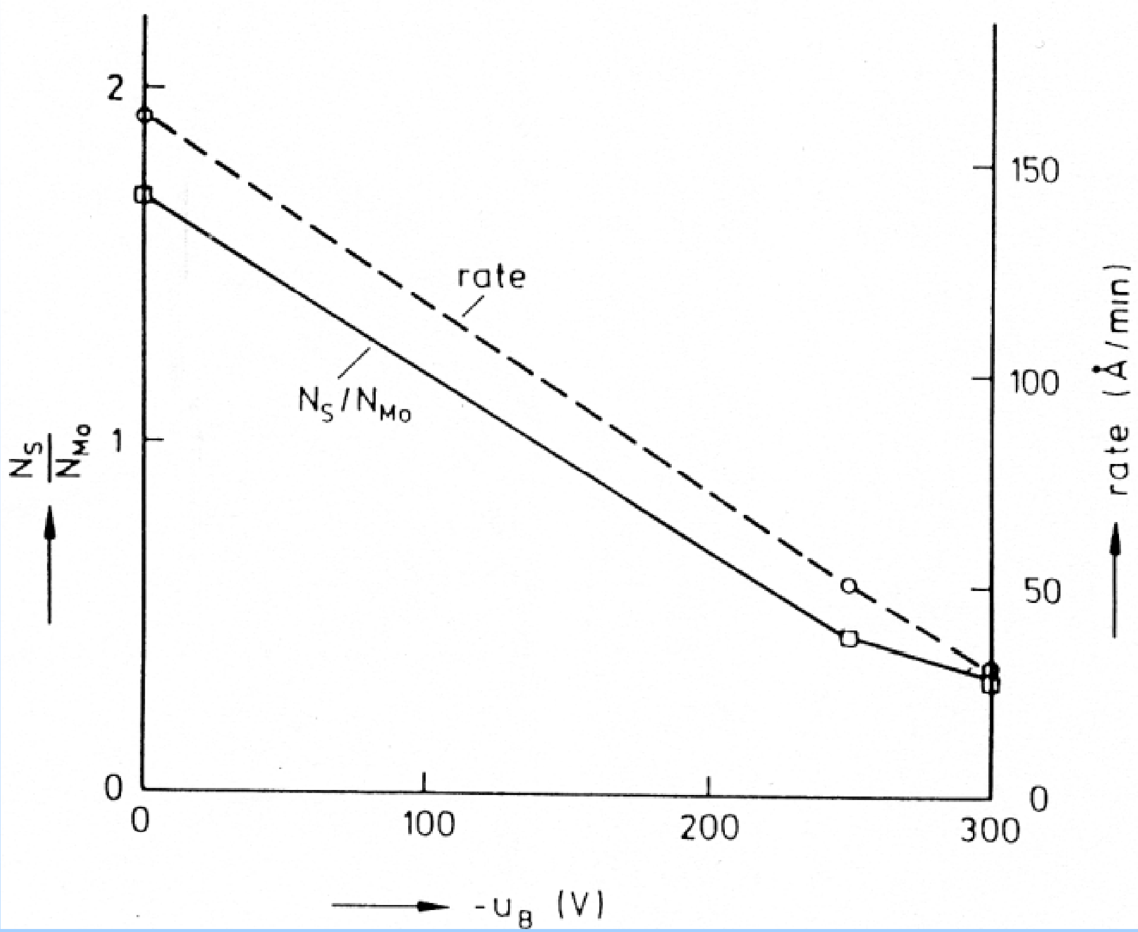


A very large range of particles energies is employed for material processes which include deposition, etching and implantation

Cluster density of Ge on amorphous carbon substrate as function of deposition time



Back - sputtering effect

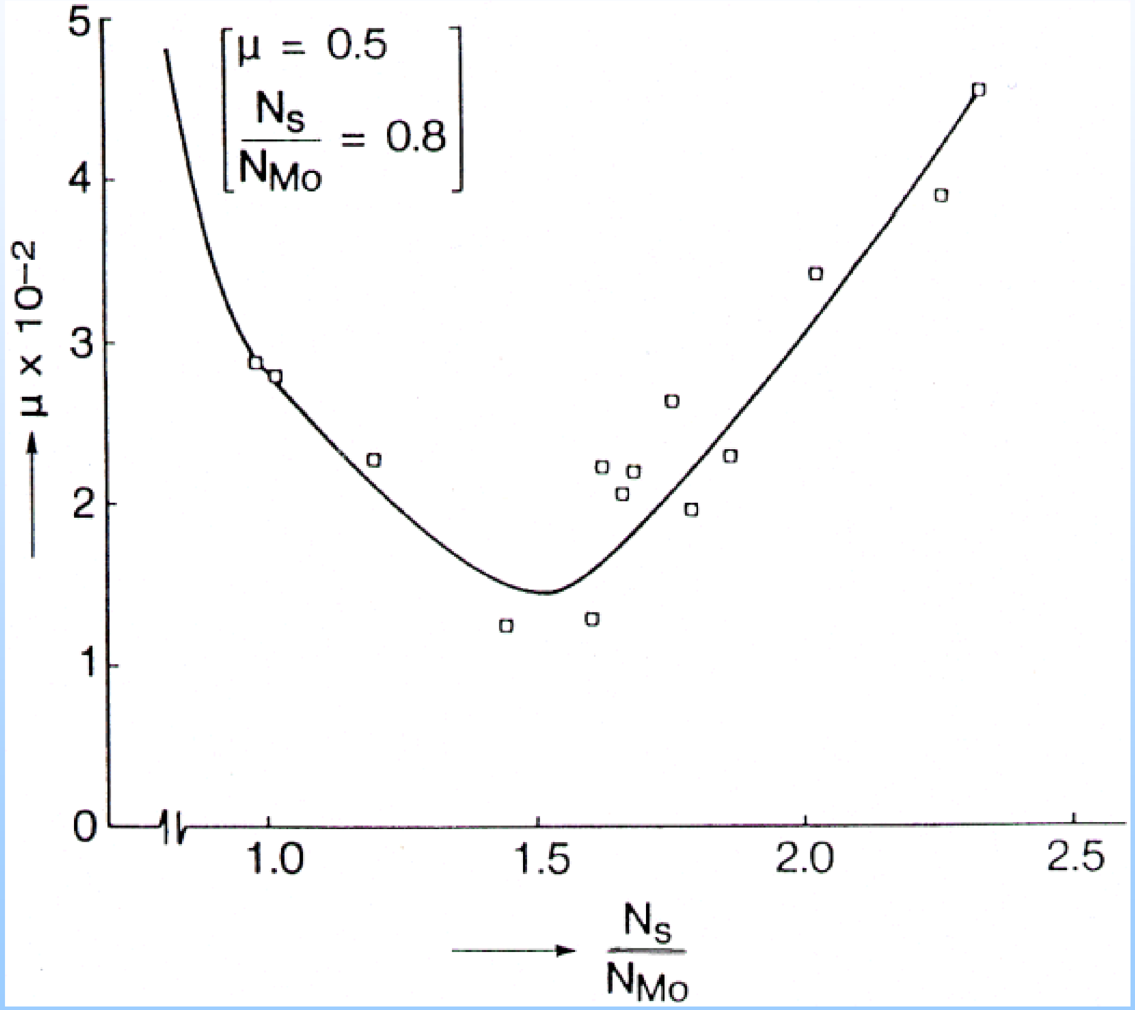


Deposition rate and composition of MoS_x films as function of the bias voltage

Back-sputtering effect → Variation of the film composition.

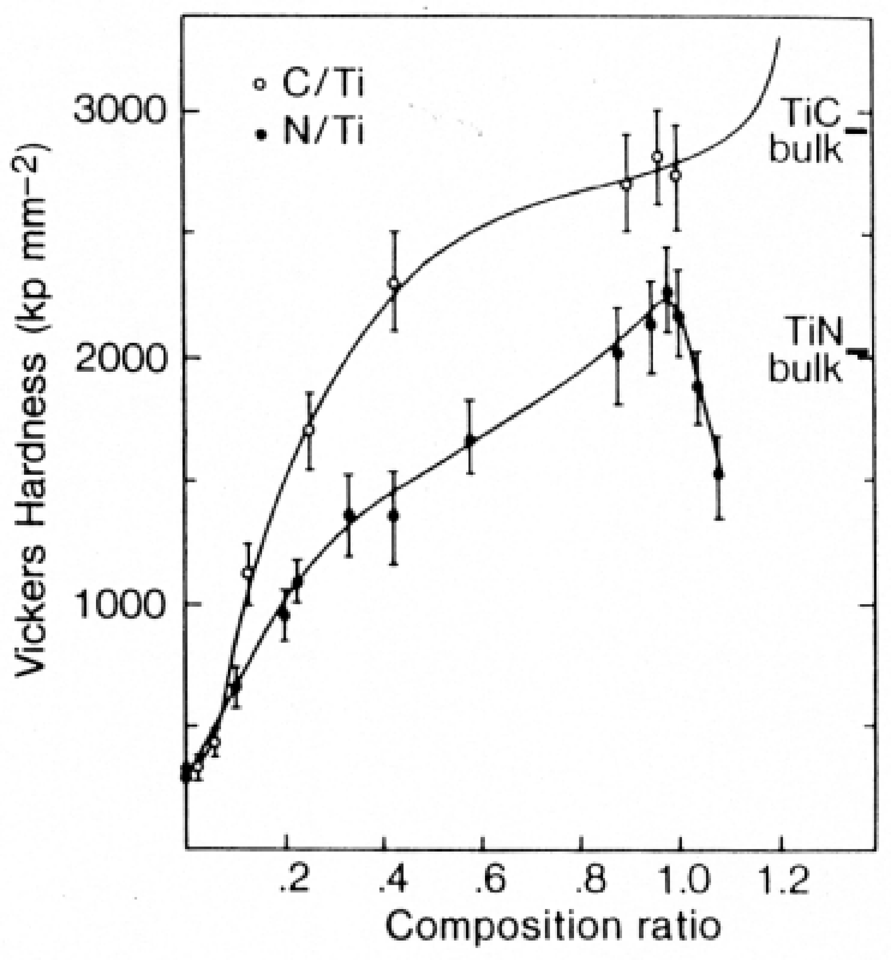
Advantage: Preparation of the gradient films

Friction coefficient



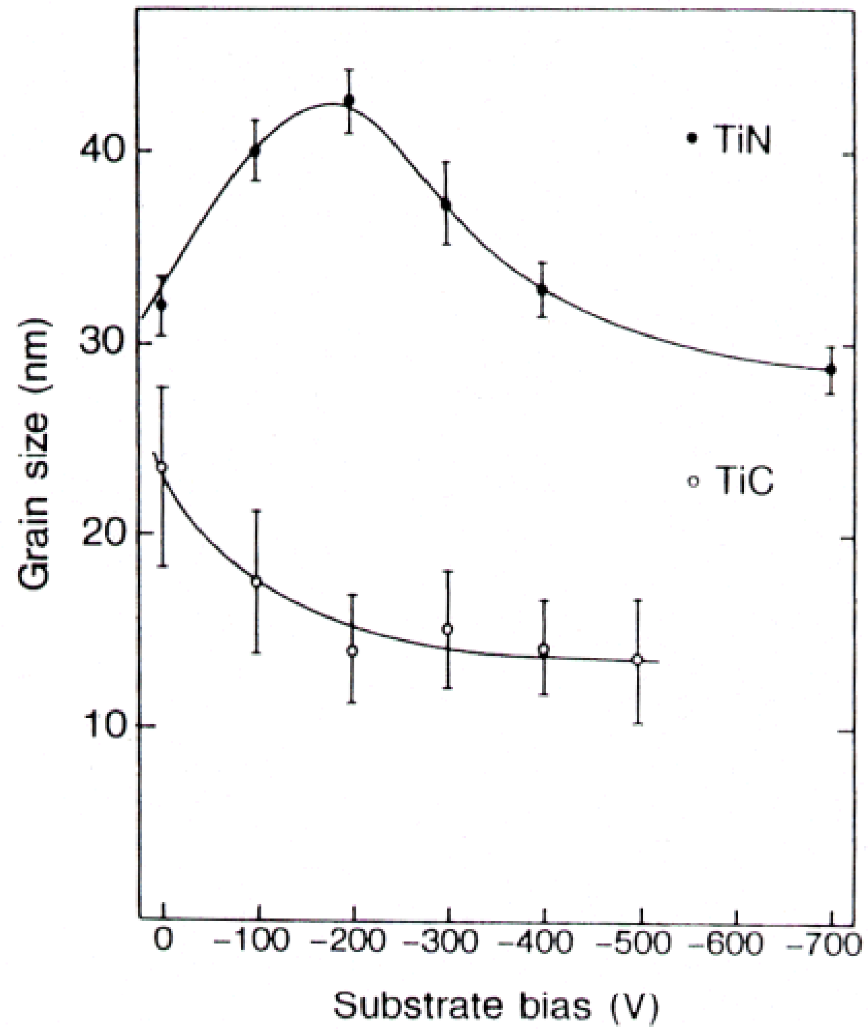
Friction coefficient of MoS_x films in dependence of the film composition.

Hardness



Vickers hardness of TiC$_x$ and TiN$_x$ films as function of composition

Grain size



Increase of the adatom mobility

→ Variation of the grain size

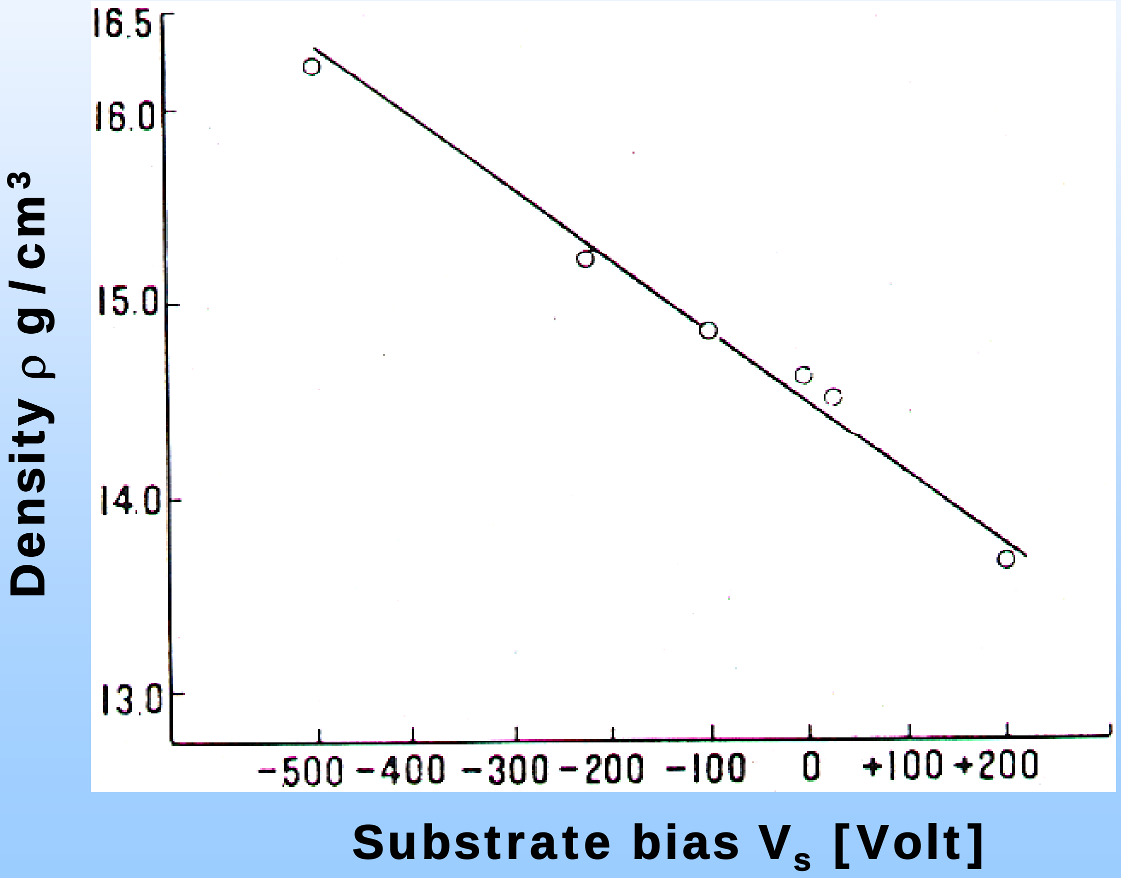
→ Variation of the density

Grain size as function of the bias voltage

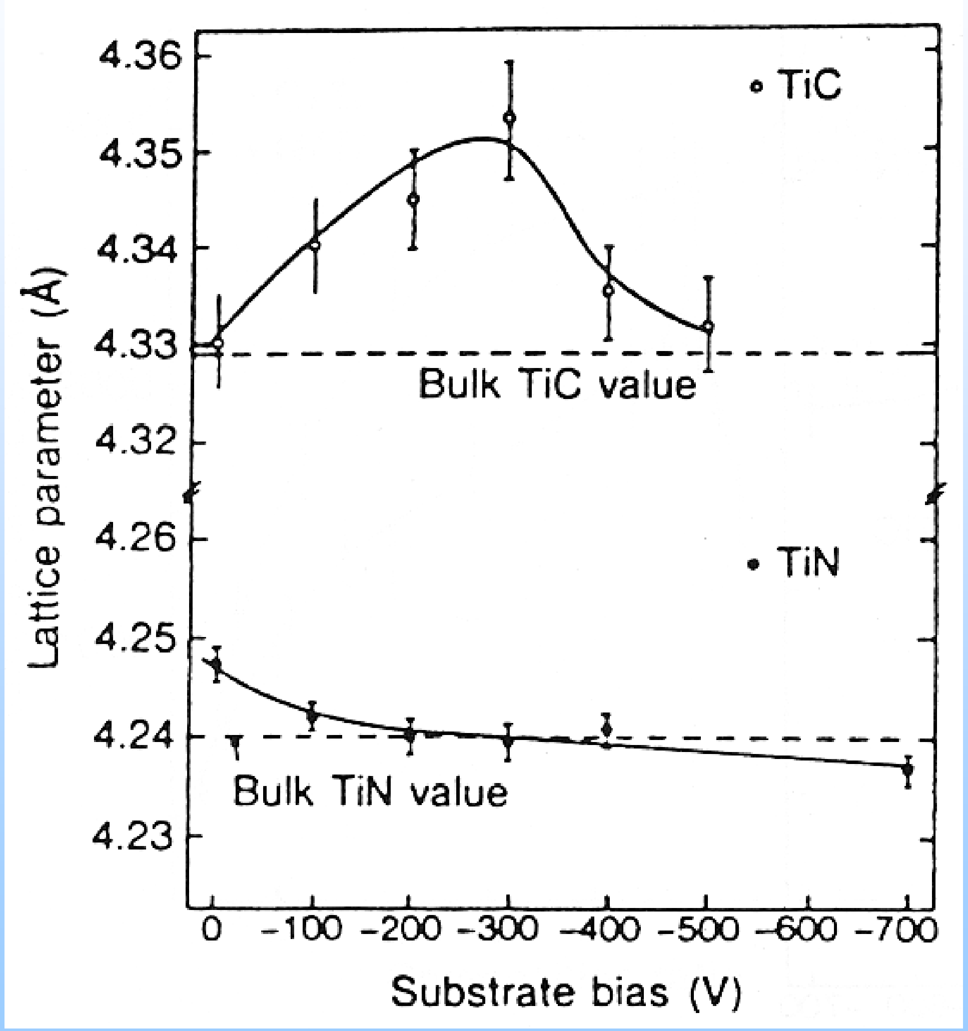
C / Ti = N / Ti = 1

Density

Density as function of the substrate bias for sputtered Ta films



Lattice parameter

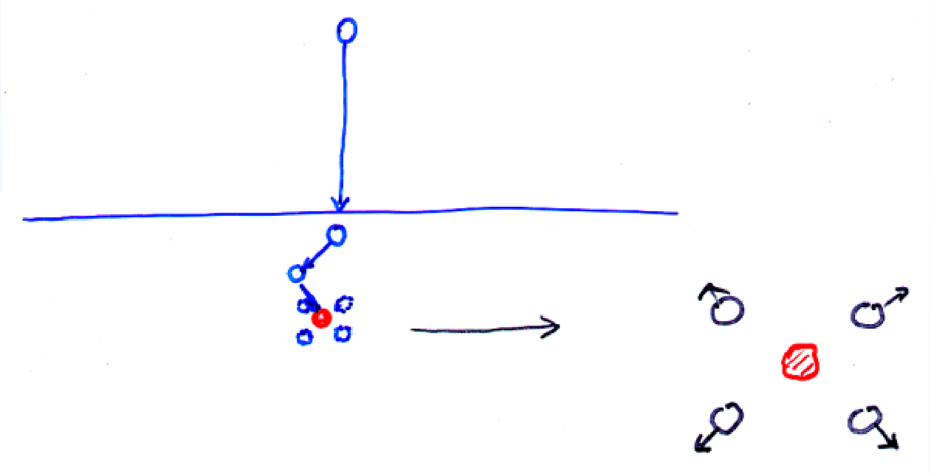


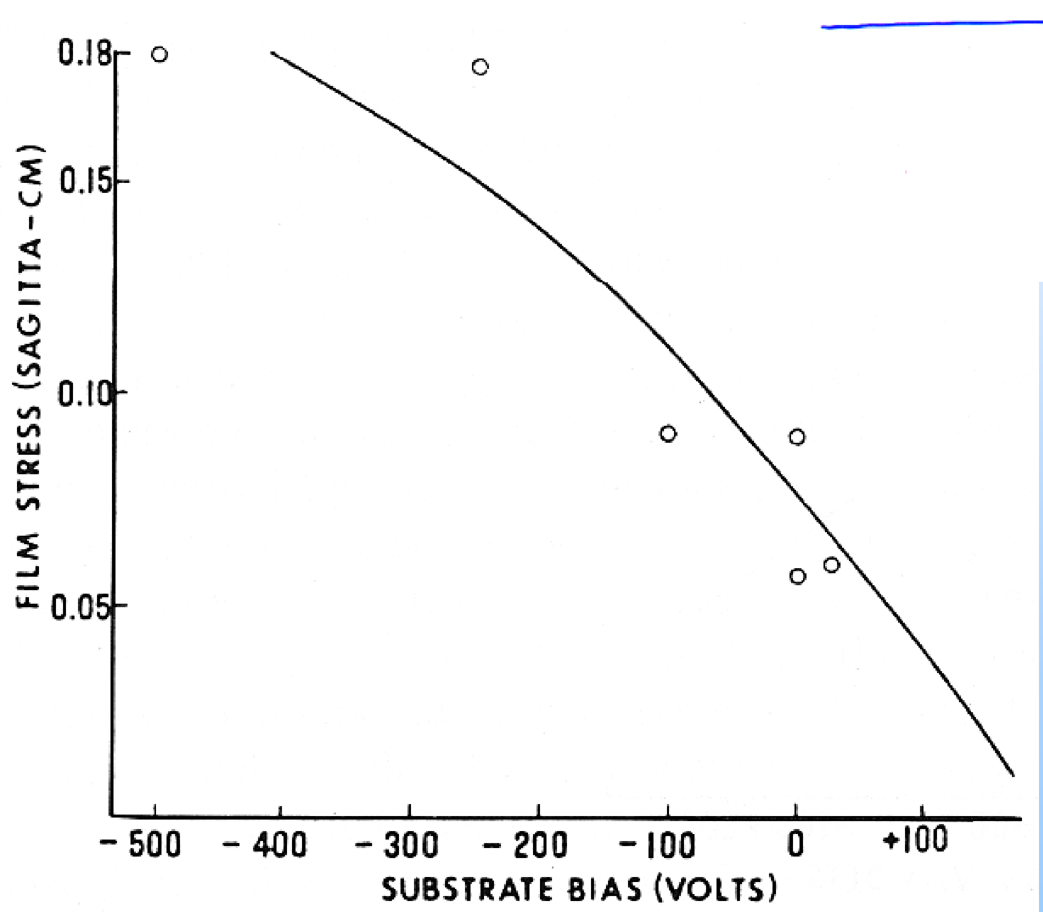
Production of interstitial atoms and vacancies → Variation of the lattice parameter, film stress

Lattice parameter variation of TiC and TiN films as function of substrate bias.

C/Ti = 1, N/Ti = 1

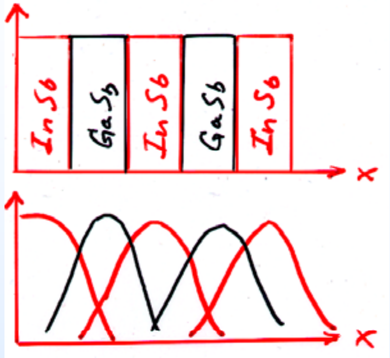
Compressive stress





Compressive stress of sputtered Ta films as function of substrate bias

Diffusionskoeffizient

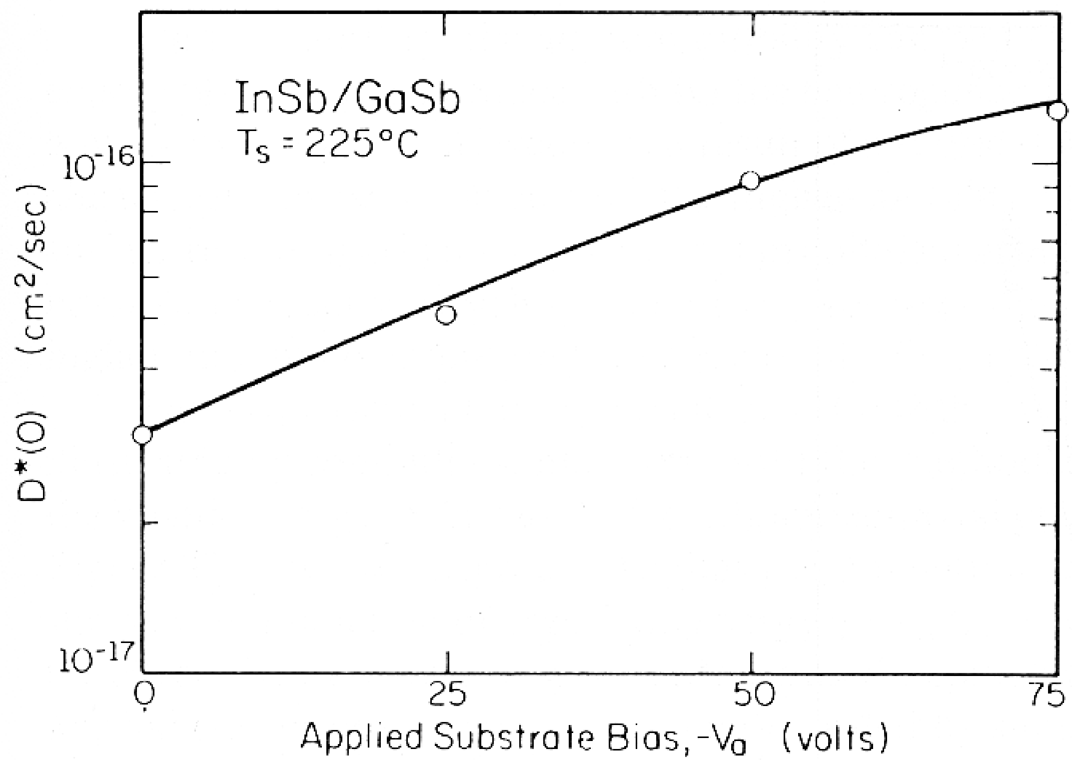


Composition

Low bias voltage

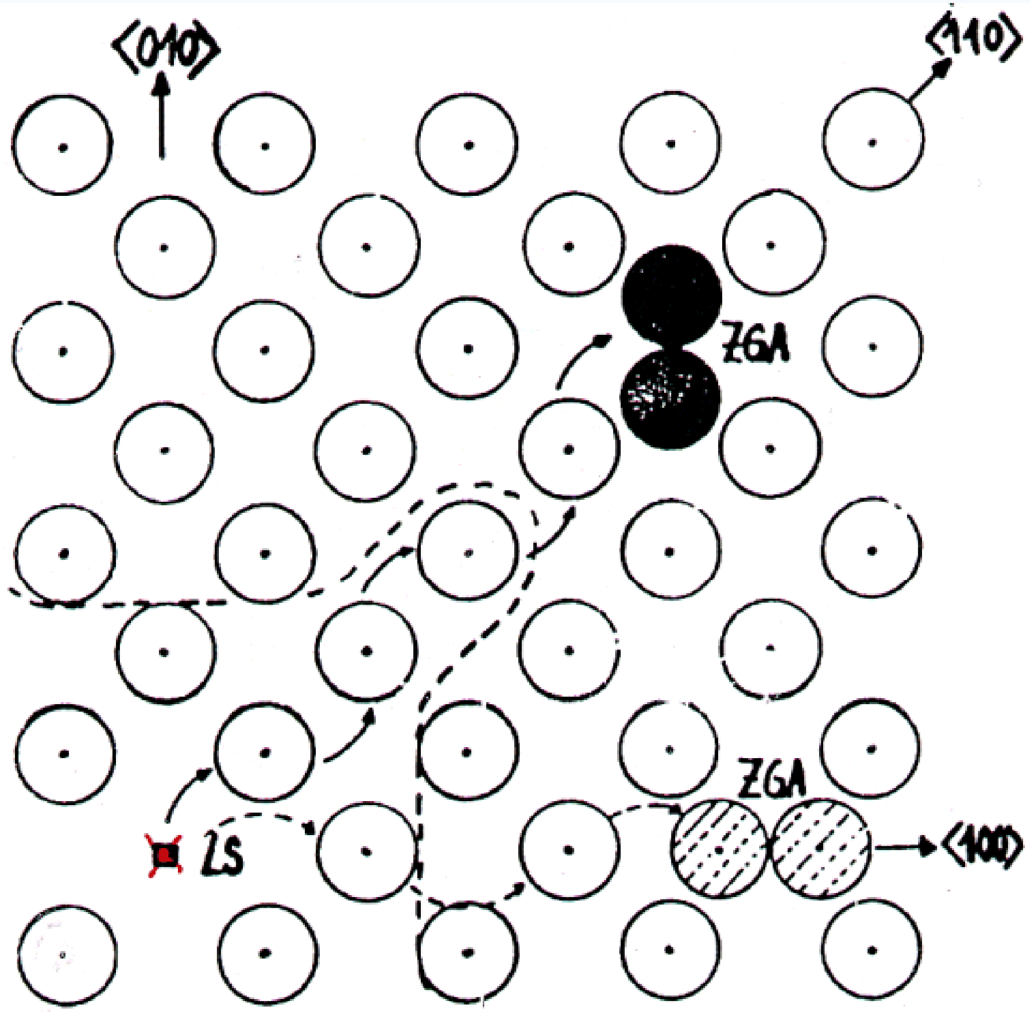
Internal diffusion

High bias voltage



Diffusion coefficient, rises with ion bombardment, as function of the substrate bias for growth of InSb/GaSb superlattice

Frenkel pair



Creation of a vacancy (LS, x) and an interstitial atom (ZGA) (so called Frenkel pair) i

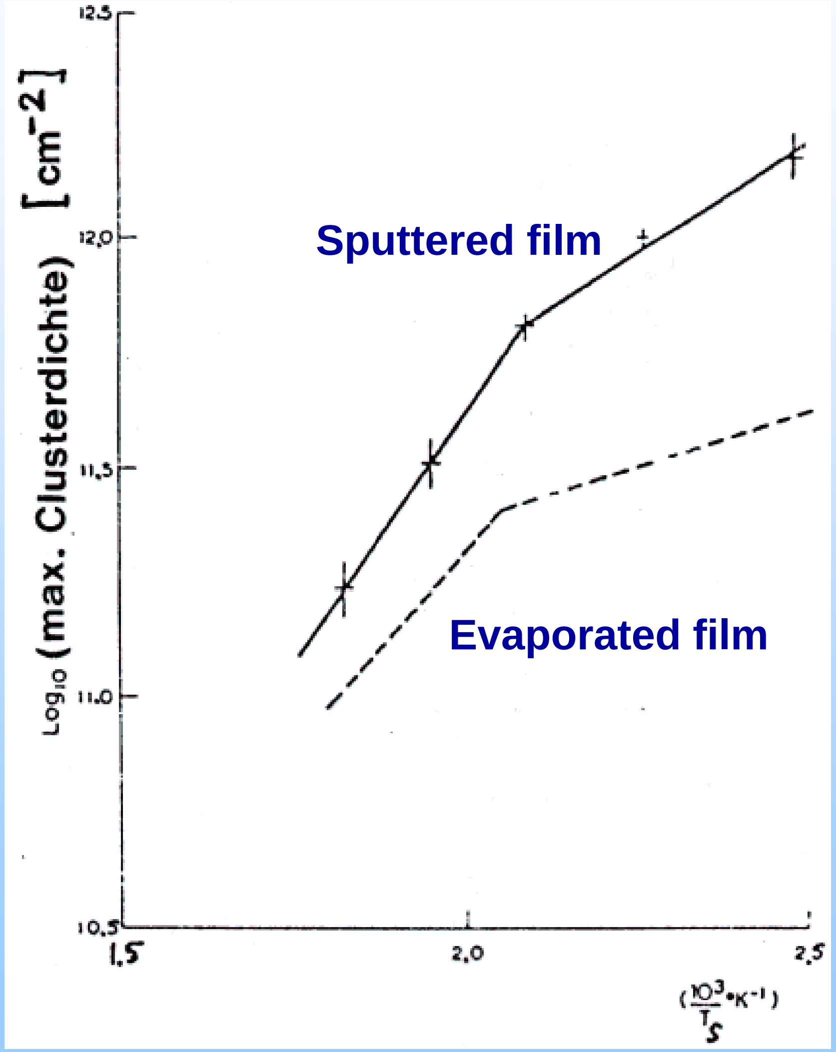
Influence of substrate temperature on crystallinity, order, density, Adhesion

For many materials different grades of structural order can be deposited, e.g. for Si:

$T_s <$ 600°C $< T_s <$ 900°C $< T_s$

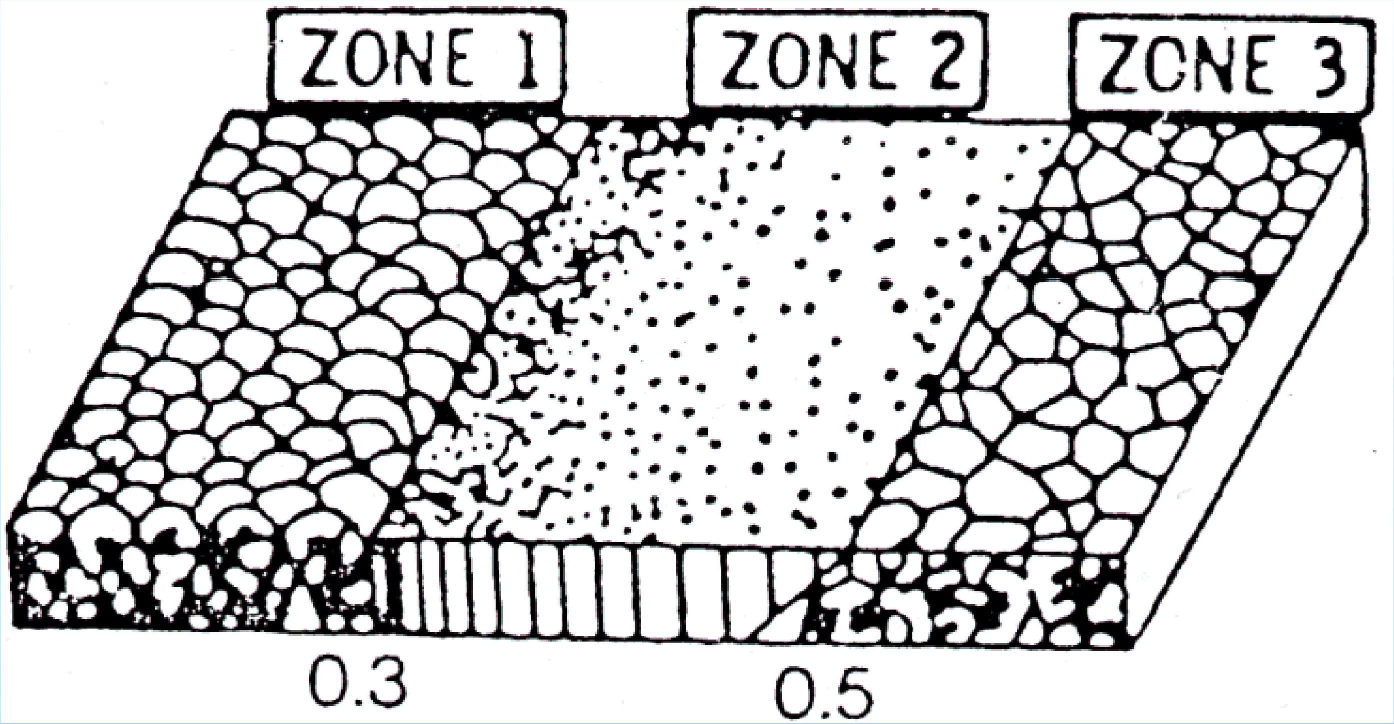
a-Si	Polycrystalline, Texture	Single crystalline on single crystalline substrate

Cluster density as function of substrate temperature



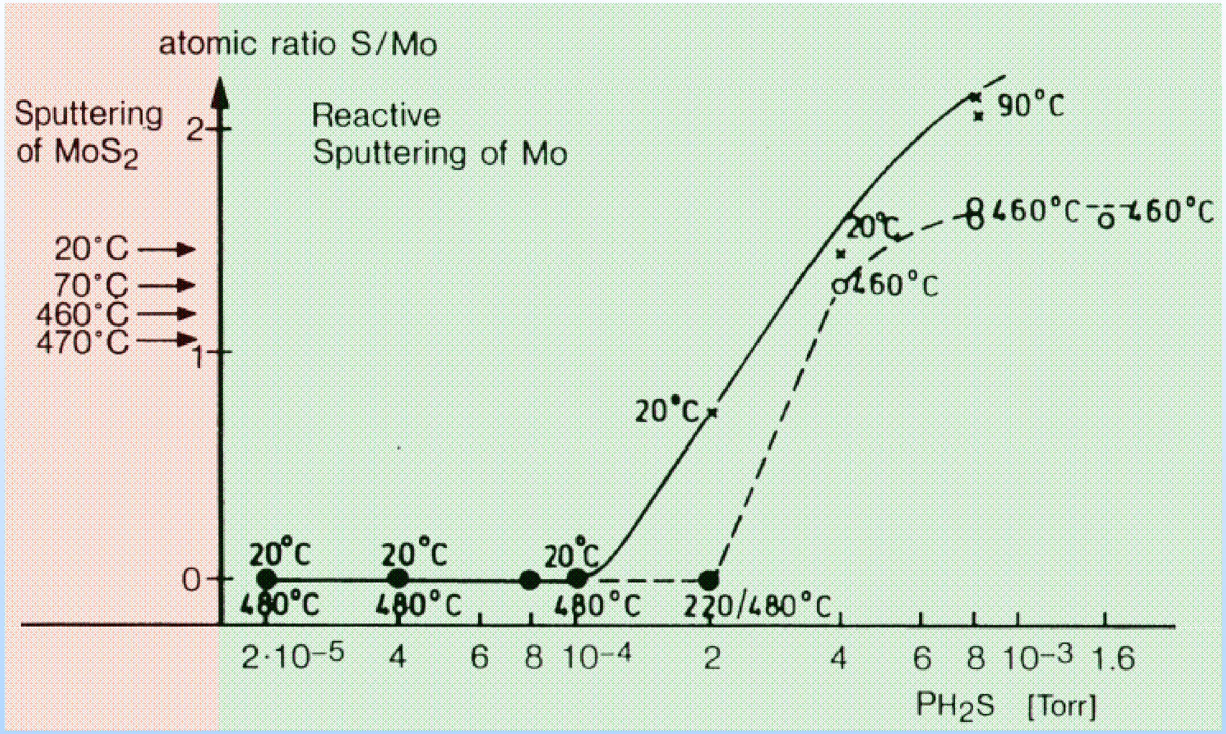
Maximal cluster density as function of reciprocal substrate temperature

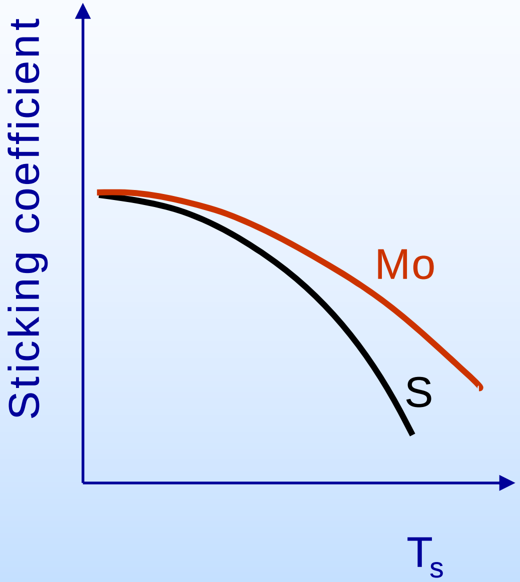
Growth model after Moucham and Demchiskin



Substrate temperature (T/Tm)

Stoichiometry





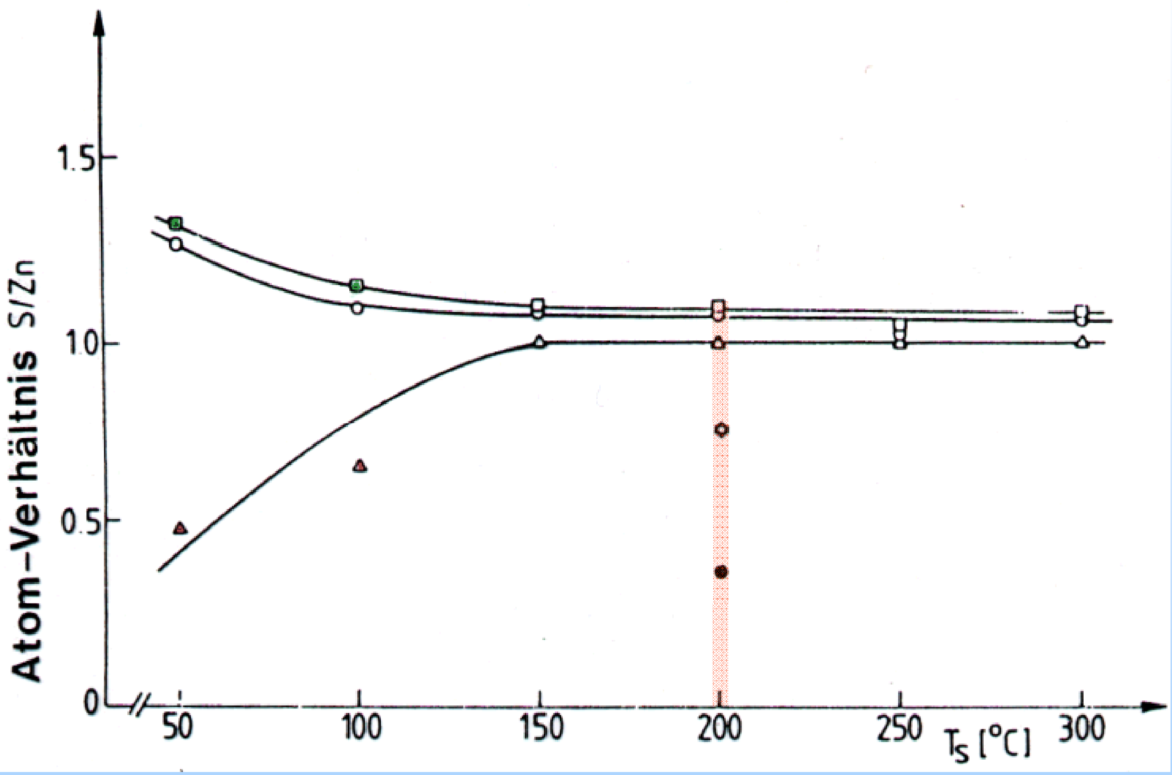
Right: Composition of reactively sputtered MoS_x films in dependence of H_2S partial pressure (Mo = Target).
Left: Sputtered MoS_2 target in a pure Ar. The numbers are the substrate temperatures.

2 factors are decisive:

- Arriving rate
- Sticking coefficient

Both are influenced by gas pressure and T_s

Film composition in dependence of gas pressure and temperature



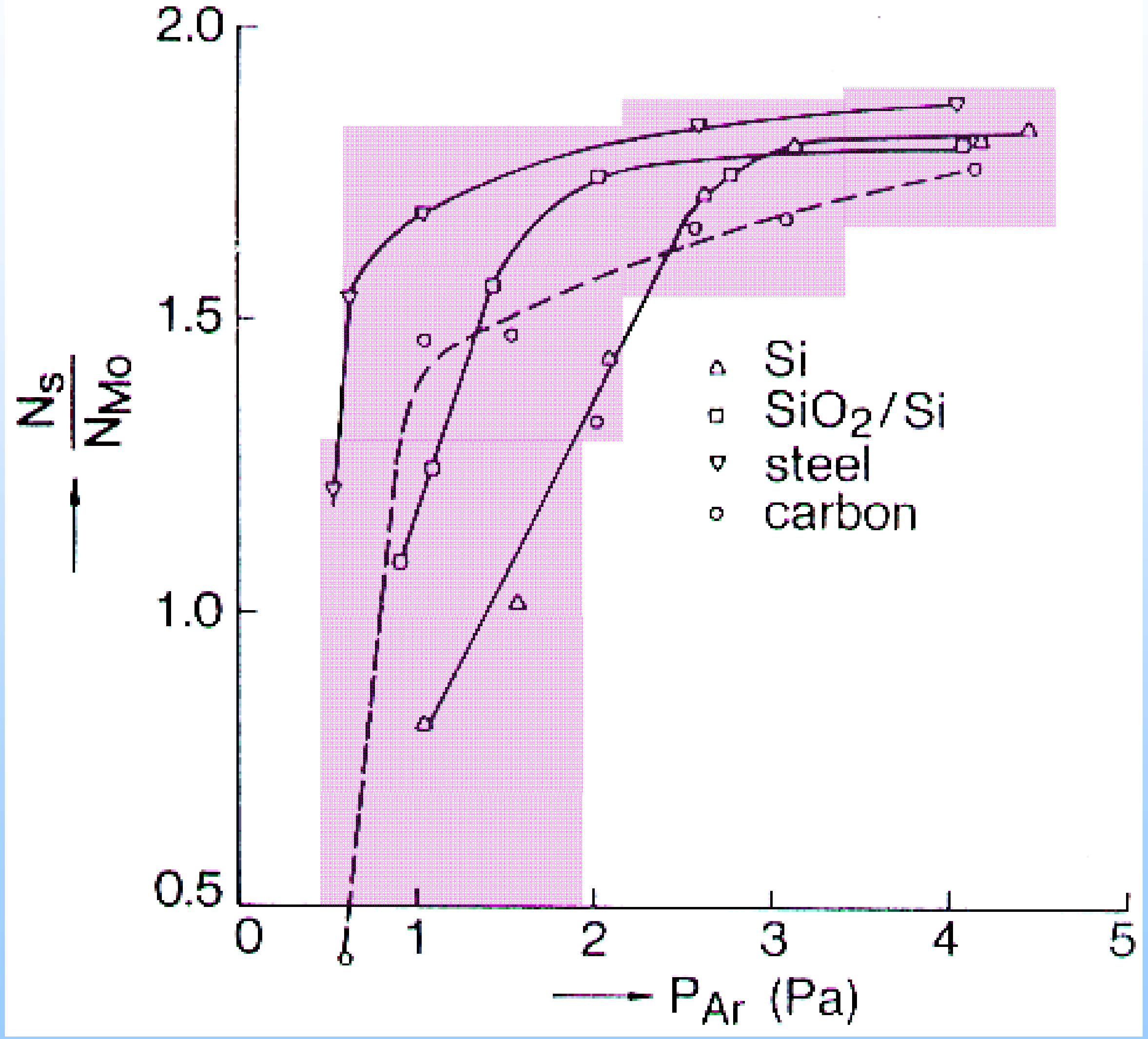
For T_s<150 °C the influence of P_{H2S} is stronger

Film composition of reactively sputtered ZnS film in dependence of temperature and partial gas pressure of H_2S.

P_{H2S}: 🟩-2,66 x 10^{-3} mbar; ○-1,33 x 10^{-3} mbar; ▲ 6,66 x 10^{-4} mbar;

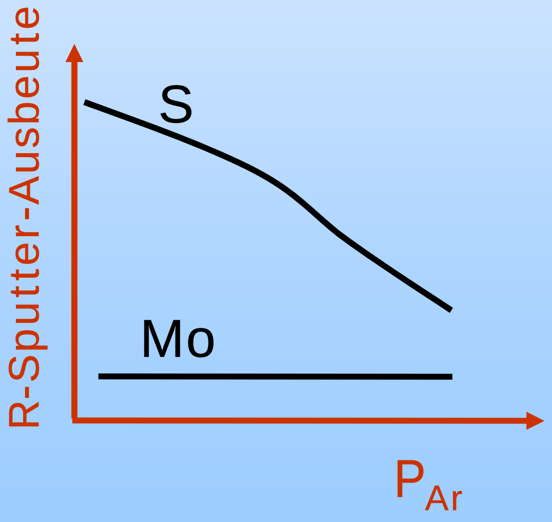
⭘-2,66 x 10^{-4} mbar; ●-1,33 x 10^{-4} mbar

Influence of the gas pressure

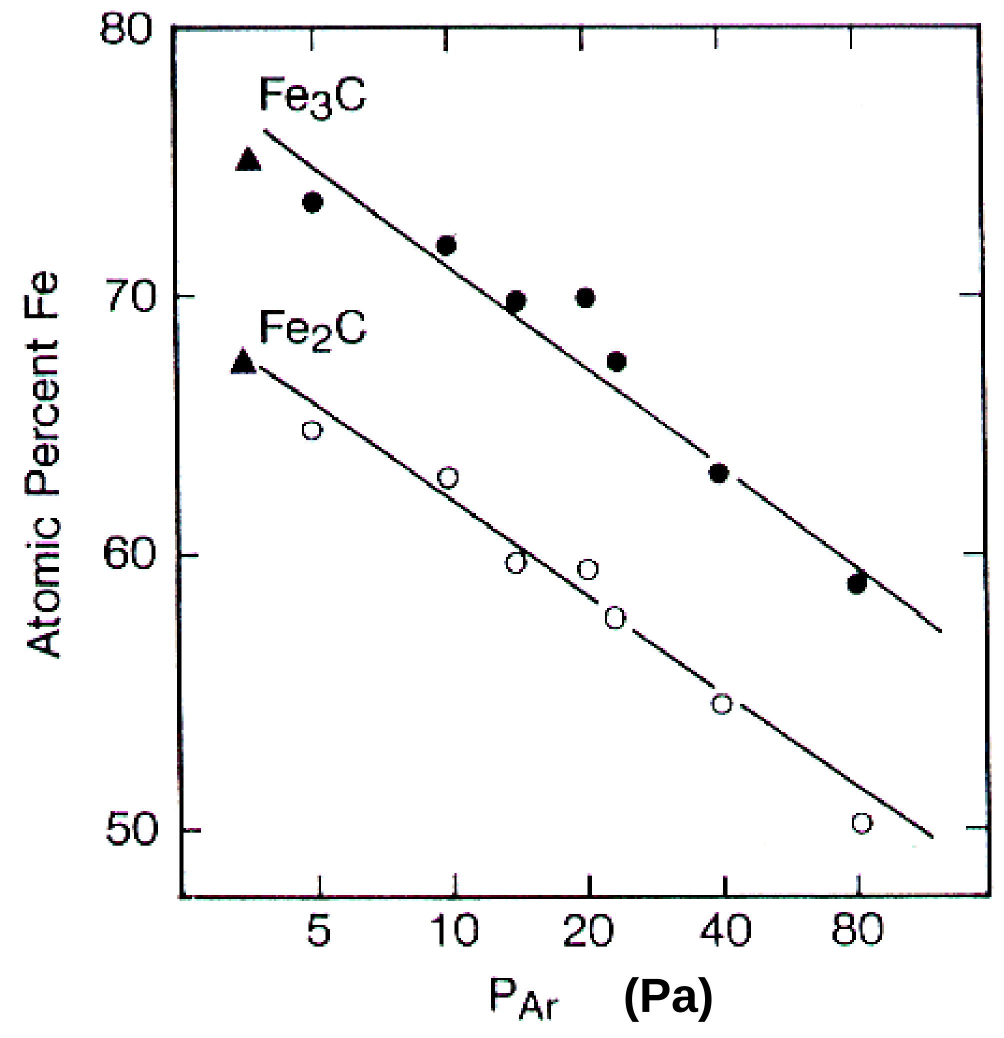


Chemical composition of MoS_x films.

The influence of ion bombardment can be reduced by increasing Ar gas pressure.

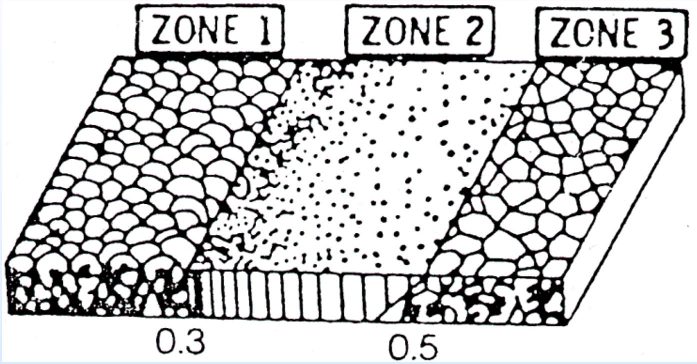


Pressure of the inert gases



Dependence of the composition of FeC_x films on pressure of the inert gas

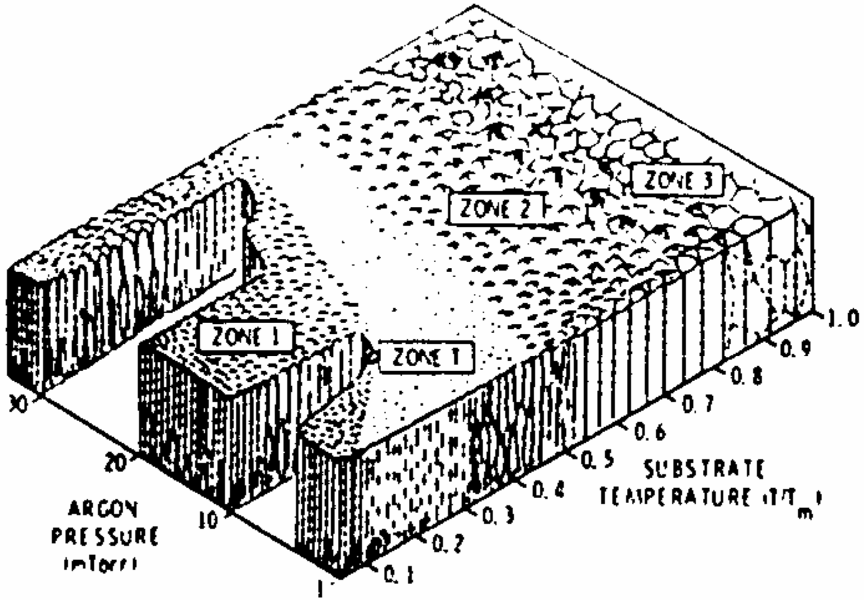
Morphology and Characteristics of the Films



- Films obtained by sputter deposition are usually polycrystalline.

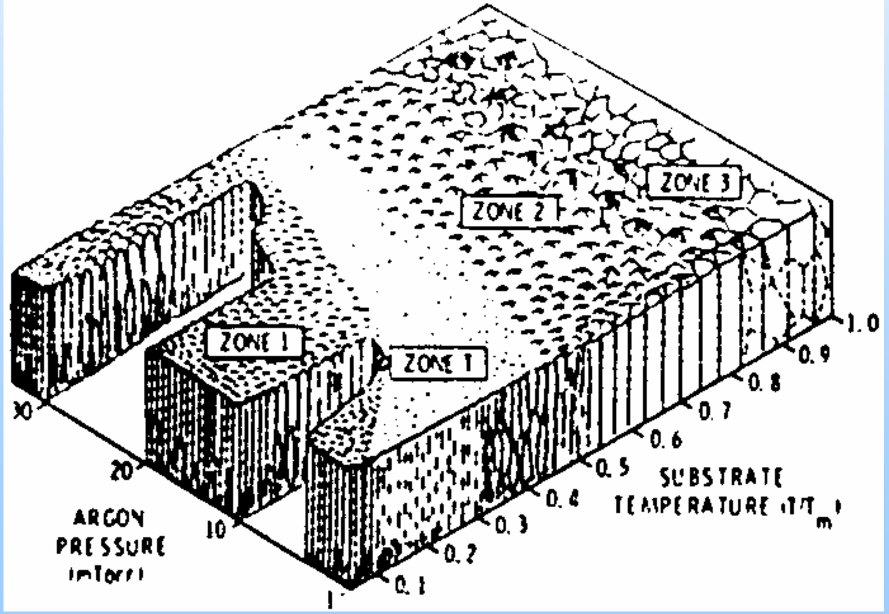
Zone 1

- Structure caused by limited migration of incident atoms.
- Effected by adsorbed atoms.
- Structure is constructed from tapered crystallites with domed heads and contains voids in the grain boundaries.



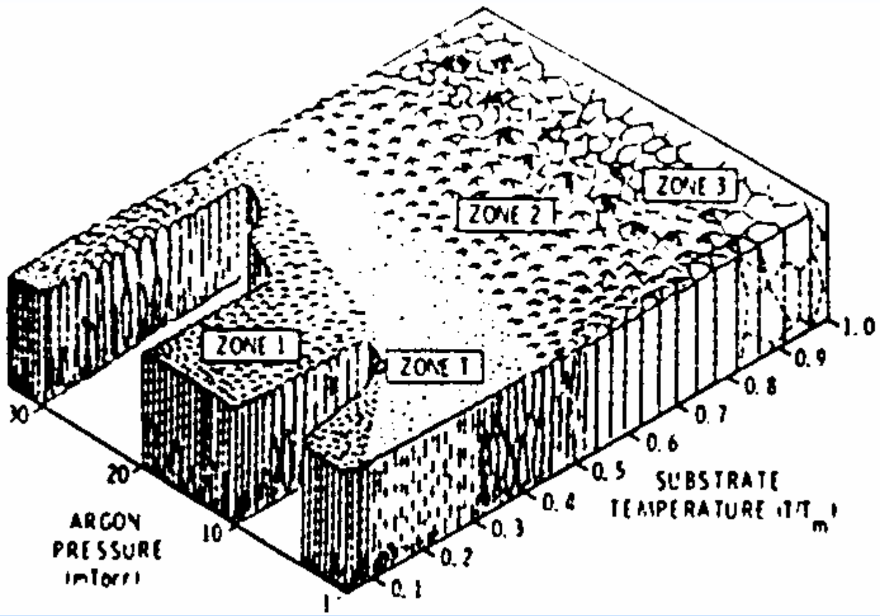
Zone T

- Appears only in sputter films
- Regarded as a transition region
- Film reveals fibrous structure crystallites grown perpendicular to the surface
- Crystallites develop close to each other
- Density is nearly equal to that of the bulk material
- Surface is relatively smooth
- Film has large tensile strength and hardness values



Zone 2

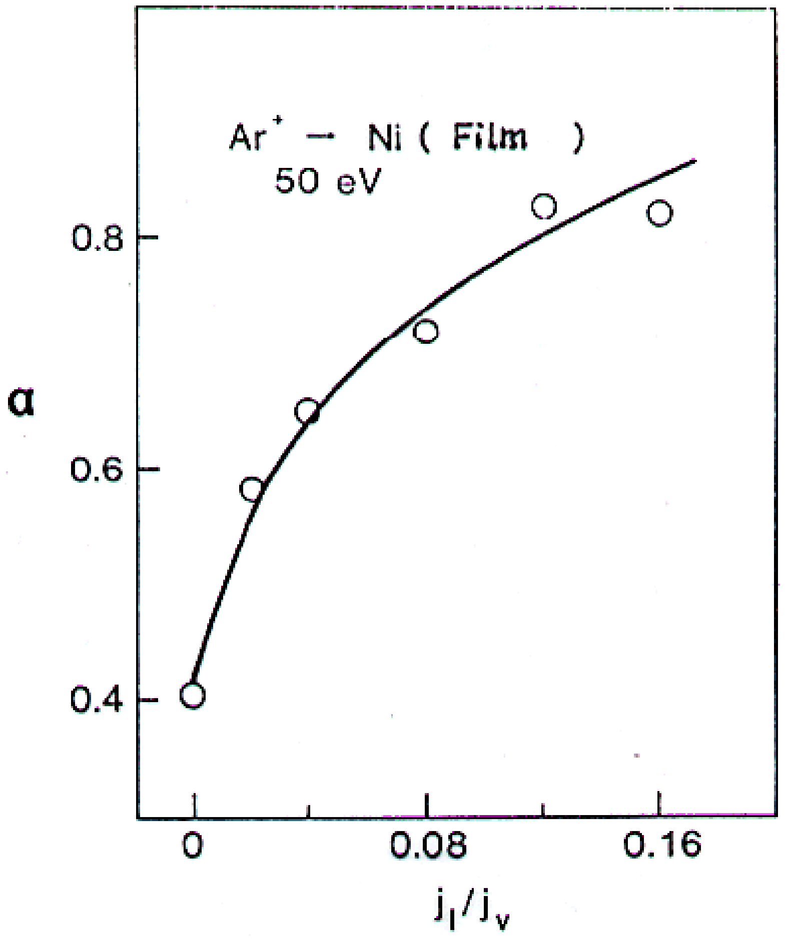
- Migration of atoms on the substrate surface becomes considerable.
- Structure is constructed of the columnar grains.
- Grain size increases with increasing T/T_m



Zone 3

- Structure controlled by interdiffusion of atoms.
- Thus, the film surface becomes smooth.
- Recrystallization progress in the film during film formation.
- Film becomes, therefore, isotropic and randomly oriented polycrystals

Homoepitaxy Grade, dependent on Ar$^+$/Ni Ratio



Computersimulation: Homoepitaxy Grade a as function of the Ar$^+$ to Ni ratio for Ar$^+$ ion assisted growth of Ni films.

Energy of Ar$^+$: 50 eV