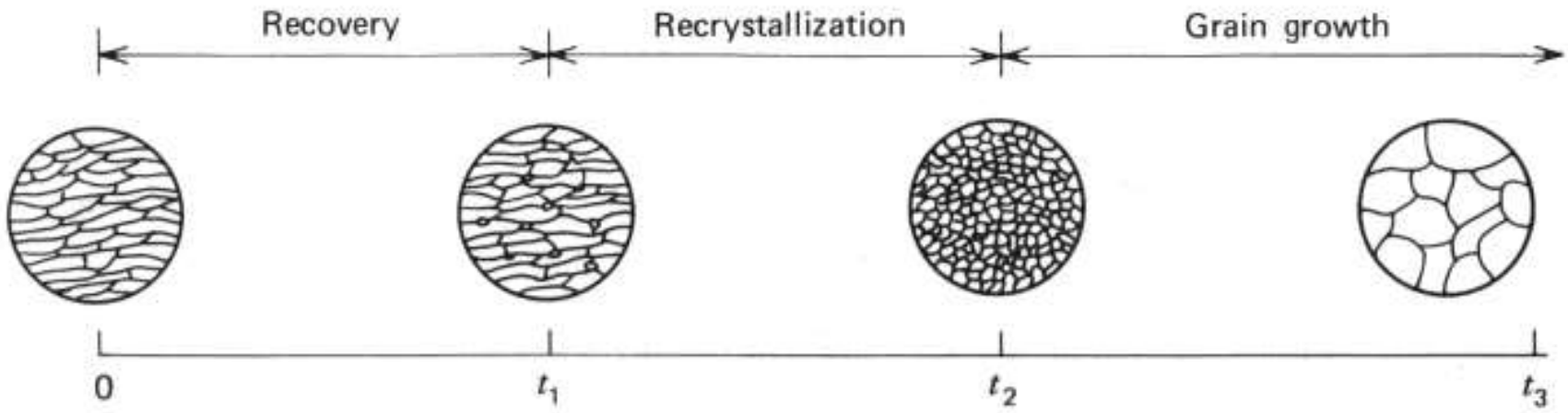
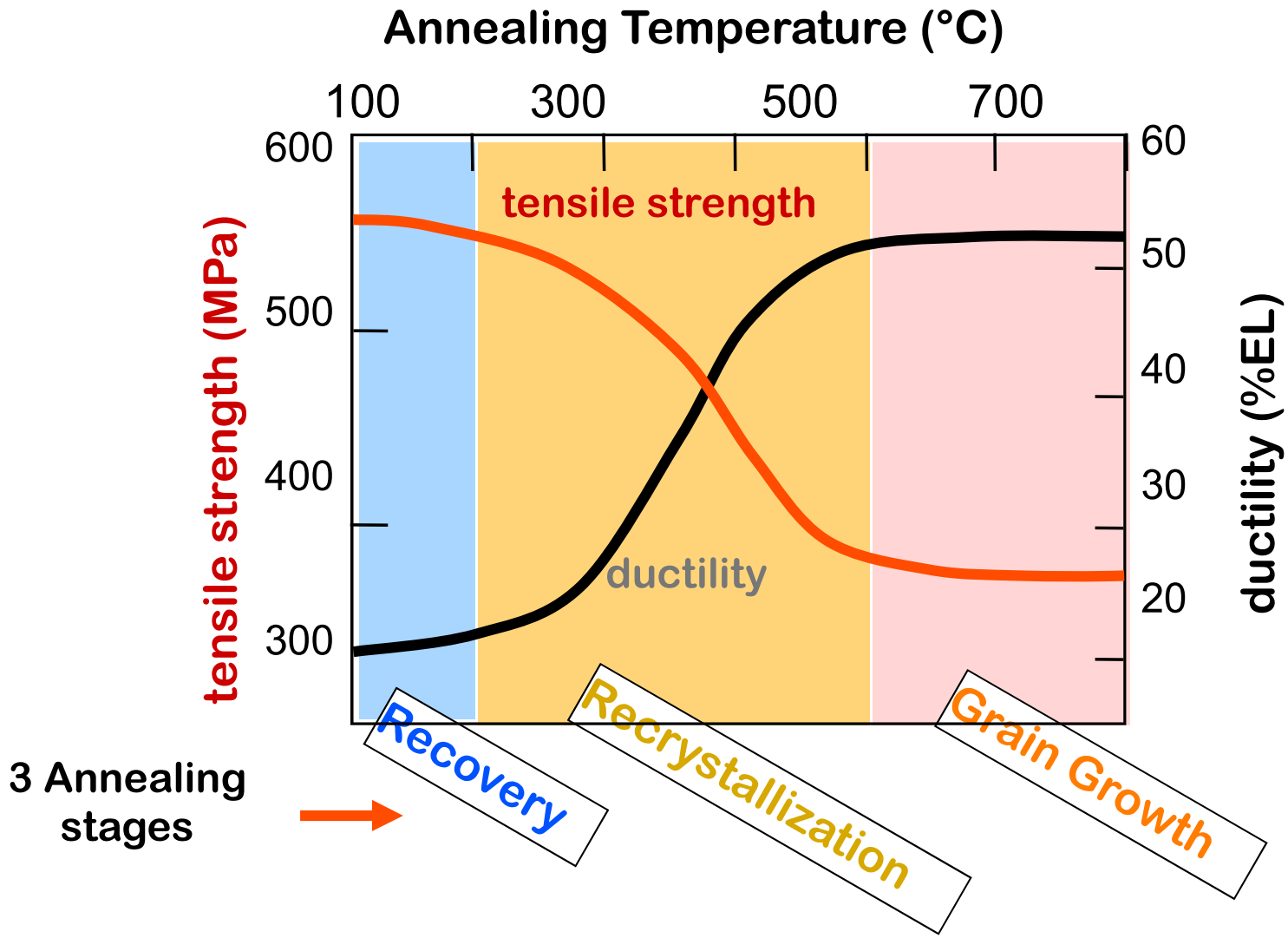
Annealing of Cold-Worked Metal

- Annealing of the cold worked structure at high temperature softens the metal and reverts to a strain-free condition.
- The transformations that take place during annealing are recovery, recrystallization and grain growth, respectively.
- The driving force for recovery and recrystallization is the energy of the defects introduced during cold working (stored energy of the deformed matrix).
- The driving force for grain growth is the boundary curvature.



Annealing of Cold-Worked Metal



Effect of 1 hour heating on mechanical properties

Recovery

Recrystallization
nucleation and growth of strain free grains

Grain growth

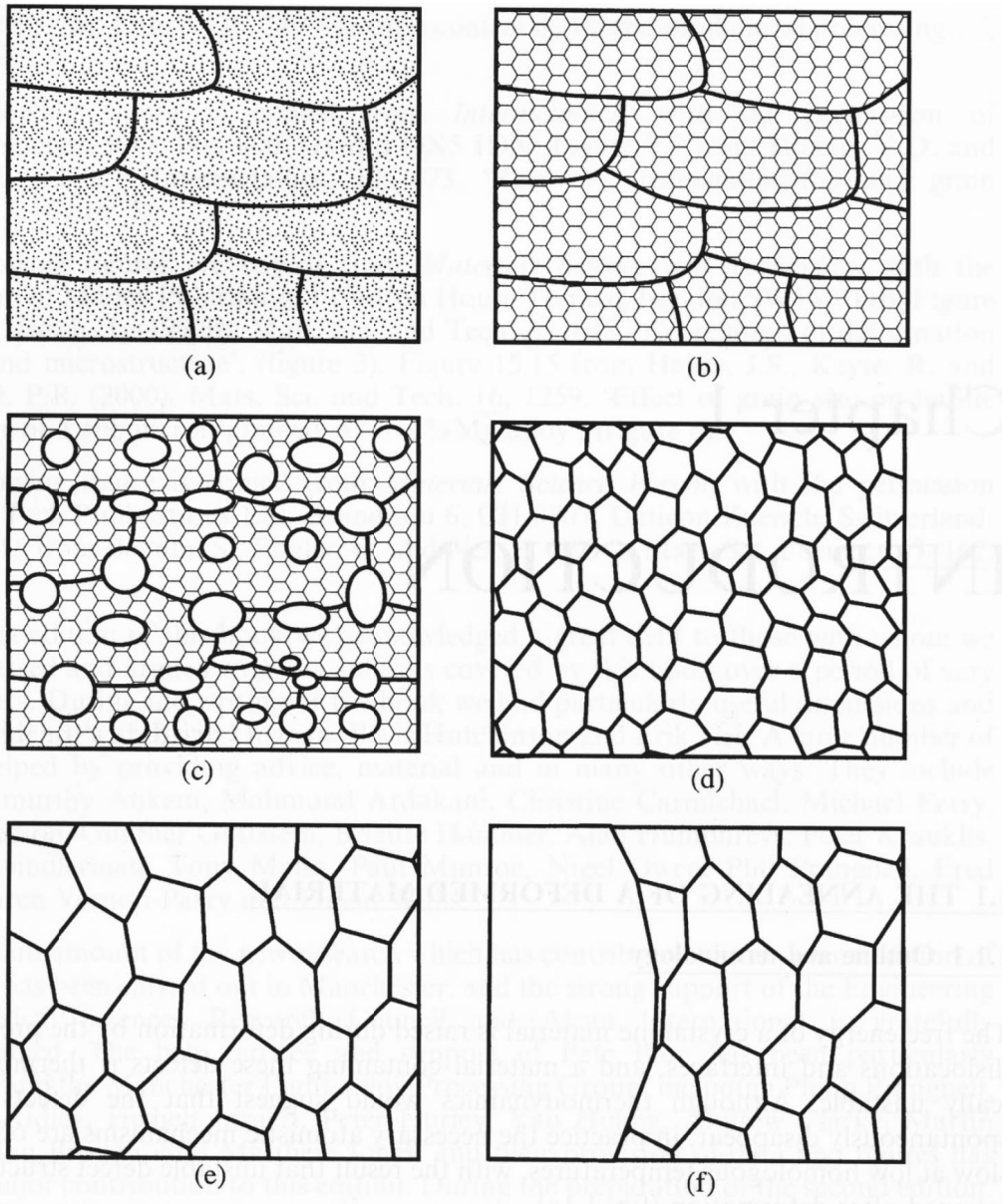
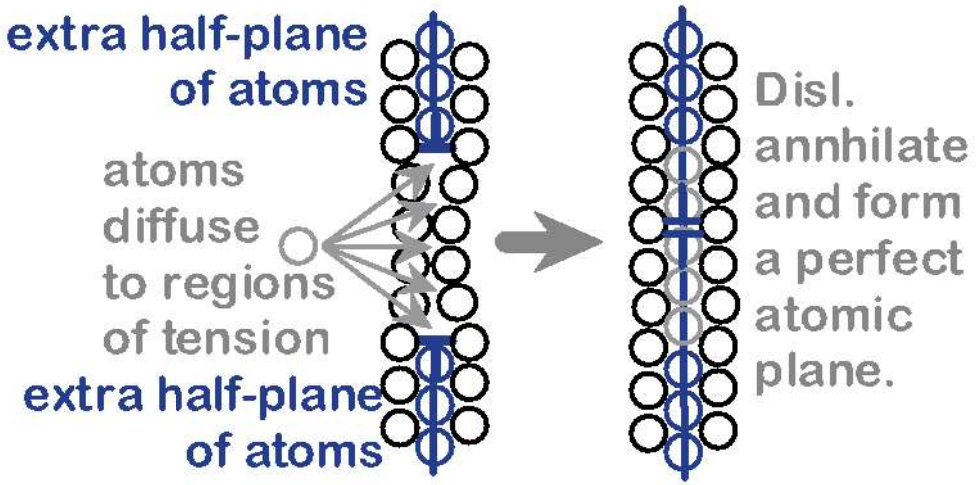


Fig. 1.1. Schematic diagram of the main annealing processes; (a) Deformed state, (b) Recovered, (c) Partially recrystallized, (d) Fully recrystallized, (e) Grain growth and (f) Abnormal grain growth.

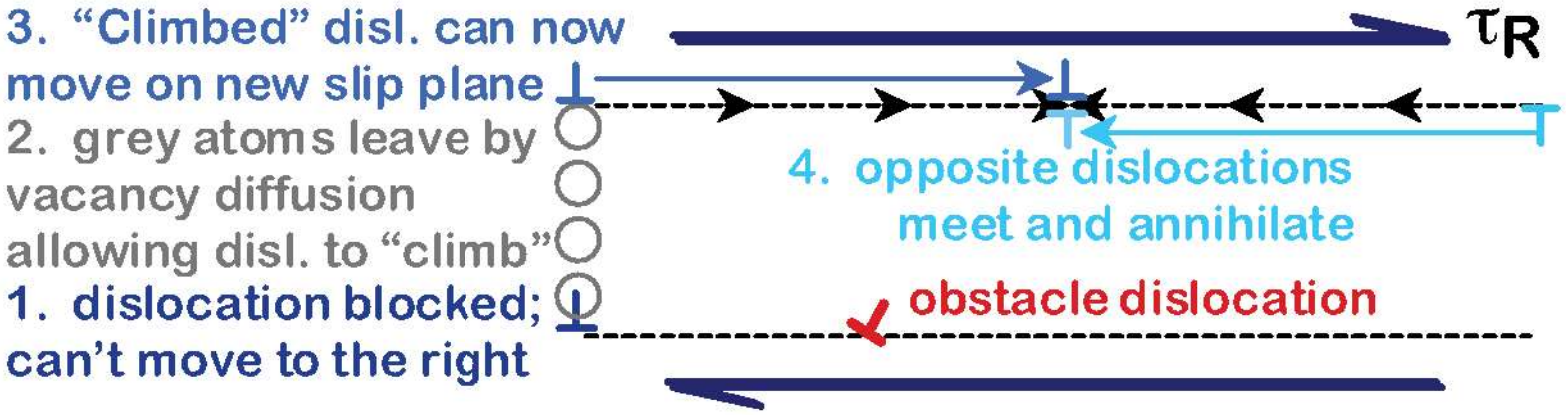
Recovery

Annihilation reduces dislocation density.

Scenario 1



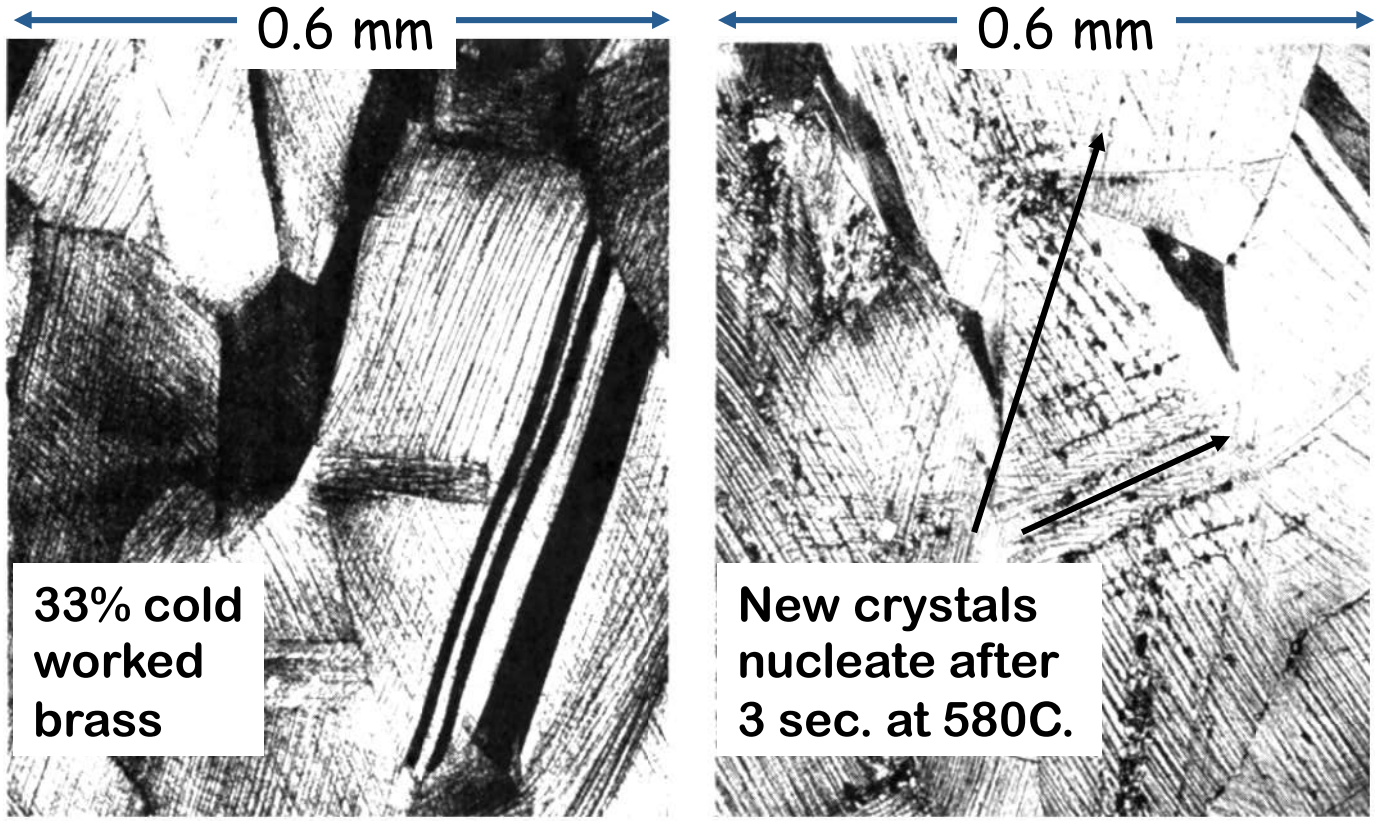
Scenario 2



Recrystallization

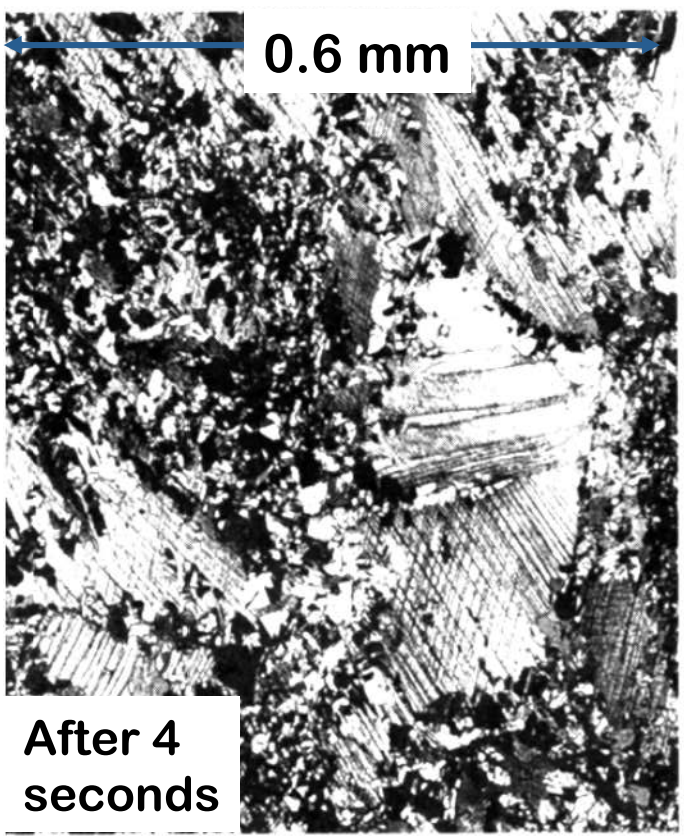
New crystals are formed that:

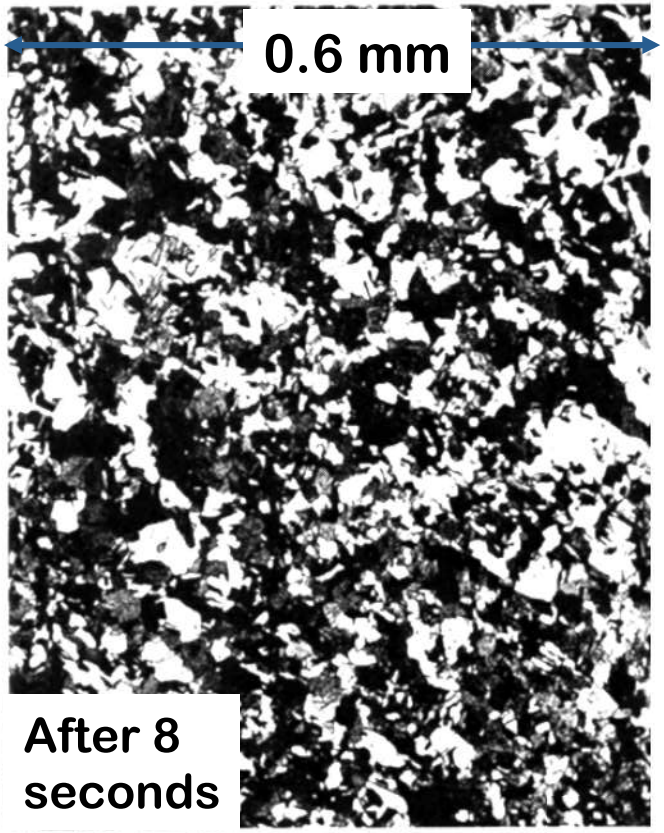
- have a small dislocation density
- are small
- consume cold-worked crystals.

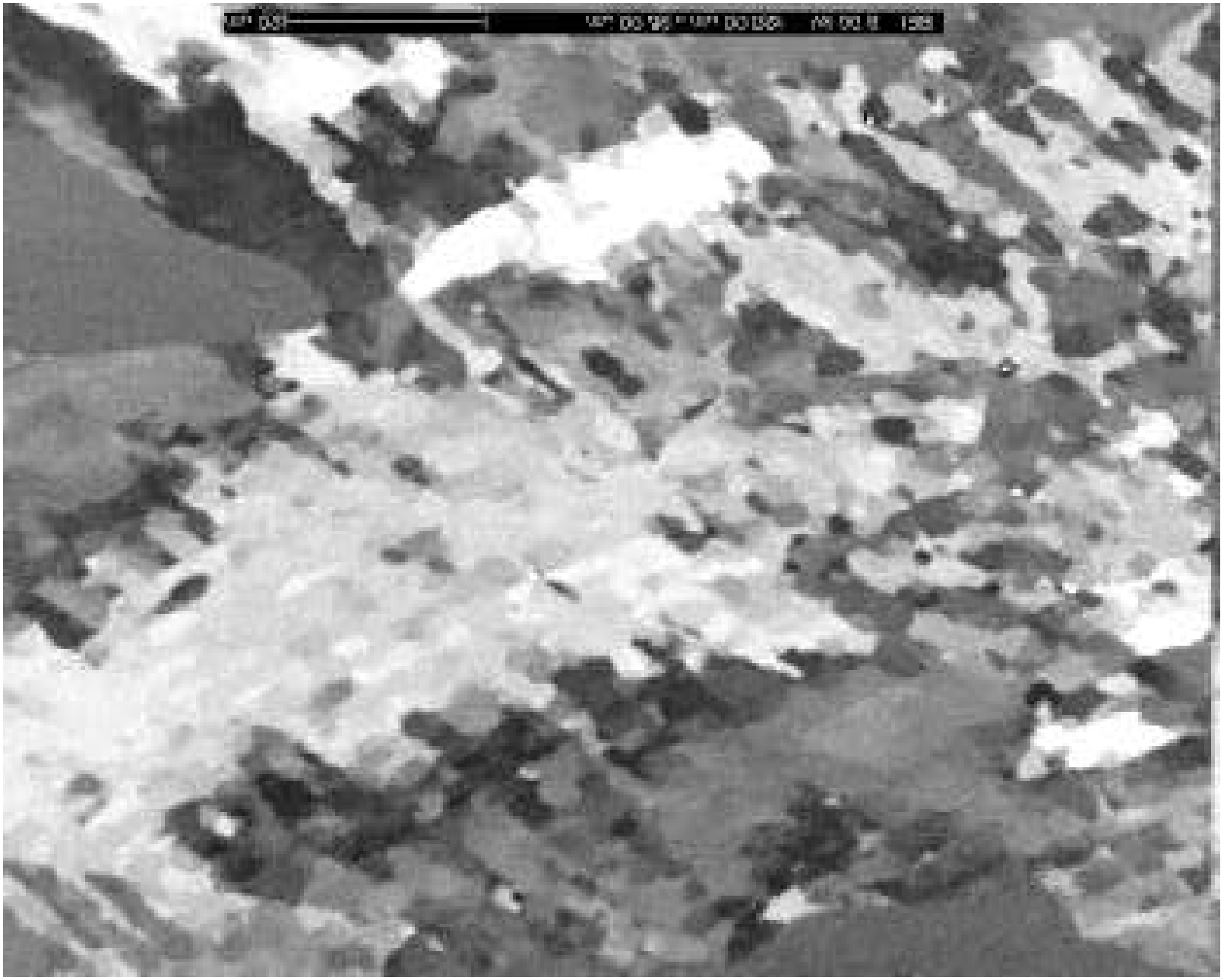


Further Recrystallization

All cold-worked crystals are consumed.







Variables Affecting Recrystallization

1) The amount of prior deformation
2) Temperature
3) Time
4) Initial grain size
5) Composition
6) Amount of recovery prior to start the recrystallisation.

Recrystallization temperature can be defined as the temperature at which a given alloy in a highly cold-worked state completely recrystallizes in 1 h.

Degree of Deformation ⇧ T_{recrys} ⇩ T_{anneal} ⇩ GS_{recrys} ⇩

Impurity ⇧ T_{recrys} ⇧

Grain Growth

- At longer times, larger grains consume smaller ones.
- Grain boundary area (and therefore energy) is reduced.