Corrosion of passive metals

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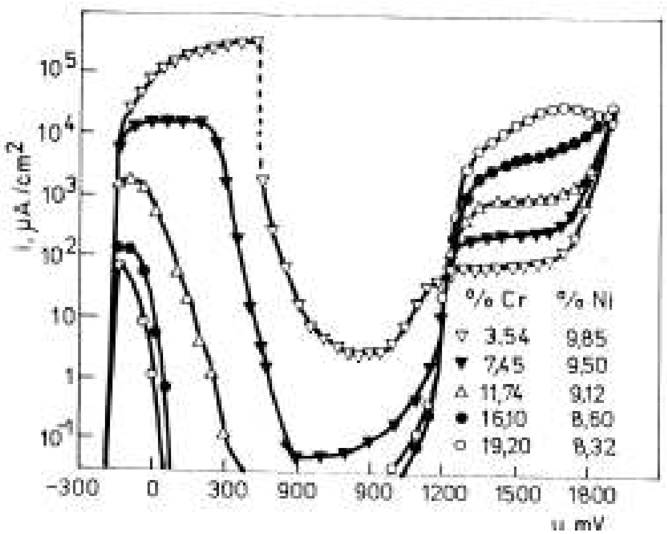
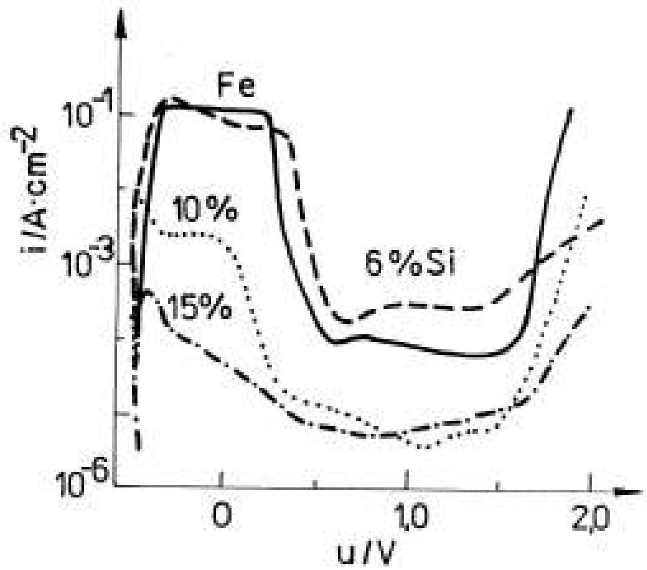
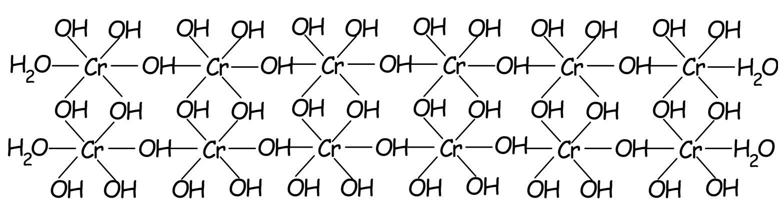
Effect of chemical composition on passive behaviour of the alloy



Stationary polarization curves of austenitic Fe-Cr-Ni alloys in 1M H_2SO_4



Stationary polarization curves of Fe-Si alloys in 1M H_2SO_4



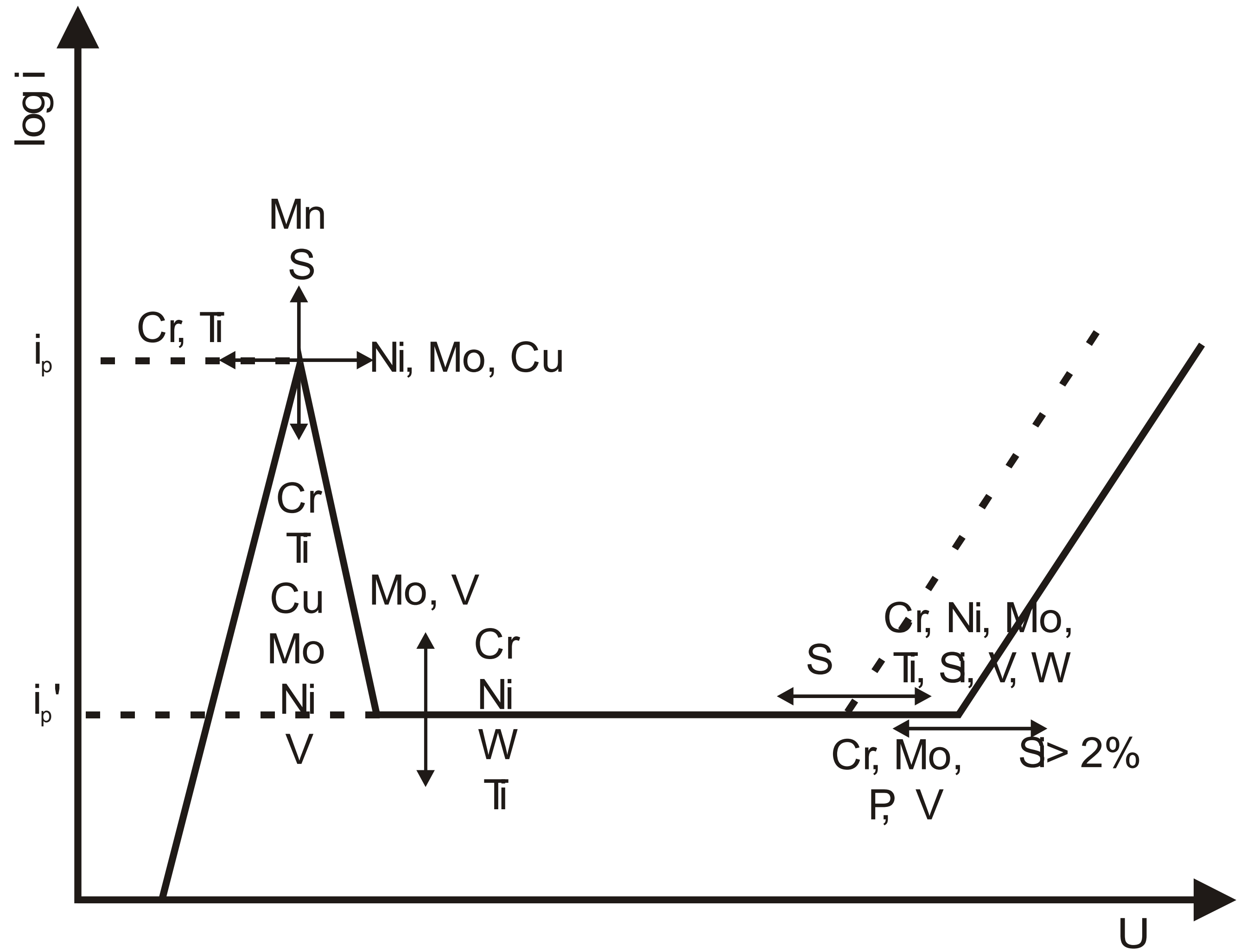
Model of passive film on pure chromium

% Cr	Structure of passive film	thickness A⁰
0	well oriented spinel	36
5	well oriented spinel	27
12	weak oriented spinel	21
19	mainly amorphous	19

Effect of chromium on the structure of passive film on Fe-Cr alloys in neutral aqueous solutions

J.Kruger in Passivity of Metals, ed.by Electroche. Soc. Inc. Princetown ,N. Jersey 1978

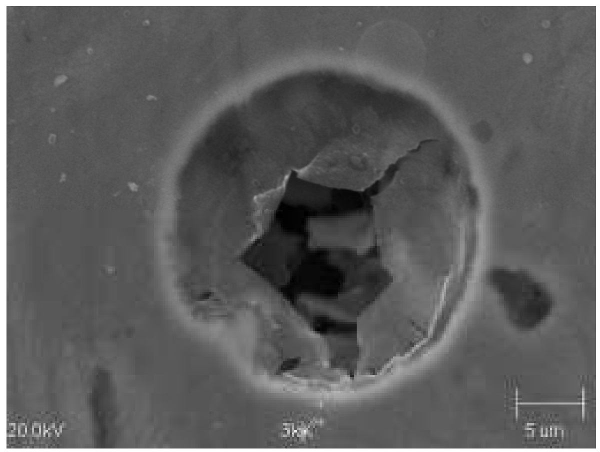
Effect of chemical composition on passive behaviour of the alloy



Corrosion of passive alloys

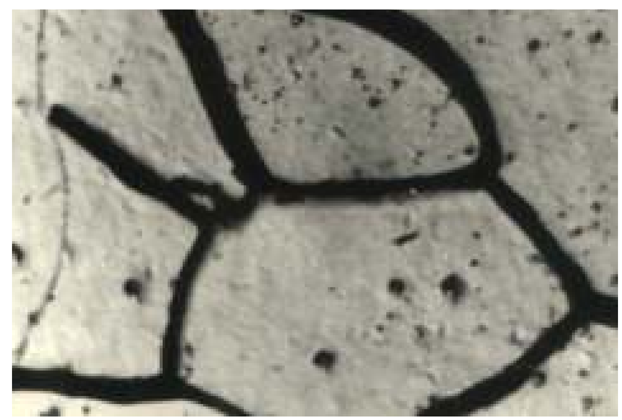
Stress corrosion

Crevice corrosion



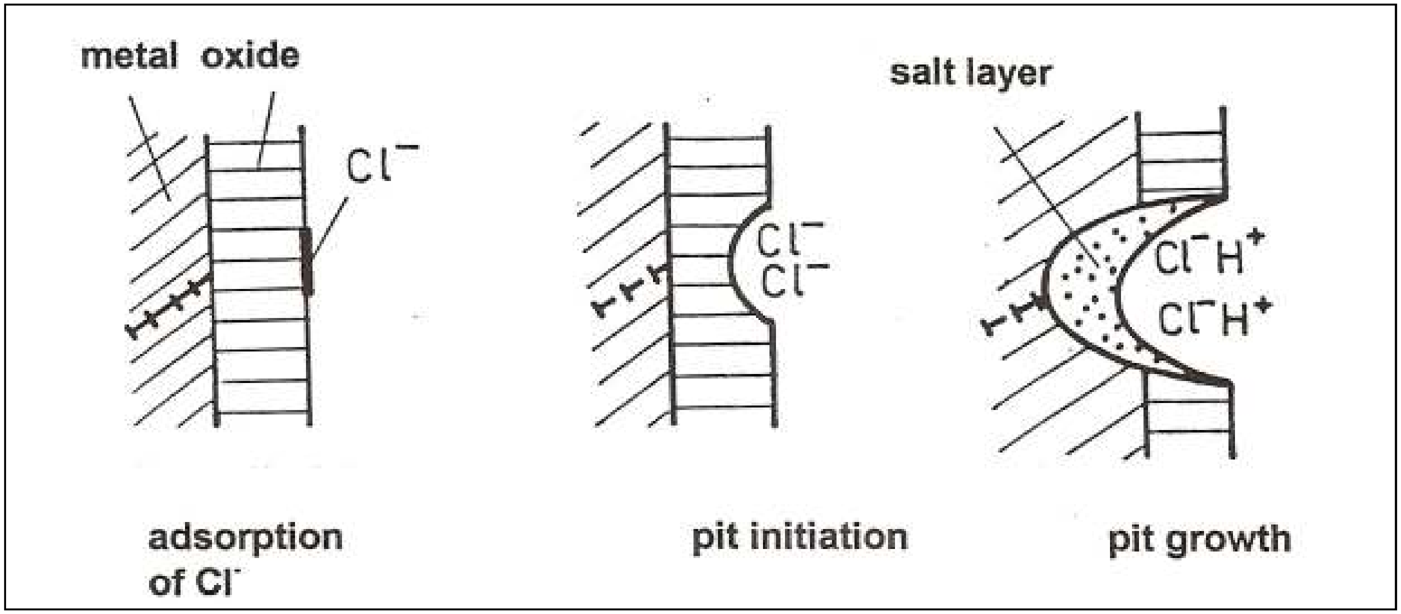
Pitting corrosion

Corrosion-erosion degradation

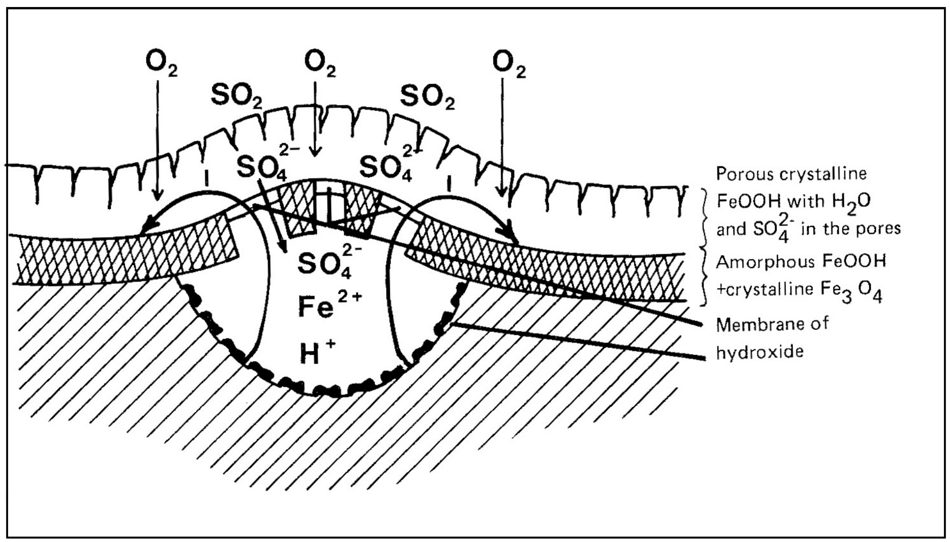


Inergranular corrosion

Pitting corrosion

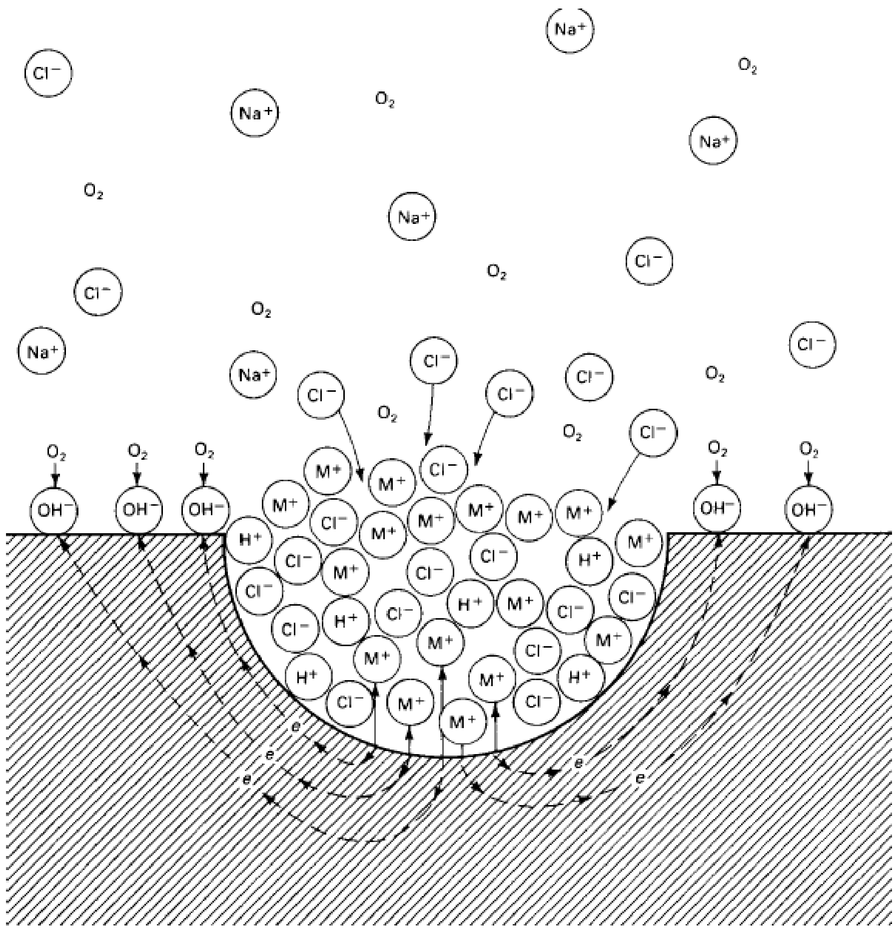


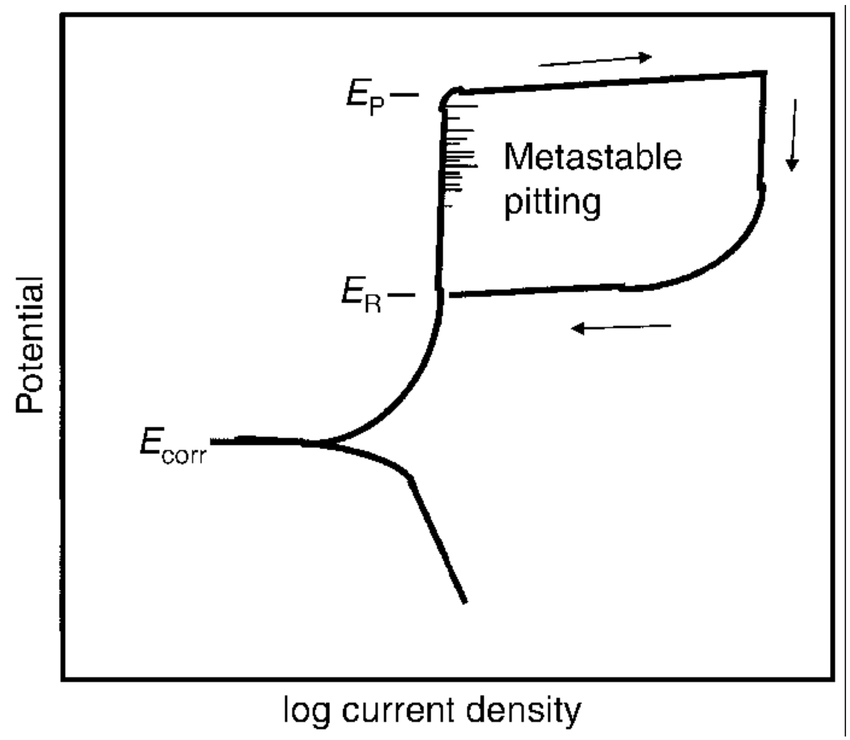
Mechanism of pitting corrosion in chloride containing media



Pitting corrosion of iron in atmosphere polluted with SO_2

Pitting corrosion

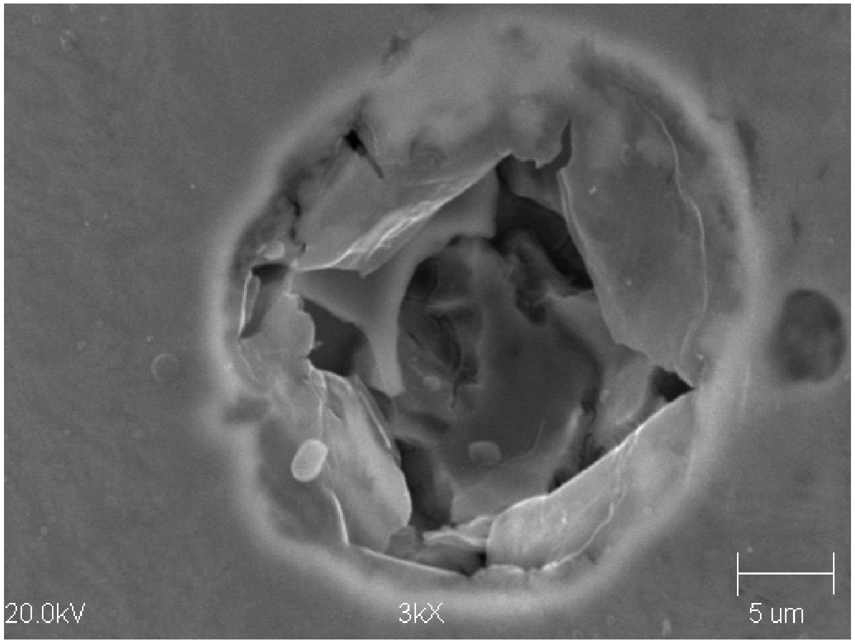




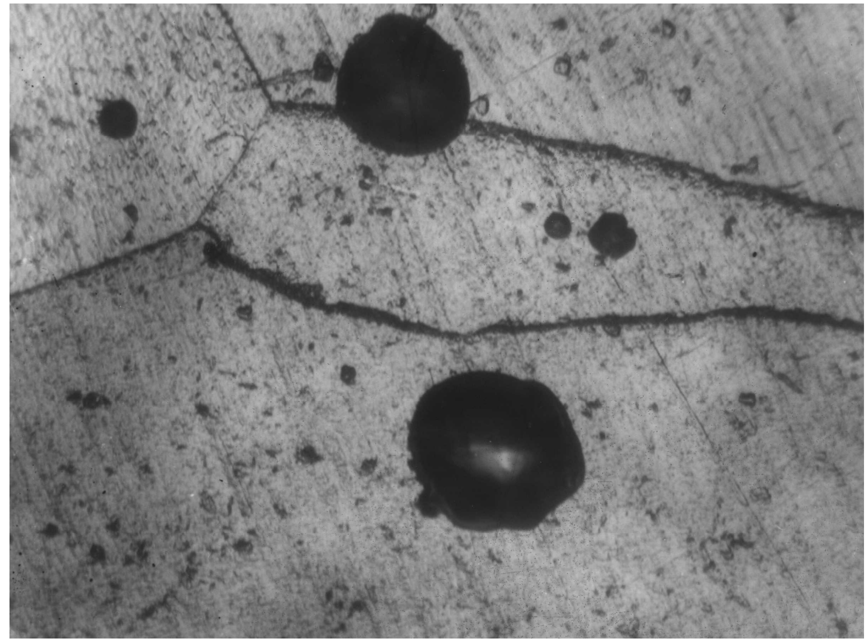
Schematic of a polarization curve showing critical potentials and metastable pitting region. EP, pitting potential; ER, repassivation potential; Ecorr, corrosion potential.

Autocatalytic process occurring in a corrosion pit. The metal, M, is being pitted by an aerated NaCl solution. Rapid dissolution occurs in the pit, while oxygen reduction takes place on the adjacent metal surfaces.

Pitting corrosion



Pitting corrosion of Ti in CH_3OH-LiCl solutions

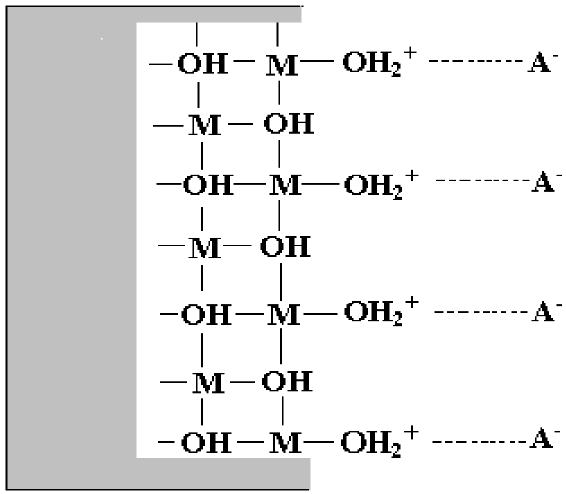


Pitting corrosion of Fe-18%Cr alloy in CH3OH-H_2SO_4 solutions

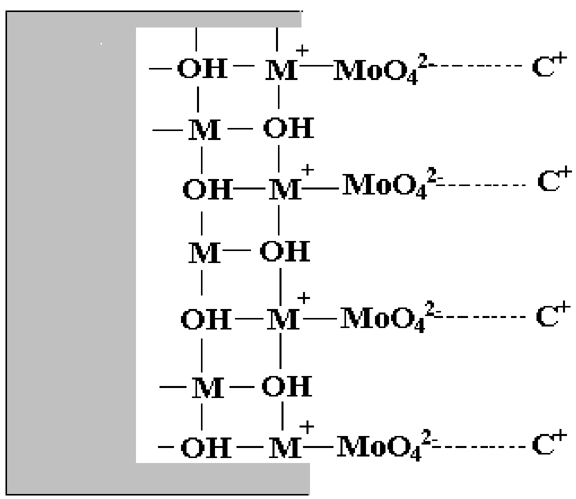
Corrosion of heat exchanger (carbon steel) in water

Effect of molybdenum on stability of passive film on stainless steels

(a)



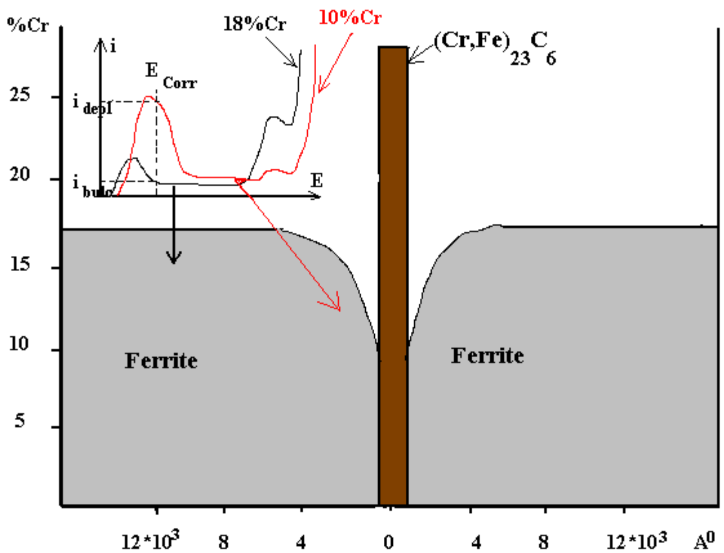
(b)

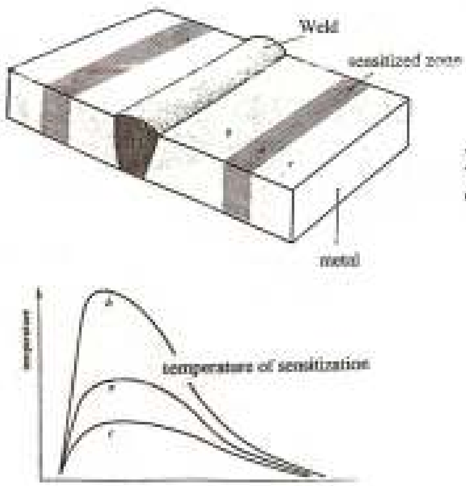


Adsorption of ions on hydrous metal oxide surface which provides the fixed charge whose determines the ion selectivity of the membranes.
(a) anion- selective, (b) cation- selective membrane[53].

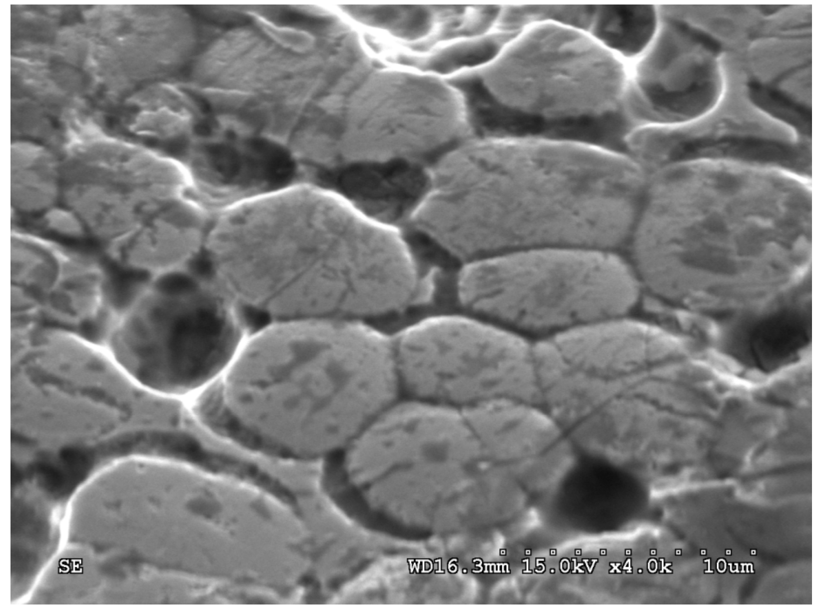
N. Sato: Corrosion 45, 5, 354 (1989)

Inergranular corrosion



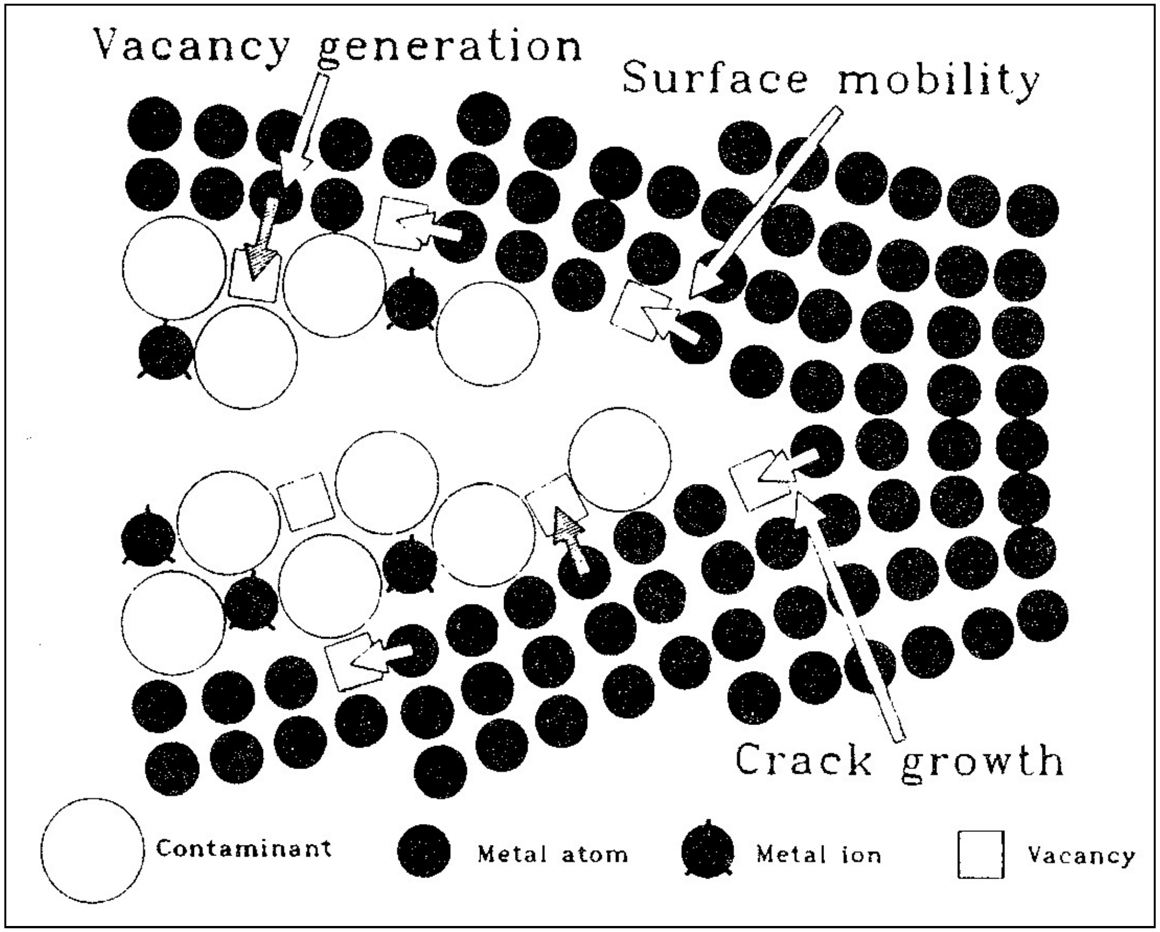


Intergranular corrosion of welded stainless steel.
Temperature distribution as a function of time and distance from the weld.



Inergranular corrosion of NIROSTA 2202 steel (22%Cr,6%Ni,3%Mo) in 93.5 wt.% H_2SO_4 (100^0C)

Stress corrosion cracking



Crack velocity:

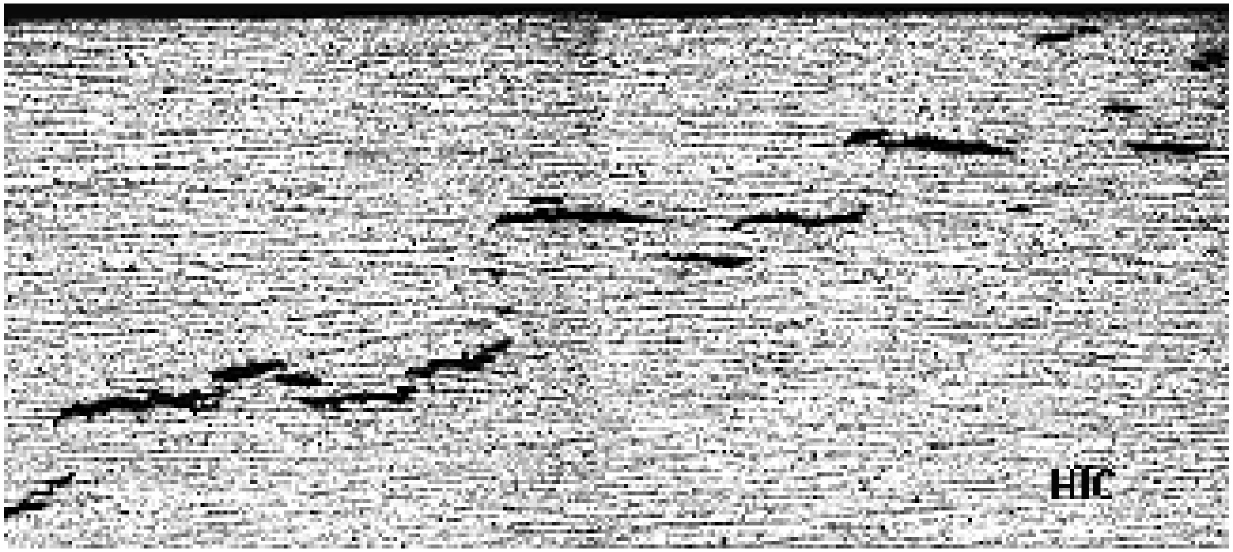
$$v = \frac{D_s}{L}\left(e^{\sigma a^3 / kT} - 1\right)$$

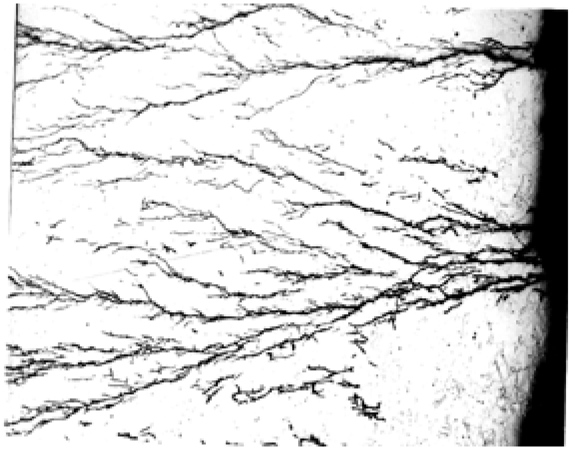
$D_{s.}$ – surface self diffusion coeficient
L – diffusion length
σ– elastic surface stress at the crack tip
a^3 – volumen of vacancy

Surface mobility model of Stress corrosion cracking (SCC) according to Galvele
J.R. Galvele, Corrosion Science 27,1 (1987)

The effect of H_2S on hydrogen embrittlement

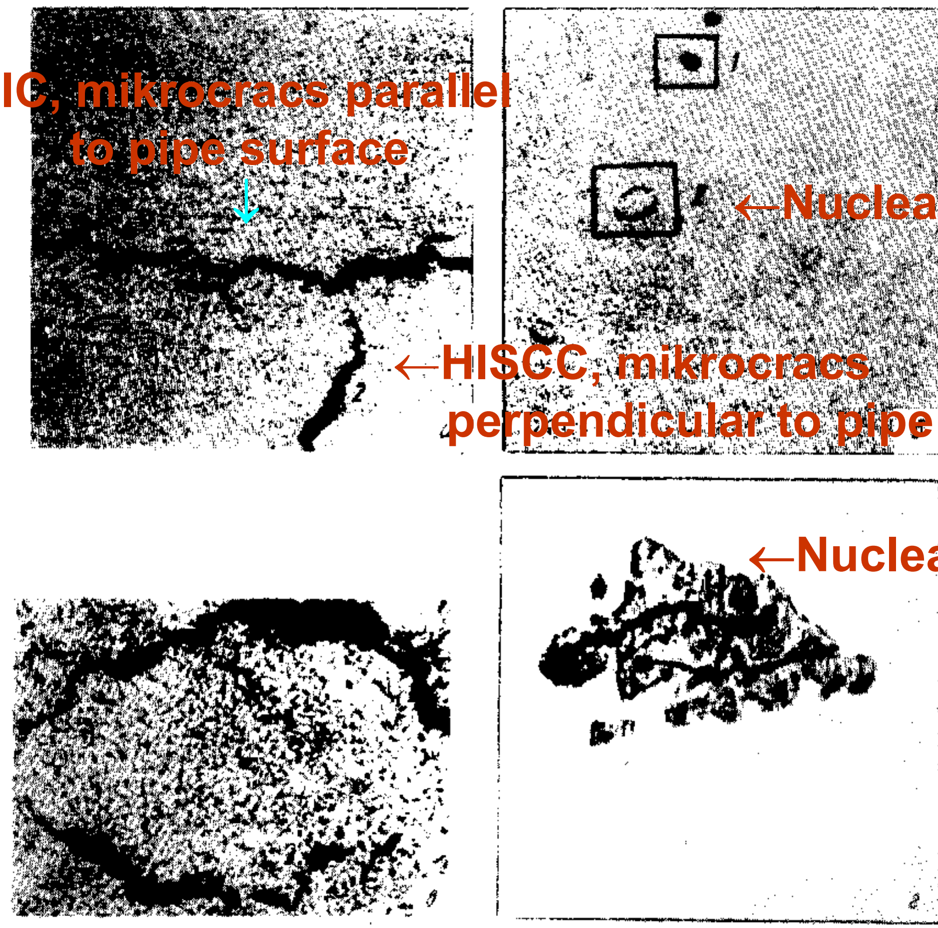
HIC – hydrogen induced cracking,
occurs in low- and high-strength steels even without external stress.
Crack propagation proceeds paralell to surface.





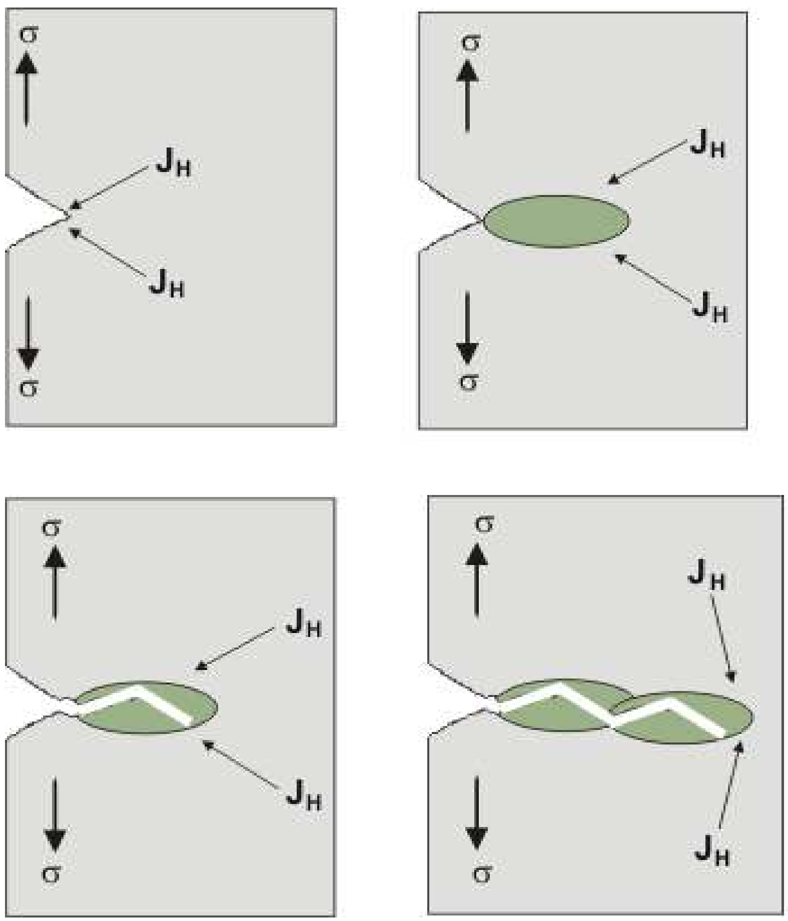
SSCC – sulphide stress corrosion cracking,
occurs in high-strength steels.
Crack propagation proceeds perpendicular to surface.

The effect of H_2S on hydrogen embrittlement



HIC and HISCC of pipelines after 10 years exploitation in natural gas containing 4.5% H_2S.

<u>Hydrogen embrittlement</u>



Mechanism of hydrogen embrittlement by stress iduced hydride formation.

Hydrogen embrittlement

Hydrogen absorption $H_{ad} \rightarrow H_{Lattice}$ → Crack initiation → Crack propagation

↑ (to Hydrogen absorption)

Corrosion ($H^{+} + e \rightarrow H_{ad}$)

↑

- Alloy components
- Coatings
- Inhibitors

Crack initiation ↓

Inclusions (elongated MnS)

↑

- Low content of S and P
- Spheroidization of inclusions

Crack propagation ↓

Anomalous structure
Segregation of Mn and P

↑

- Heat treatment
- Rolling conditions