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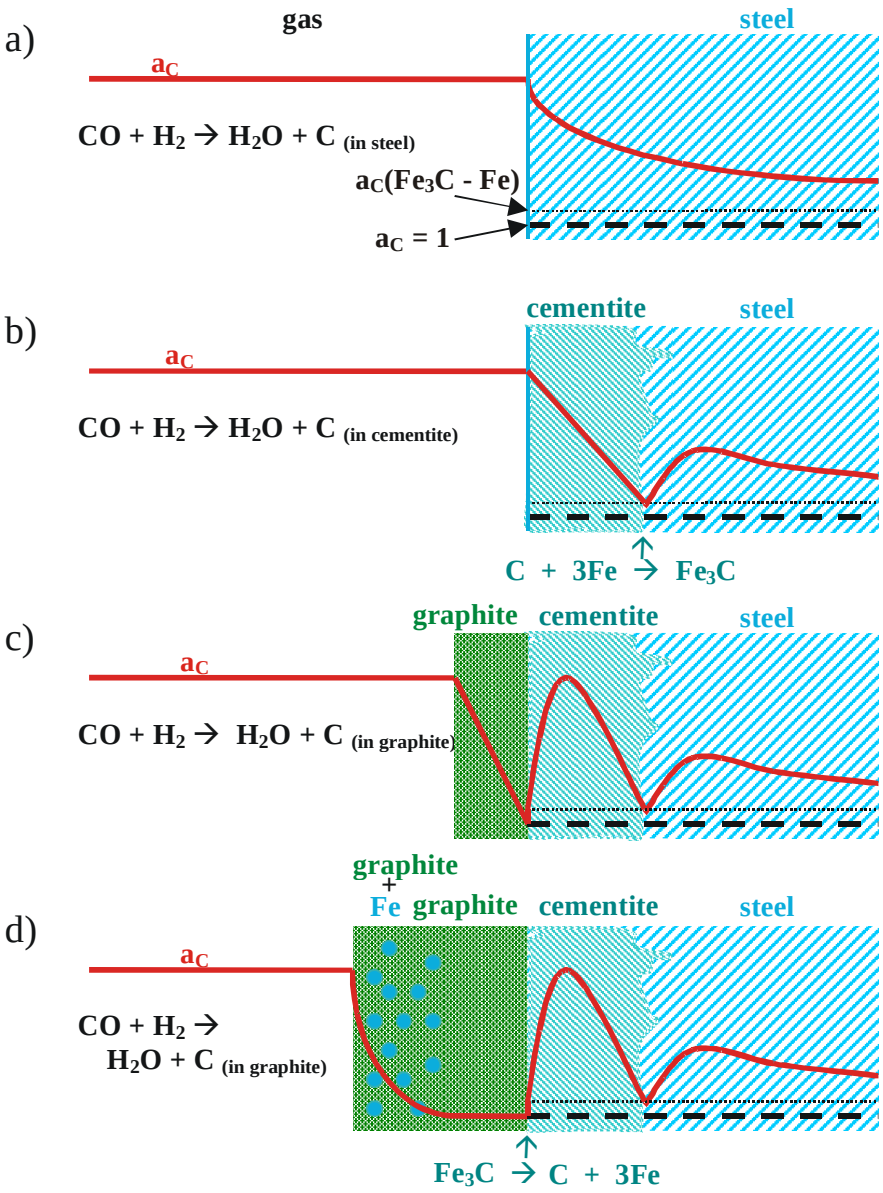
CORROSION IN CARBON CONTAINING ATMOSPHERES – METAL DUSTING

http://home.agh.edu.pl/~grzesik

Literature

1. H.J. Grabke: Mat. Corr. Vol. **49**, 303 (1998).
2. H.J. Grabke, E.M. Müller-Lorenz, B. Eltester, M. Lucas: Mat. High Temp., **17**, 339 (2000).
3. Wei Gao and Zhengwei Li ”Developments in high-temperature corrosion and protection of metals”, Ed, Woodhead Publishing Limited, Cambridge, England, 2008.
4. R. Cottis, M. Graham, R. Lindsay, S. Lyon, J. Richardson, J. Scantlebury, F. Stott, „Basic Concepts, High Temperature Corrosion, tom I” w „Shreir’s Corrosion”, Elsevier, Amsterdam, 2010.

Metal *dusting* corrosion mechanism for iron and low-alloy steel



Schematic diagram of the *metal dusting* corrosion process

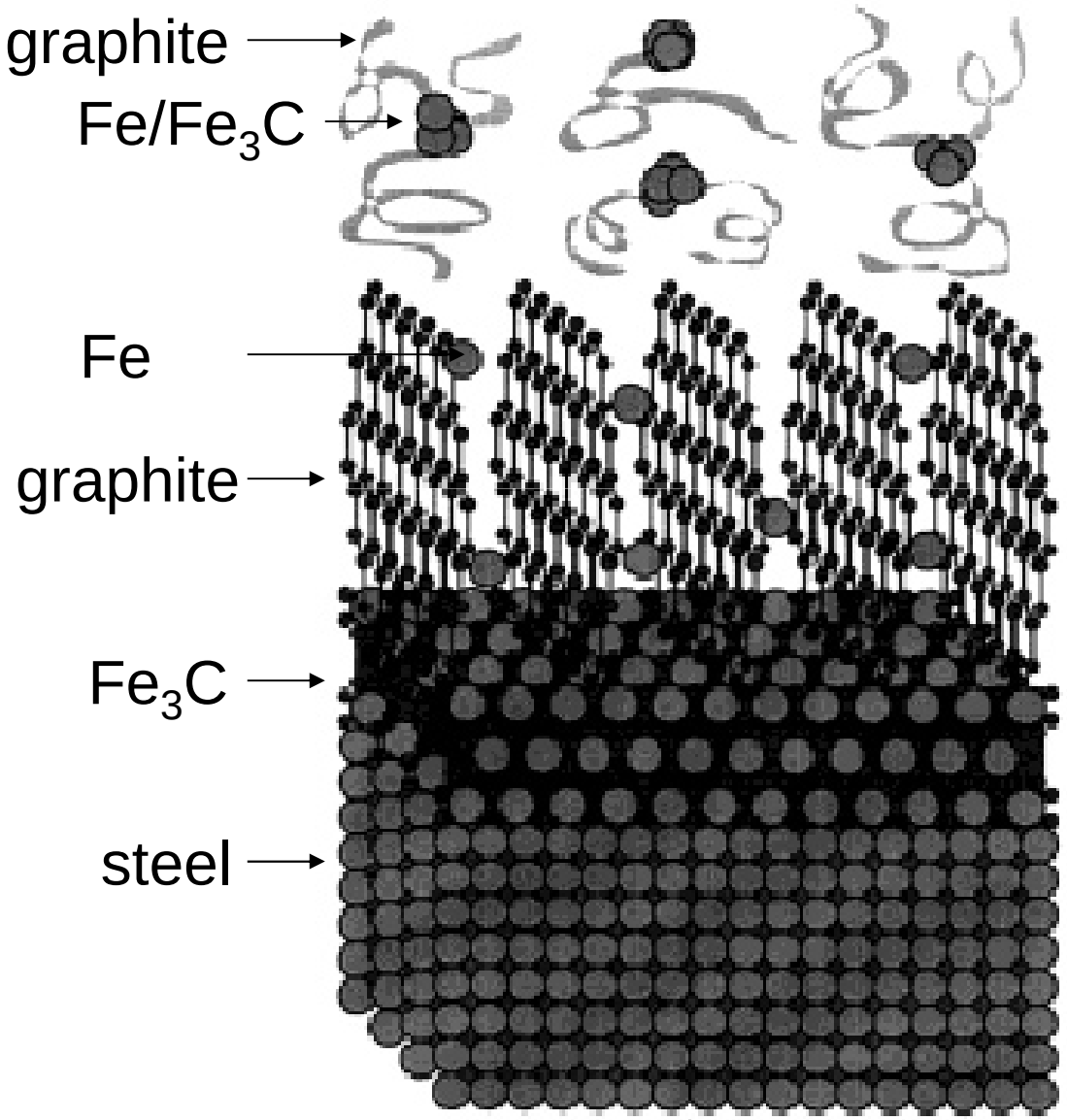


Image of nanostructured dust formed during metal dusting corrosion of a low-melting steel (T = 650 ºC, t = 3 hrs)

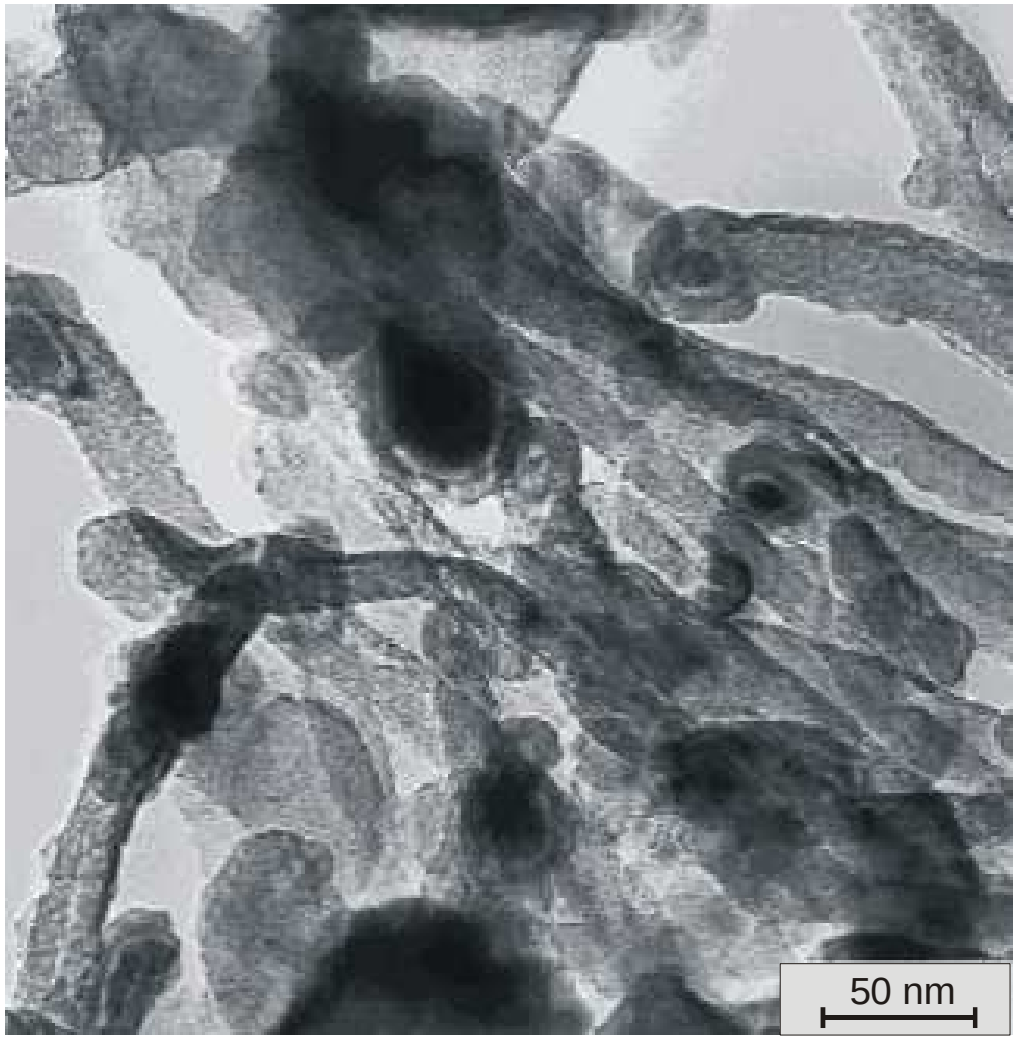
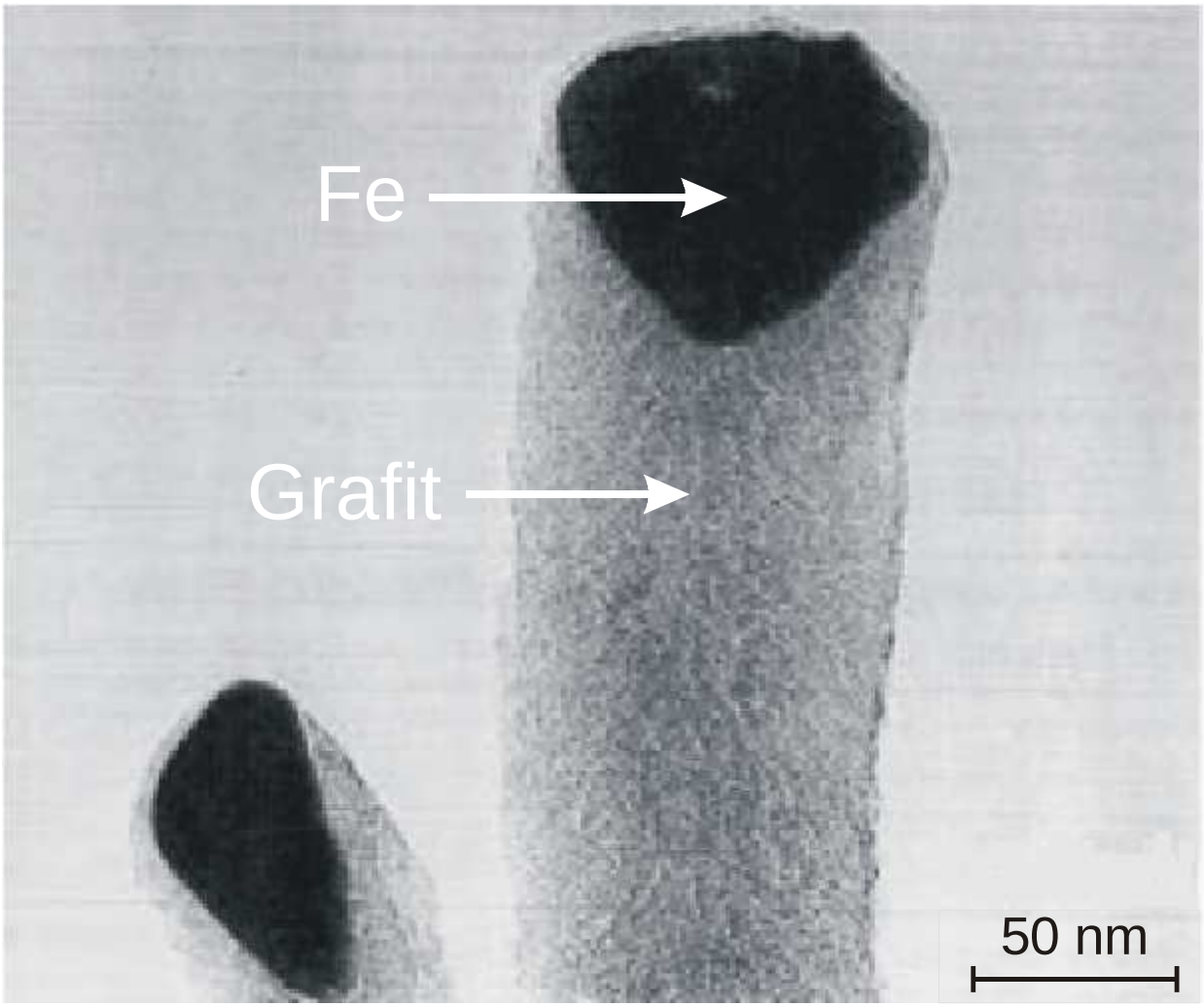
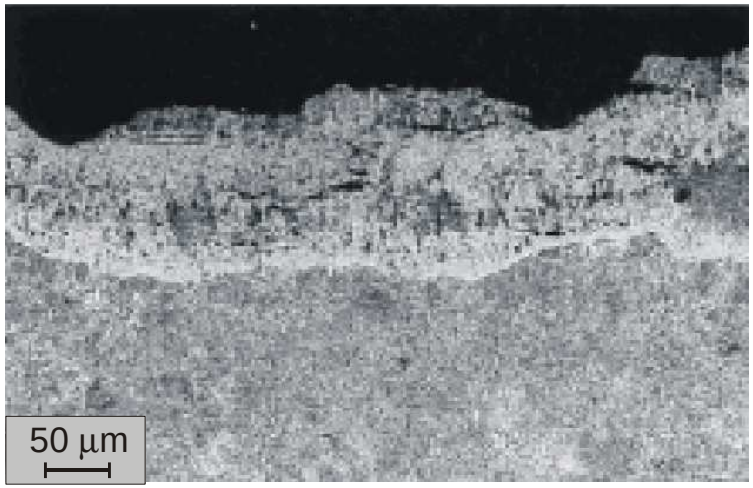


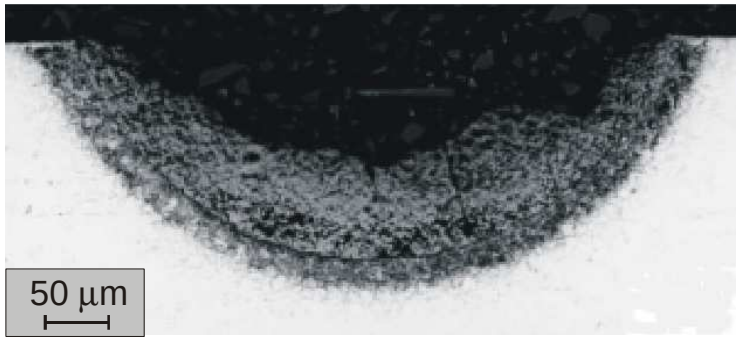
Image of a graphite fiber with an iron nanoparticle, formed during *metal dusting* corrosion of an austenitic steel (25%Cr-32%Ni) at 800 ^{o}C for 4 hrs



Typical corrosion damages



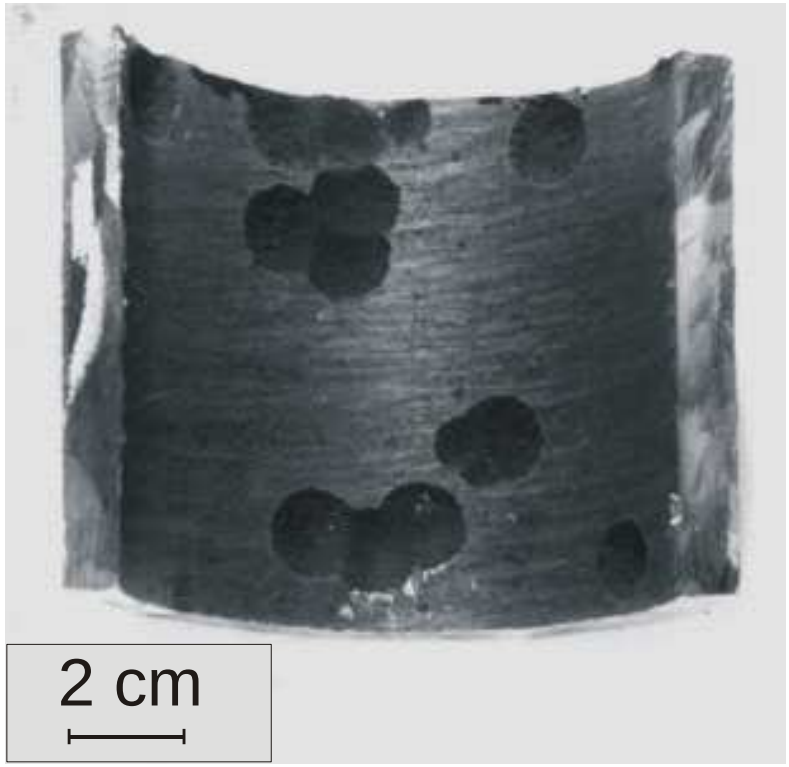
low-alloy steel

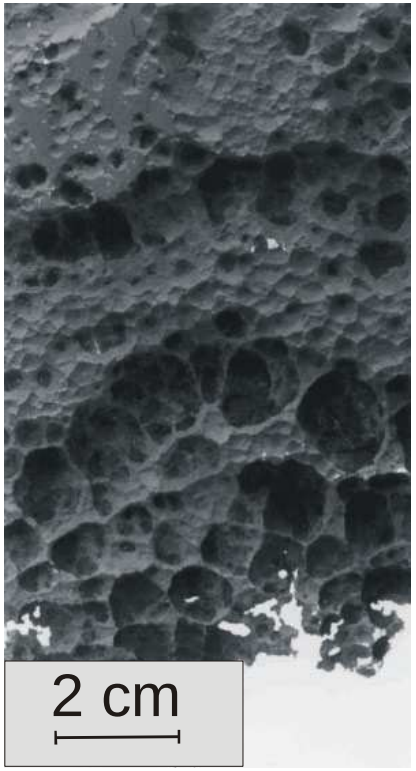


high-alloy steel

Typical corrosion damages

Typical corrosion damages





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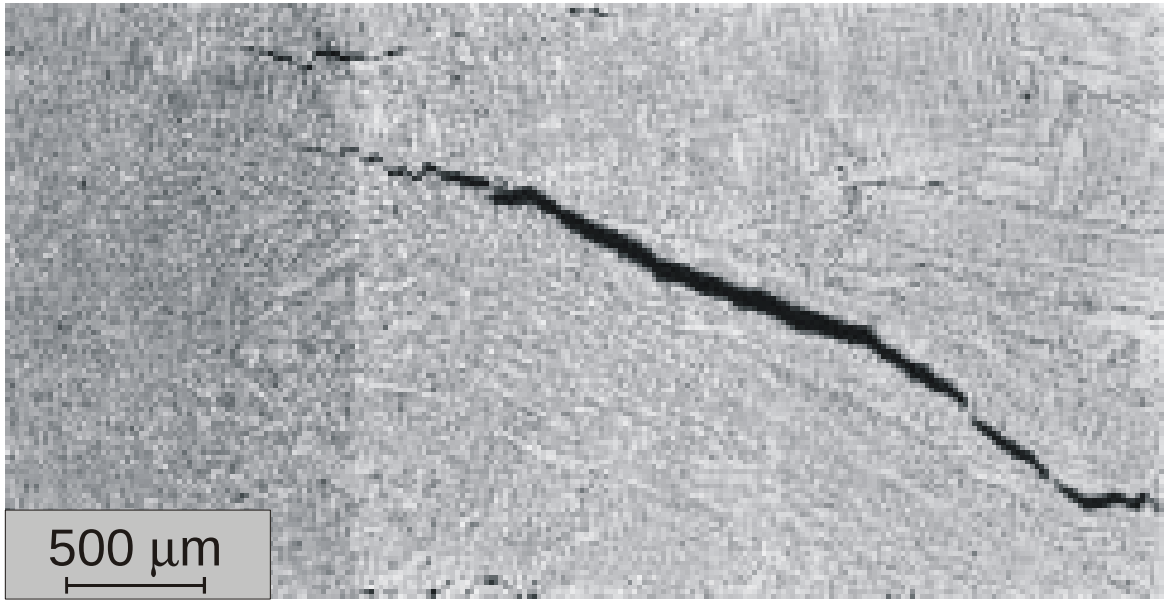

Rapid degradation of a low-alloy steel (2.25 %Cr and 1 %Mo) in CO-H_2-H_2O atmosphere after 3 h of corrosion (650 ^oC)

1 cm

Criticism of the *metal dusting* corrosion mechanism for iron and low-alloy steels, proposed by Grabke

Z. Zeng, K. Natesan, V.A. Maroni: Oxid. Met. Vol. 58 (2002), p. 147

Z. Zeng, K. Natesan: Chem. Mat. Vol. 15 (2003), p. 872

C.H. Toh, P.R. Munroe and D.J. Young: Mat. High Temp. Vol. 20 (2003), p. 527

C.H. Toh, P.R. Munroe and D.J. Young: Oxid. Met. Vol. 58 (2002), p. 1

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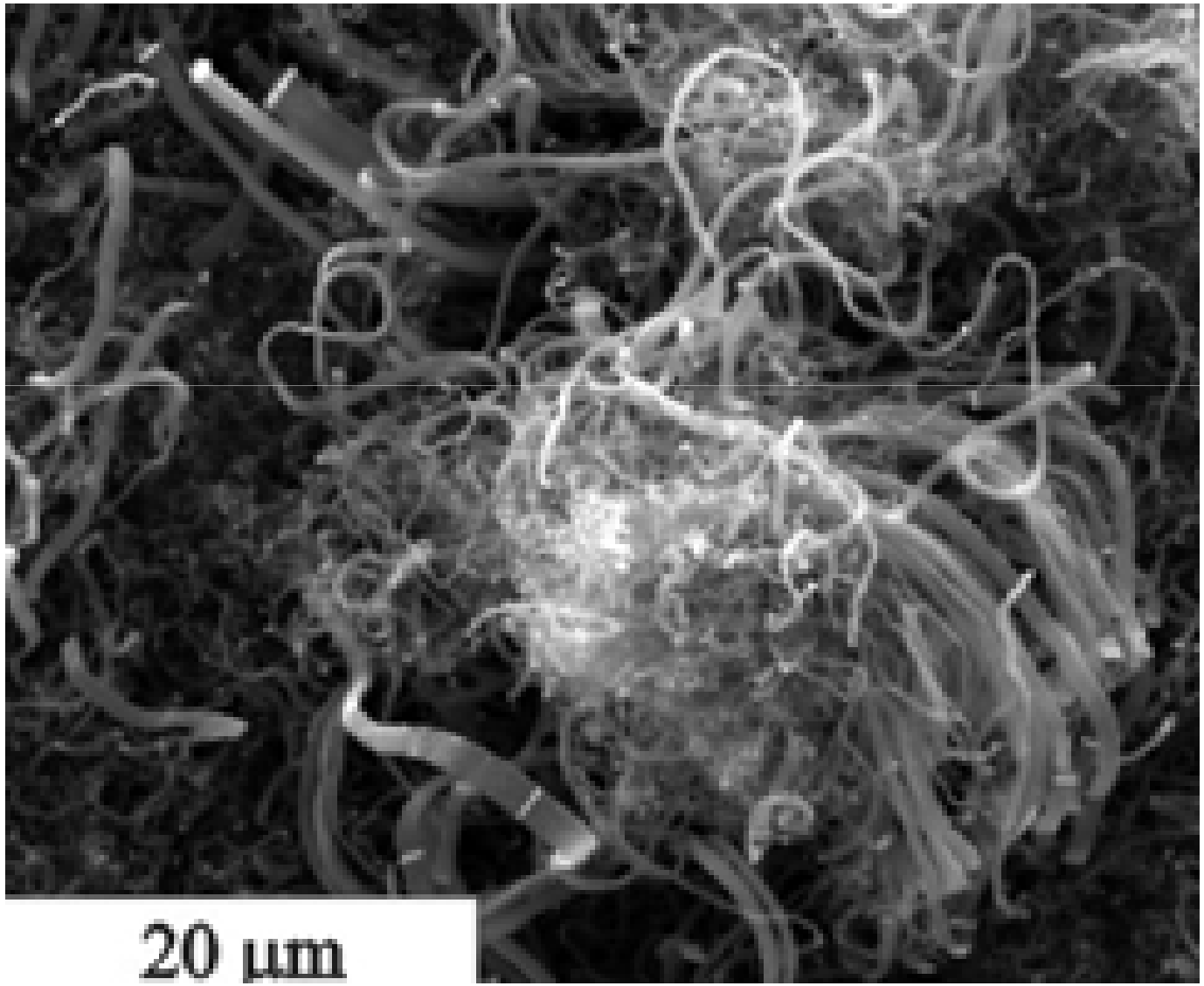

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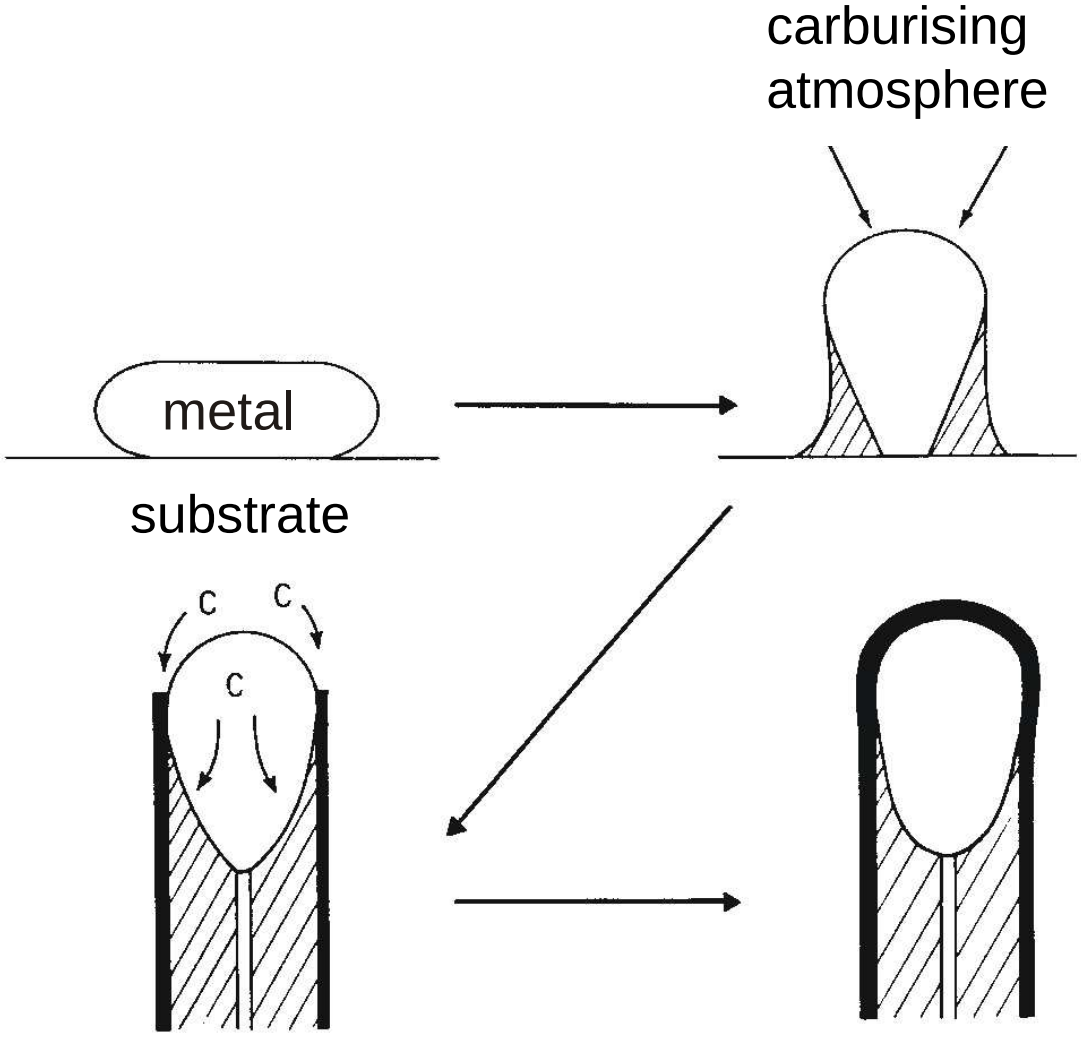


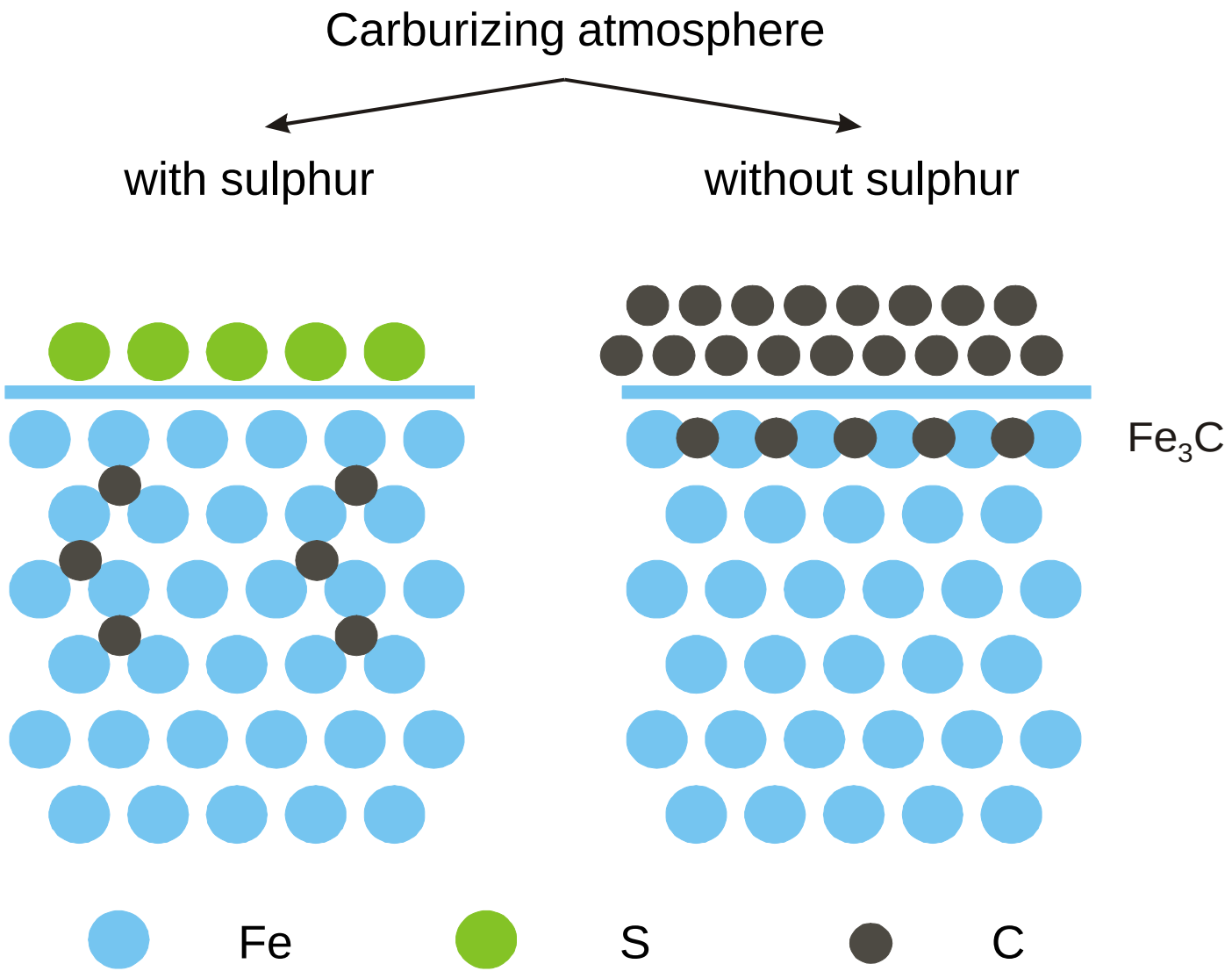
Atmospheres the cause *metal dusting* corrosion

- CO, H_2O, H_2
- CH_4, H_2O, H_2

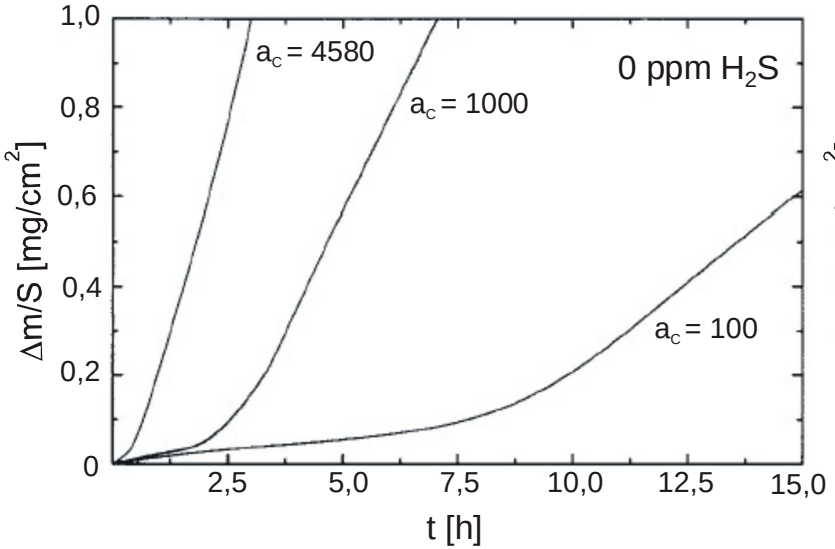
Methods of limiting *metal dusting* corrosion

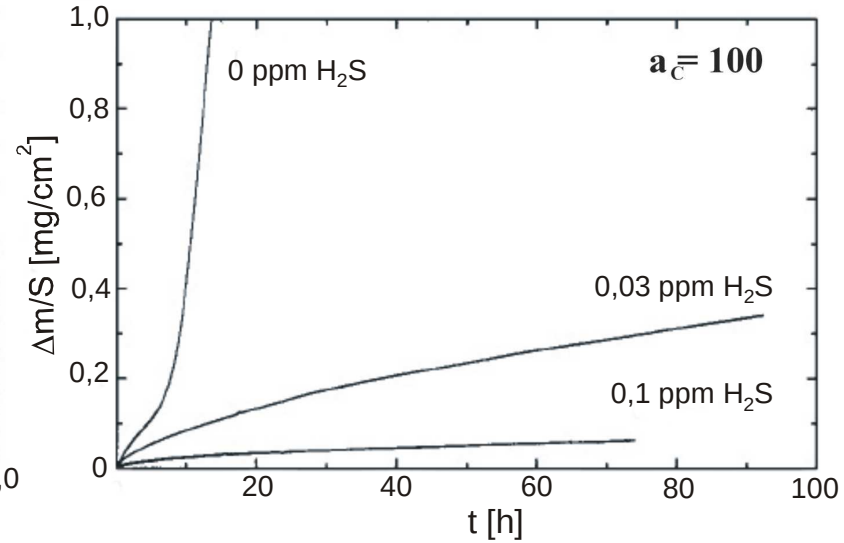
- inserting small amounts of sulfur into the atmosphere
- growing a protective layer built of Cr_2O_3 lub Al_2O_3 on the steel surface

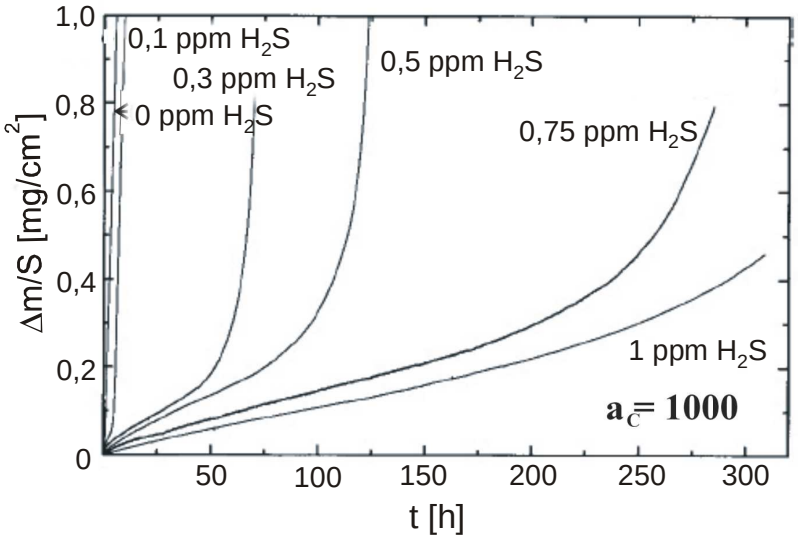
Role of sulfur in inhibiting *metal dusting* corrosion

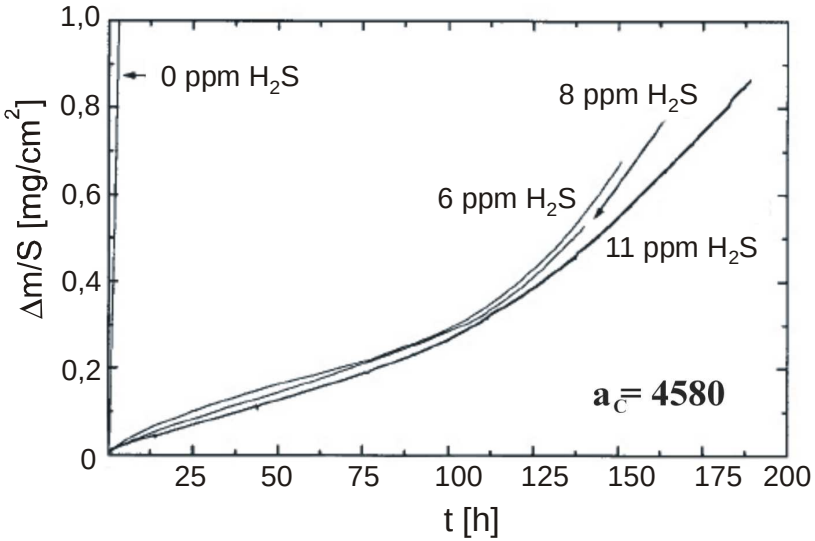


Effectiveness of sulfur in inhibiting corrosion

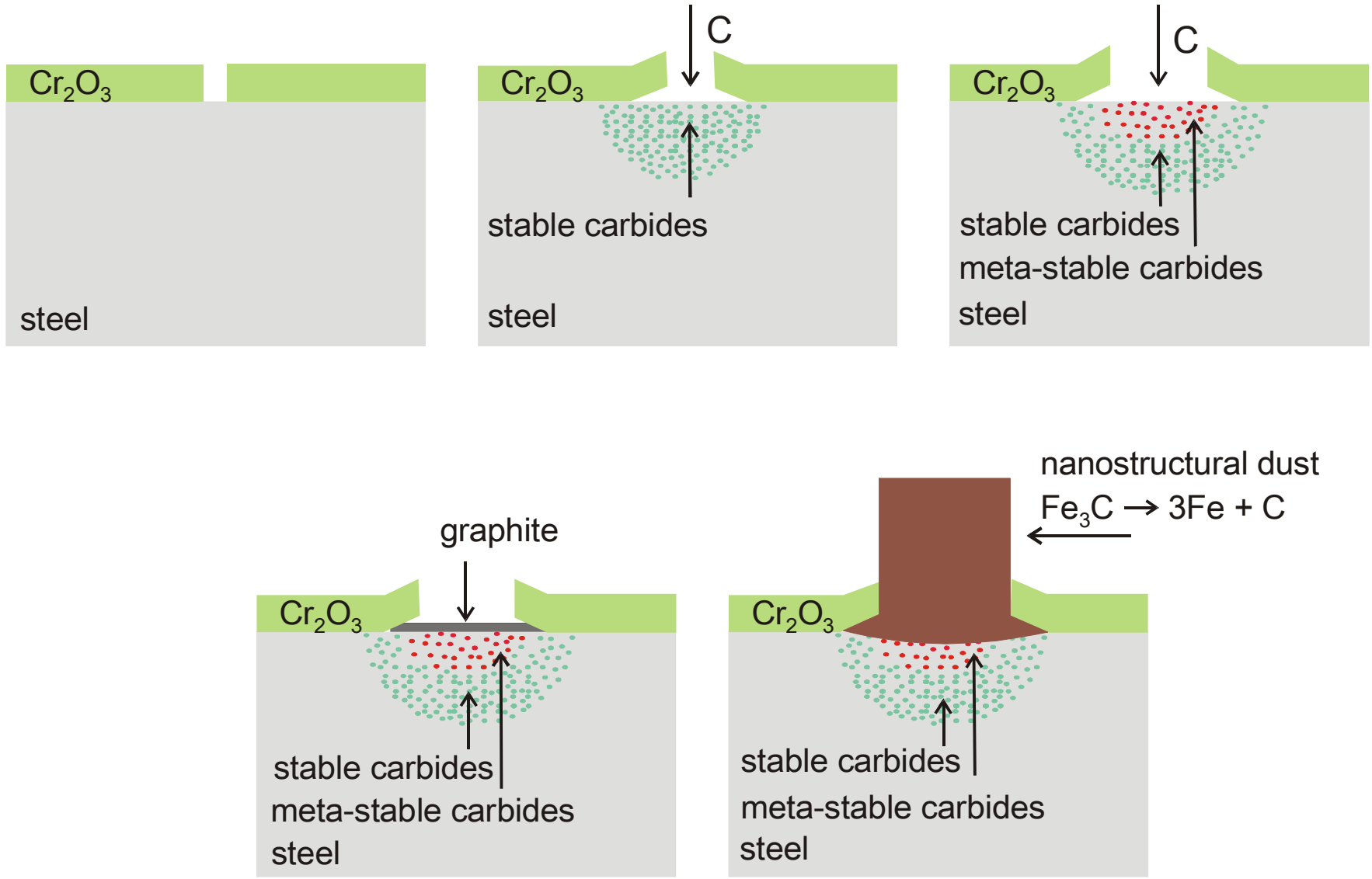




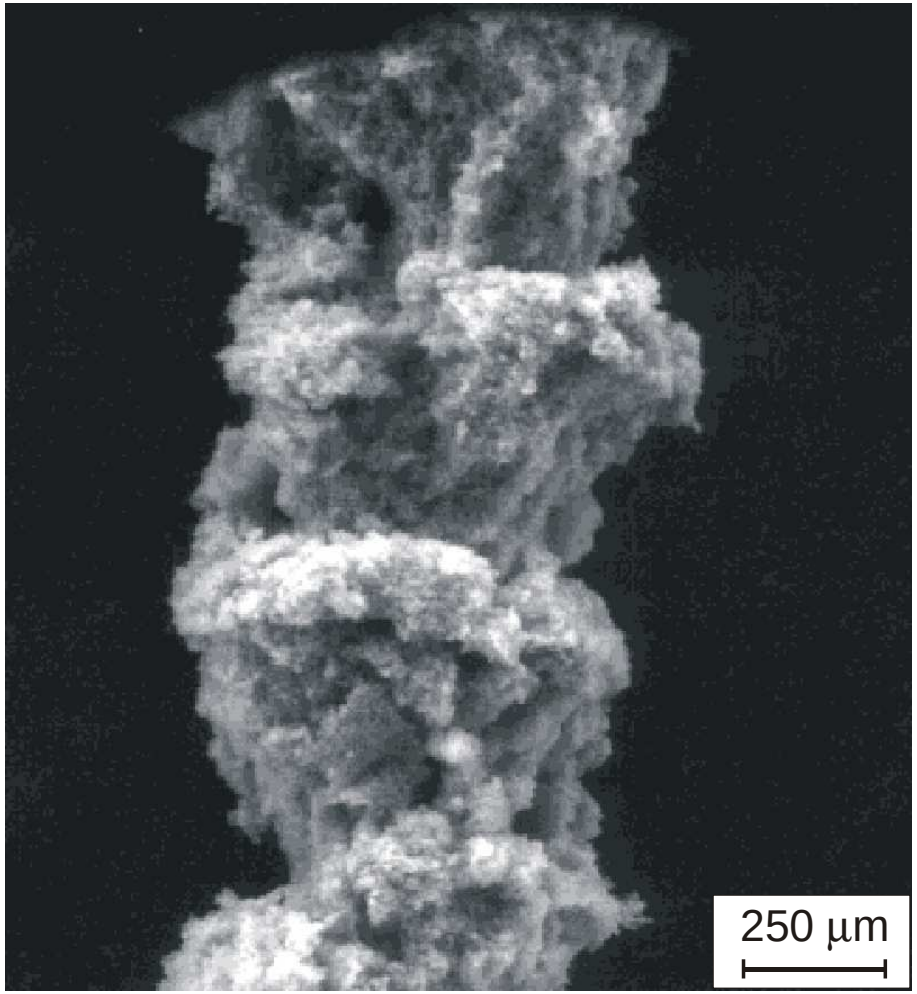


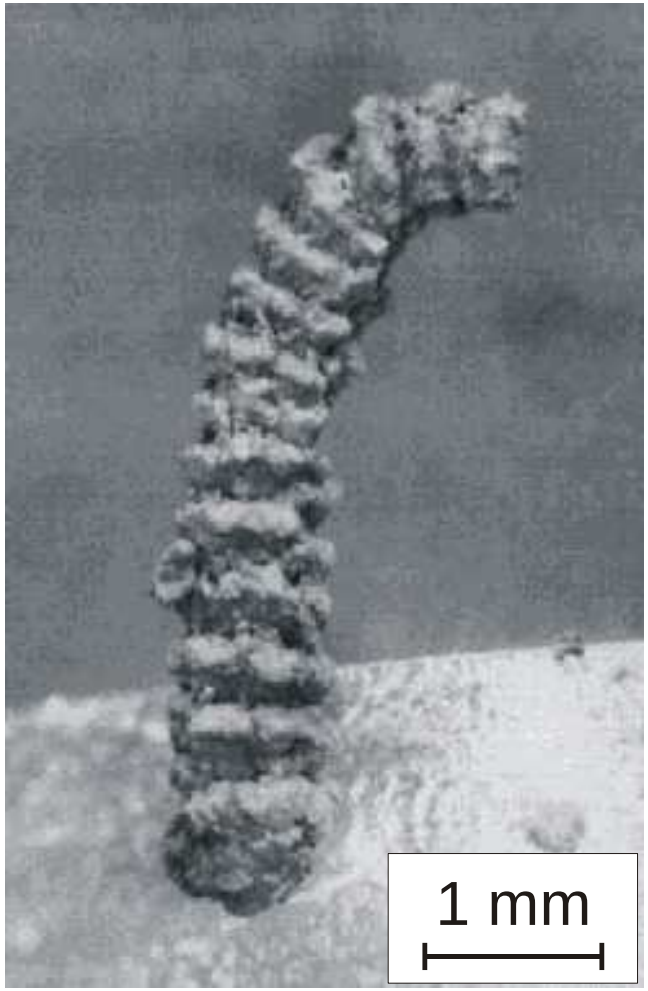


Metal *dusting* corrosion mechanism for high-alloy steels



M*etal dusting* corrosion of high-alloy steels





Studies performed in KFCS WIMiC AGH

Studied materials:

- Carbon steel (97 at. % Fe, 2.5 at. % C and 0.5 at. % Si)
- 9Cr-1Mo steel (9.32 wt. % Cr; 0.99 wt. % Mo; 0.10 wt. % C; 0.44 wt. % Mn; 0.39 wt. % Si; 0.0095 wt. % P; 0.008 wt. % S; Fe – bal.)
- Fe-10Cr, Fe-30Cr, Fe-50Cr

Applied carburizing atmospheres:

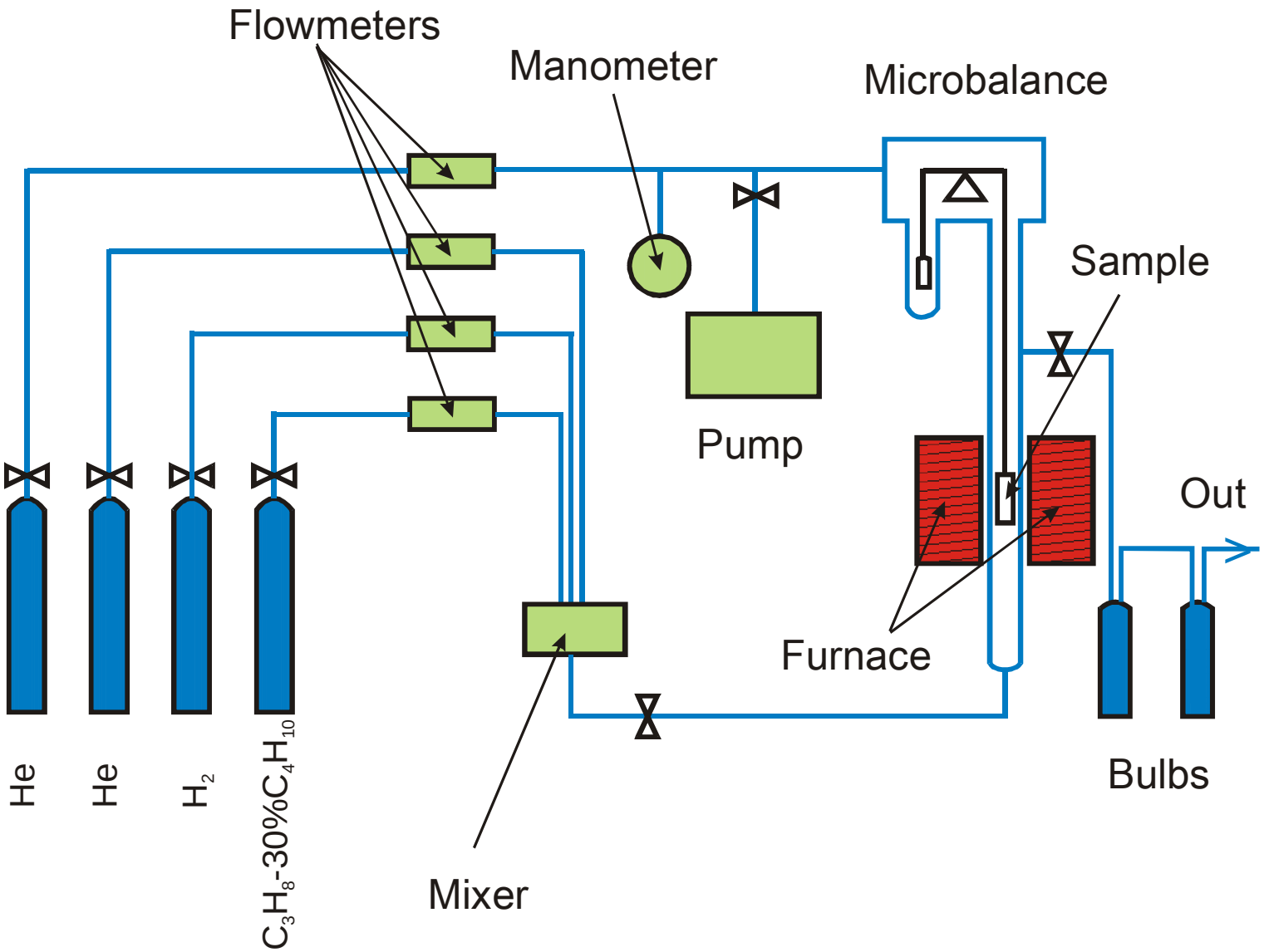
- CH_4, CH_4-1%H_2O, CH_4-H_2
- CH_4-C_2H_6
- C_3H_8-30%C_4H_{10}

Corrosion tests:

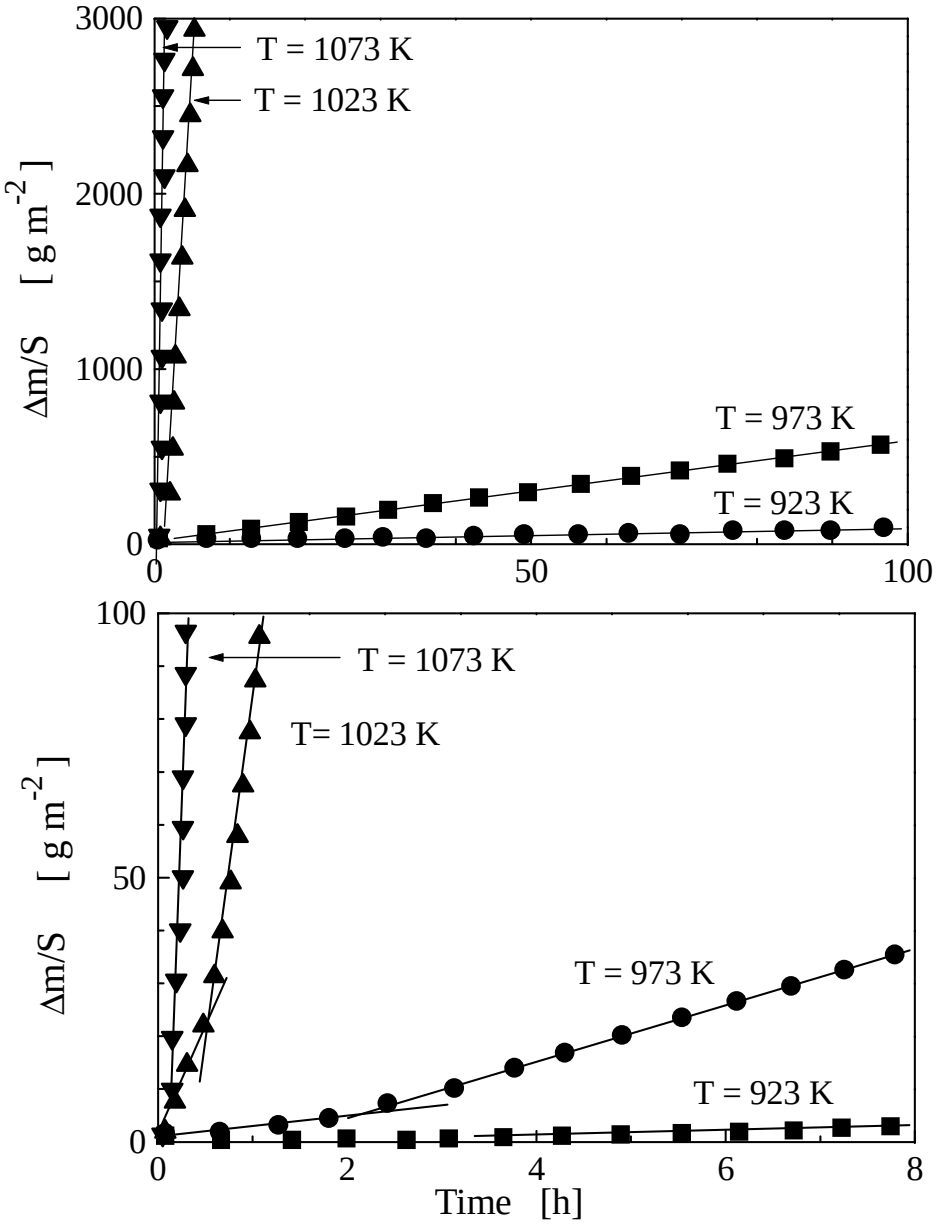
773-1173 K

Morphology and phase composition analysis of corrosion products

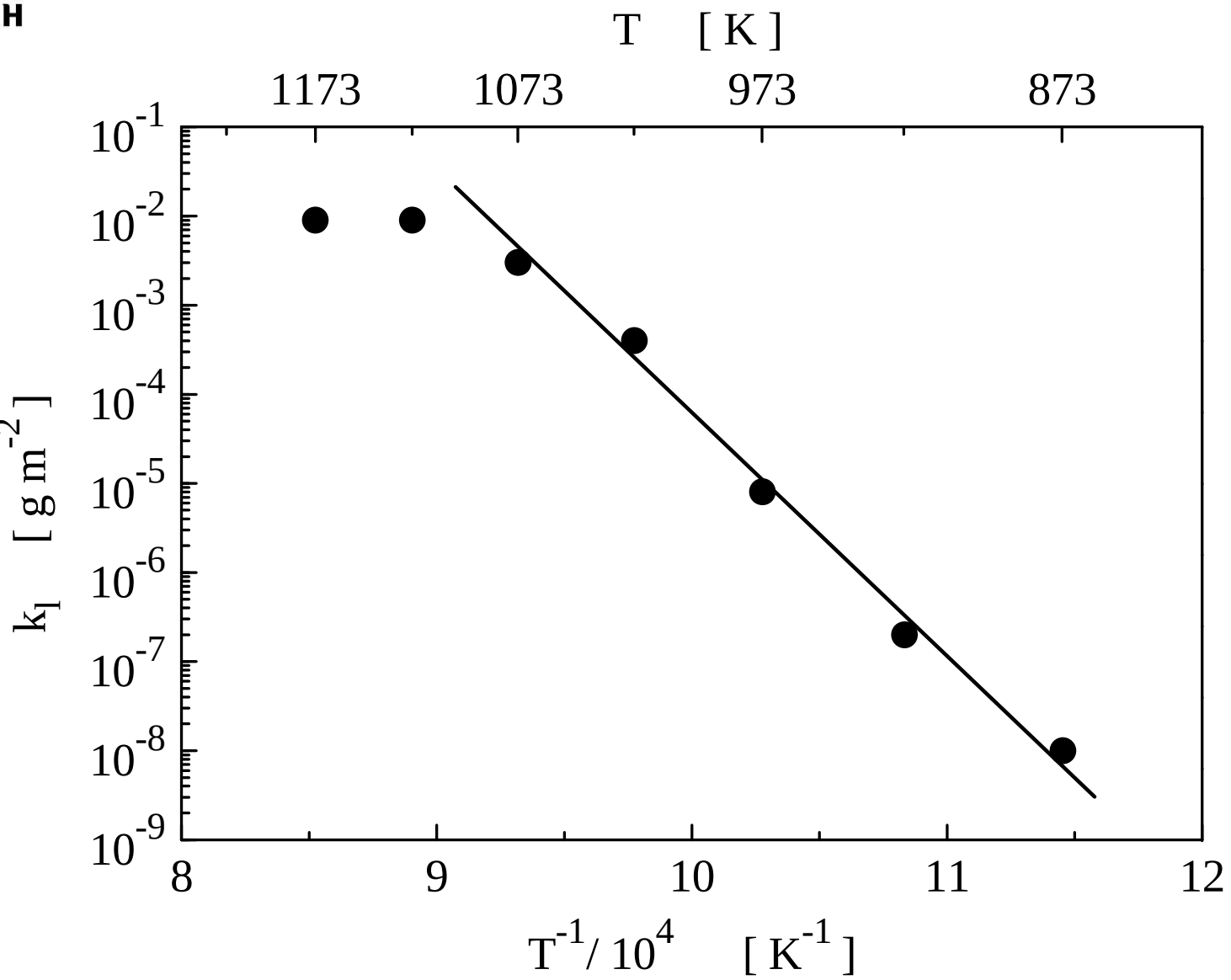
Microthermogravimetric apparatus for studying *metal dusting* corrosion



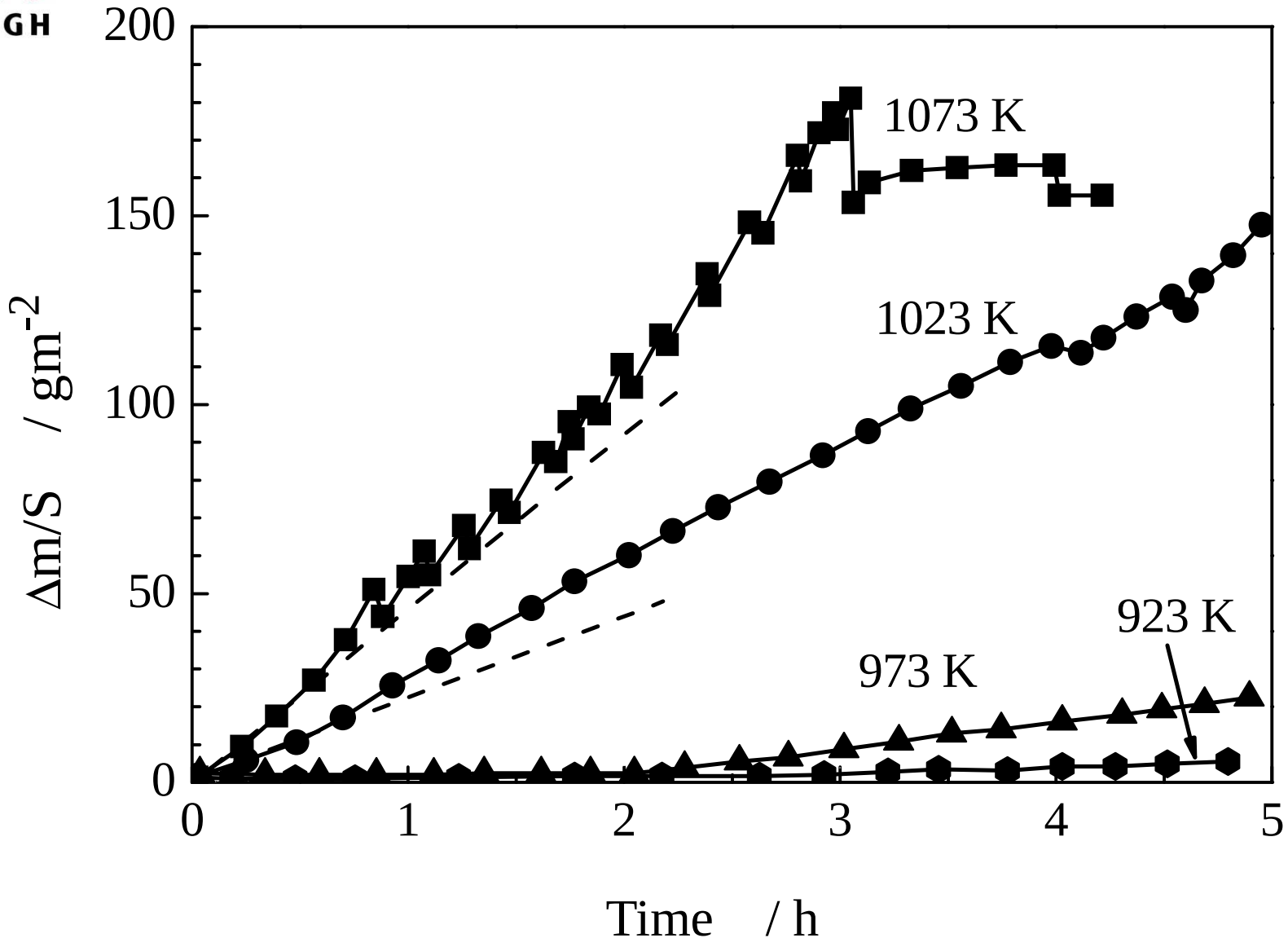
Metal dusting corrosion kinetics of carbon steels



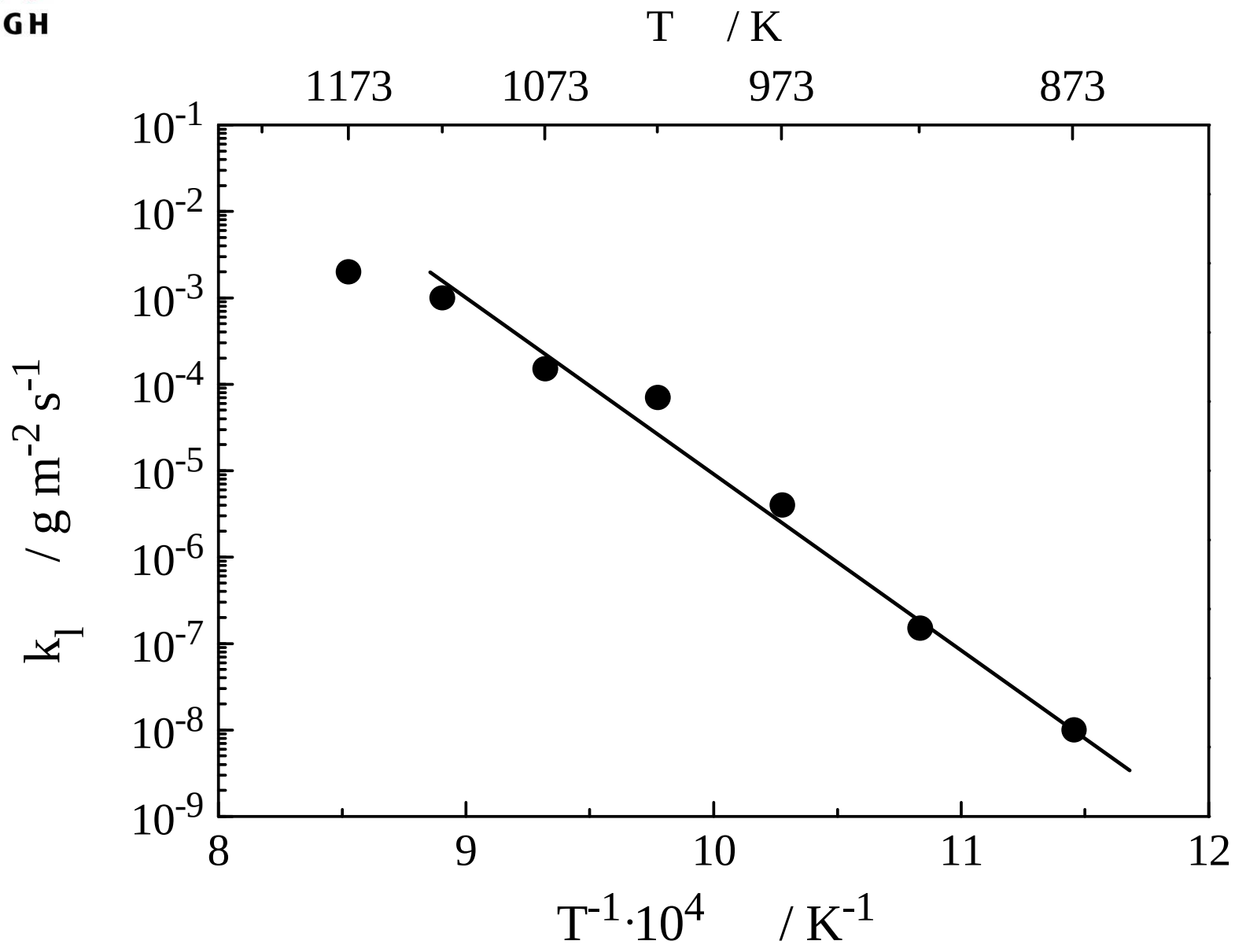
Temperature dependence of carbon steel *metal dusting* corrosion rate



Metal dusting corrosion kinetics of 9Cr-1Mo steel



Temperature dependence of 9Cr-1Mo steel *metal dusting* corrosion



Comparison between *metal dusting* corrosion rates of carbon steel and 9Cr-1Mo

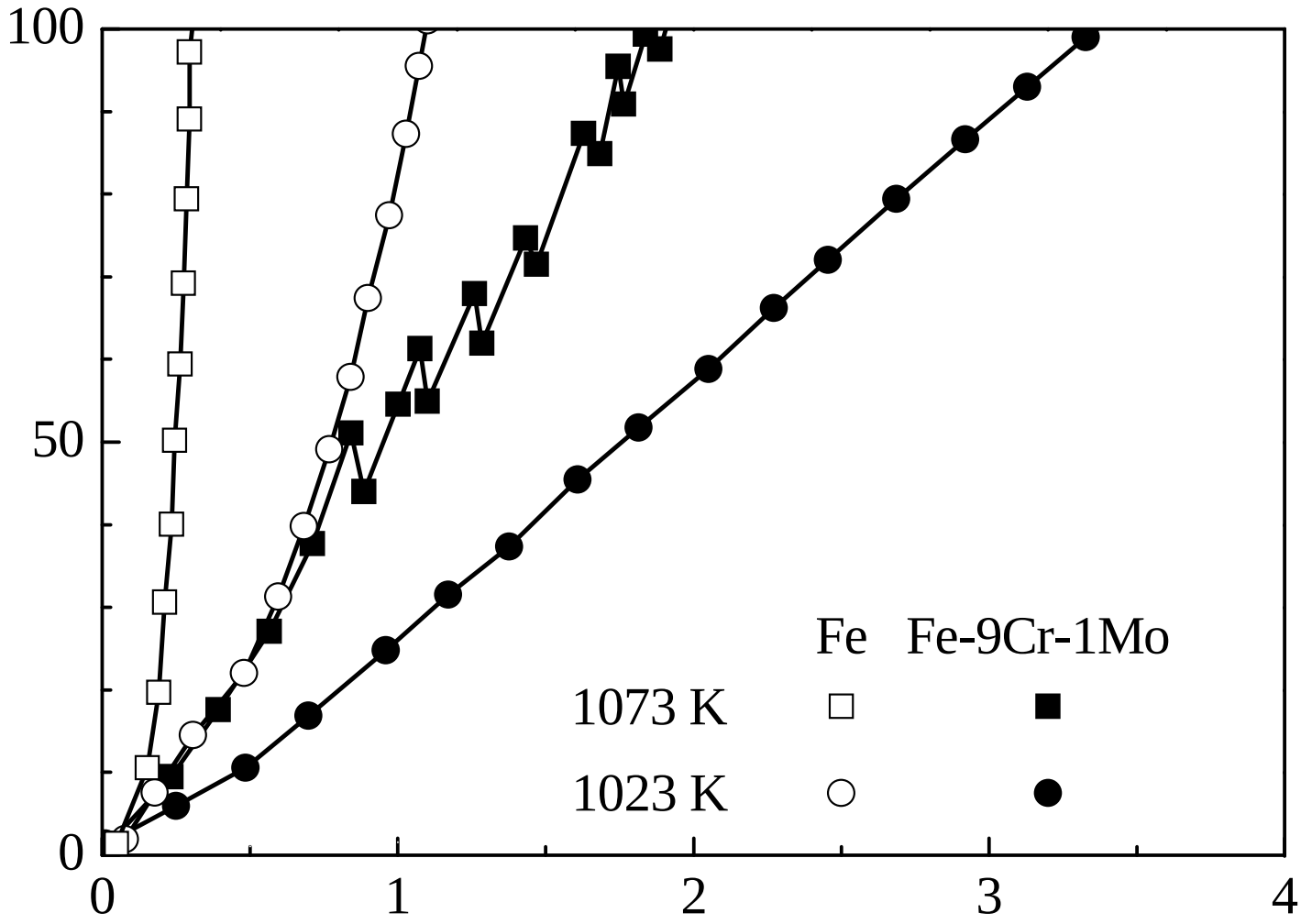


Image of a carbon steel sample after 3 h of reacting at 1173 K with an atmosphere consisting of a propane-butane mixture

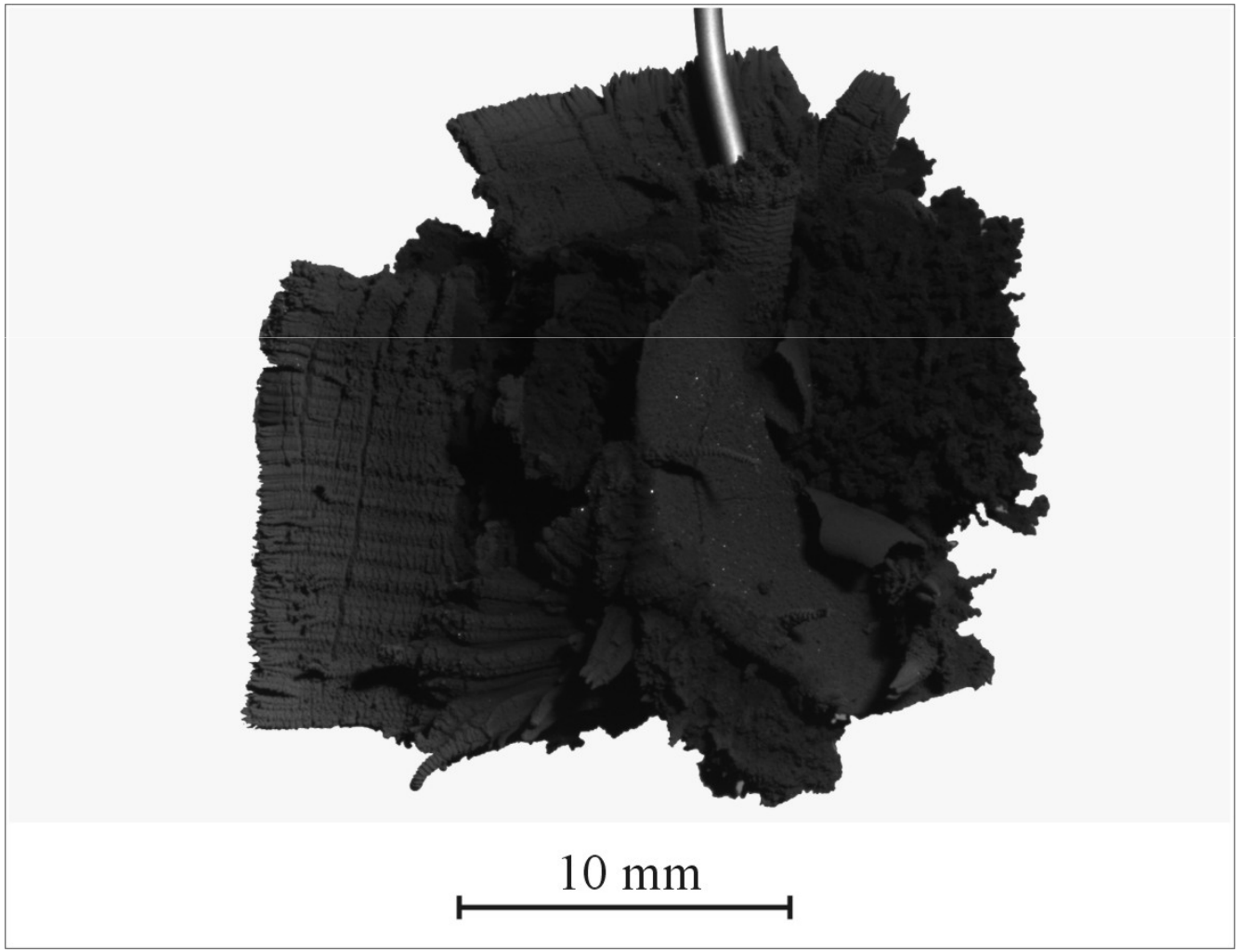
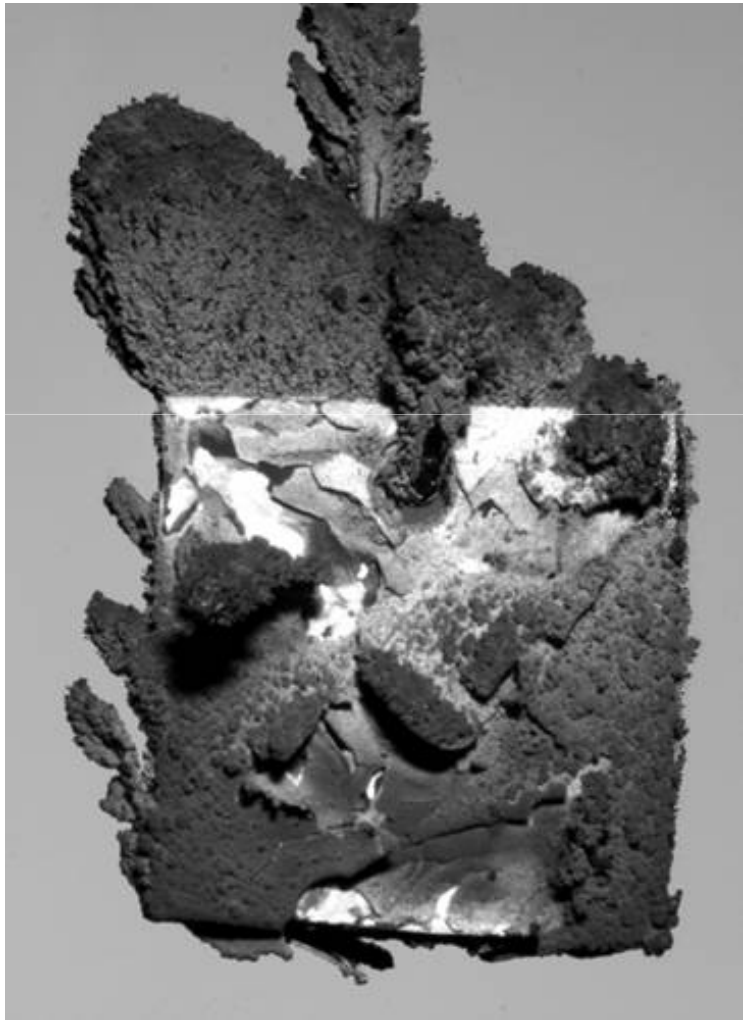
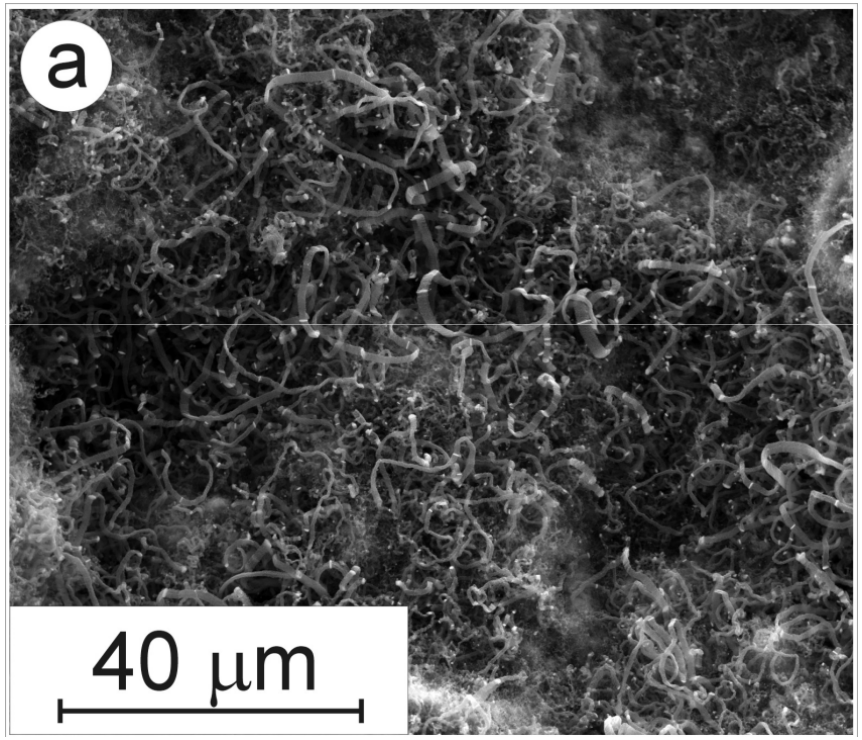
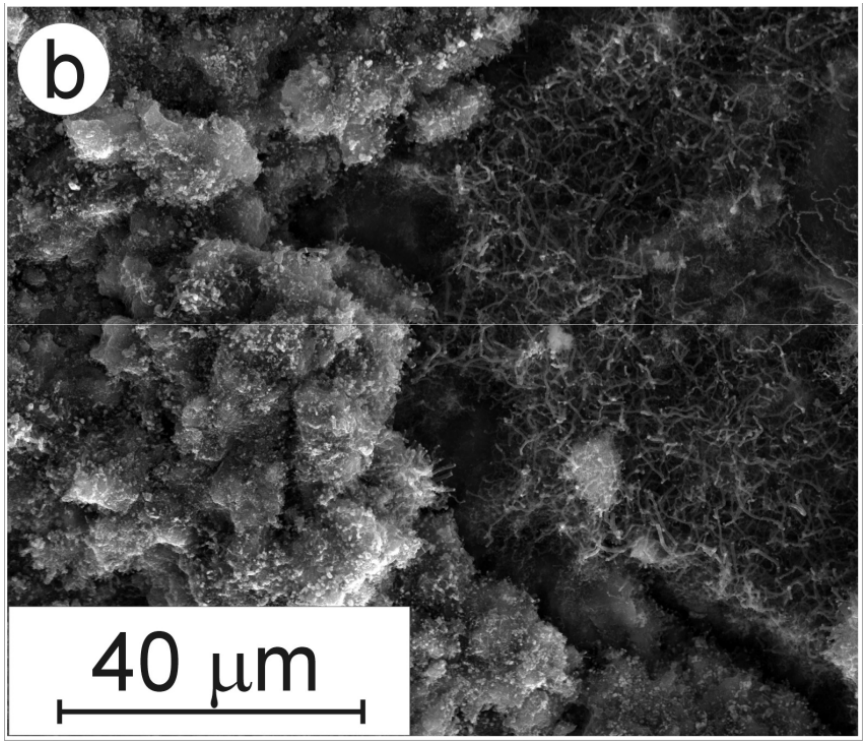


Image of a 9Cr-1Mo steel sample after 3 h of reacting at 1173 K with an atmosphere consisting of a propane-butane mixture

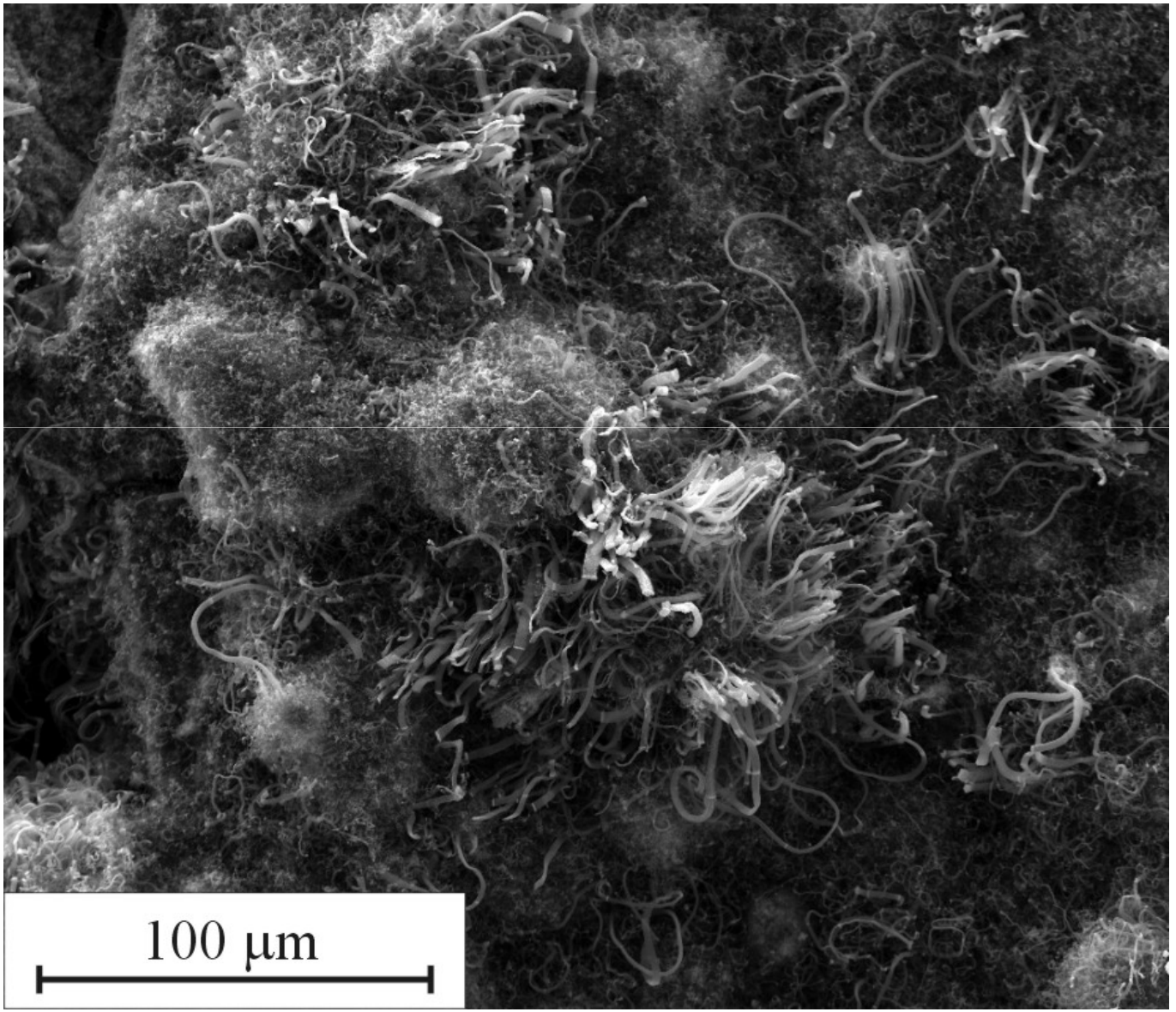


Comparison between the morphologies of carbon steel (a) and 9Cr-1Mo steel (b) after 3 h of reacting at 1173 K with an atmosphere consisting of a propane-butane mixture

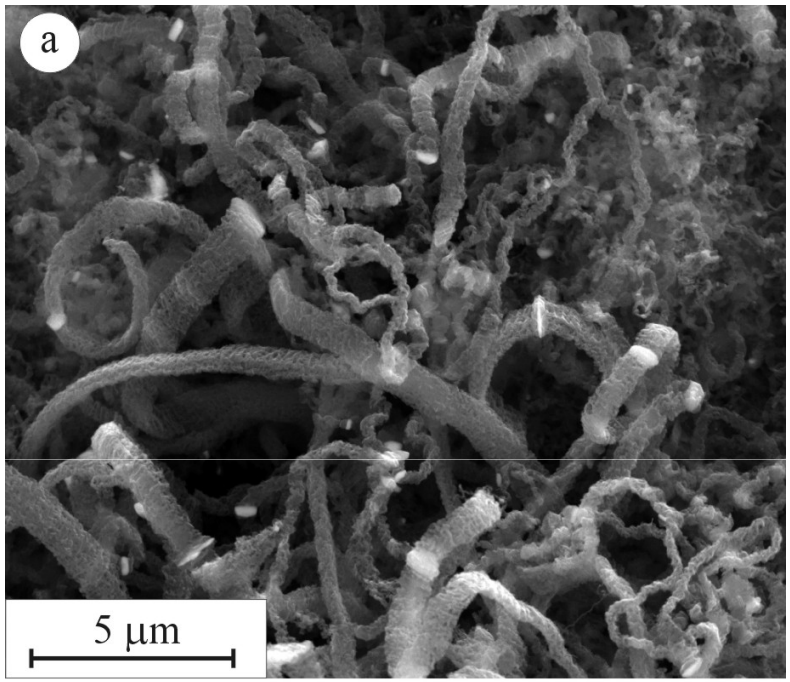


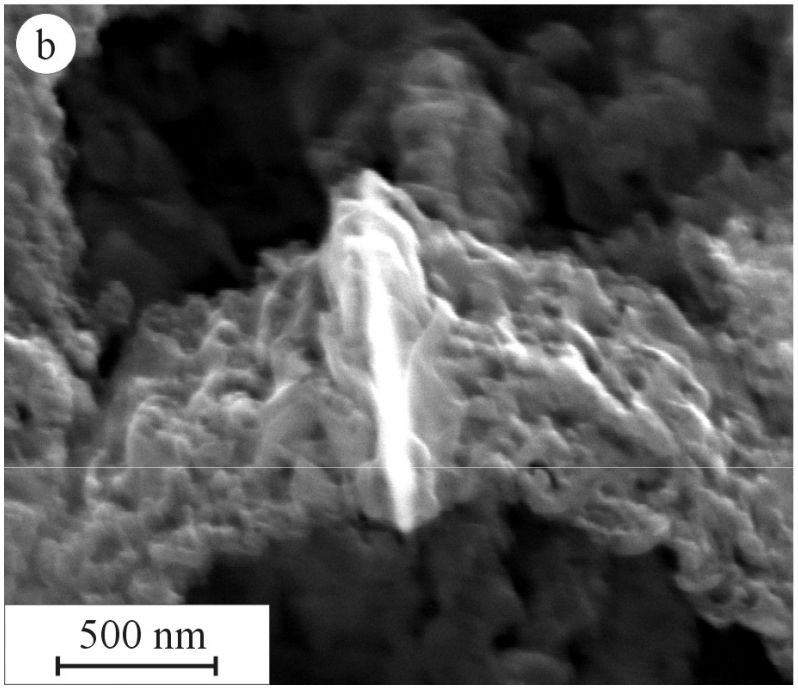


Surface of a carbon steel samples after *metal dusting* corrosion

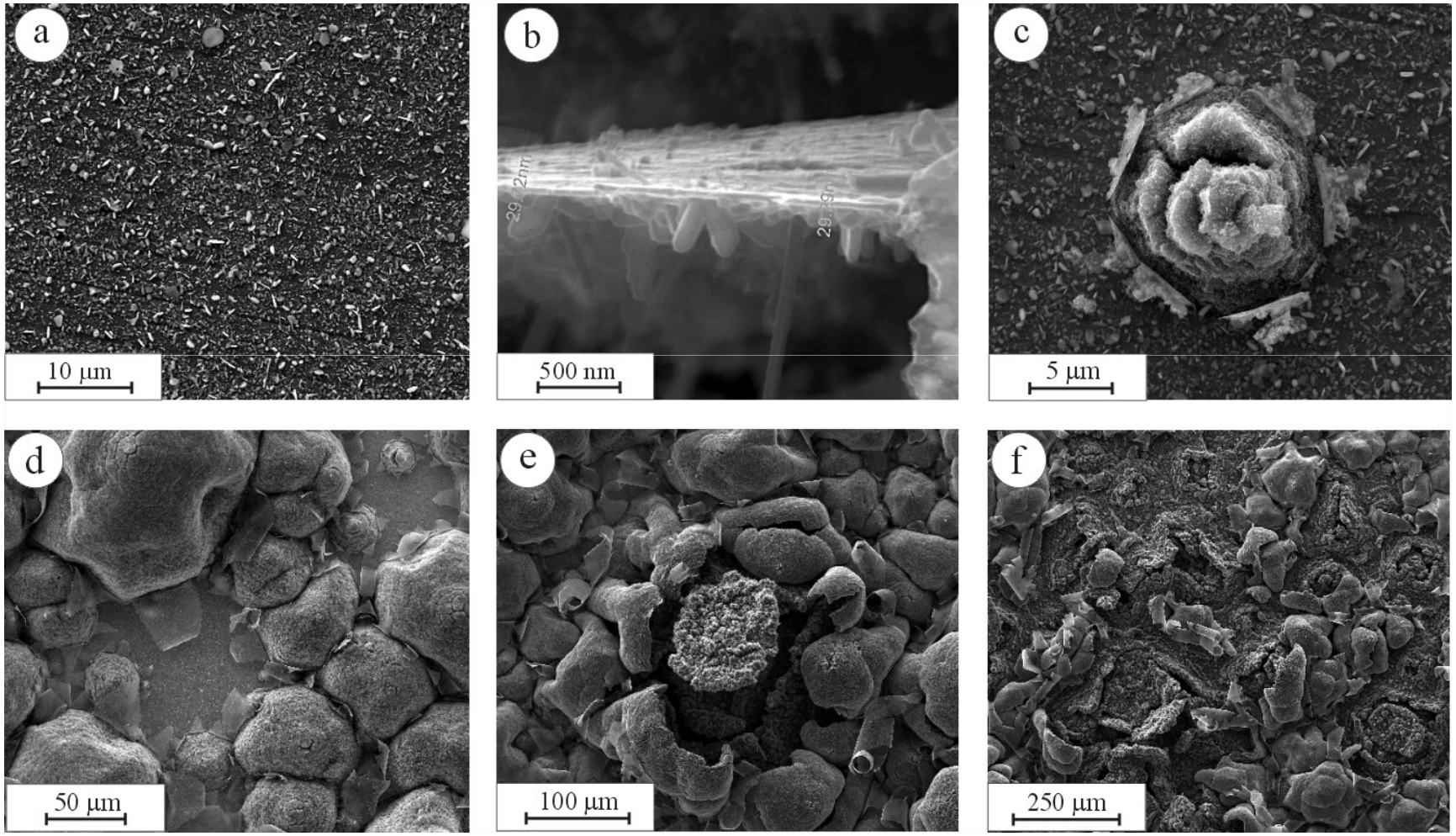


Carbon steel *metal dusting* corrosion



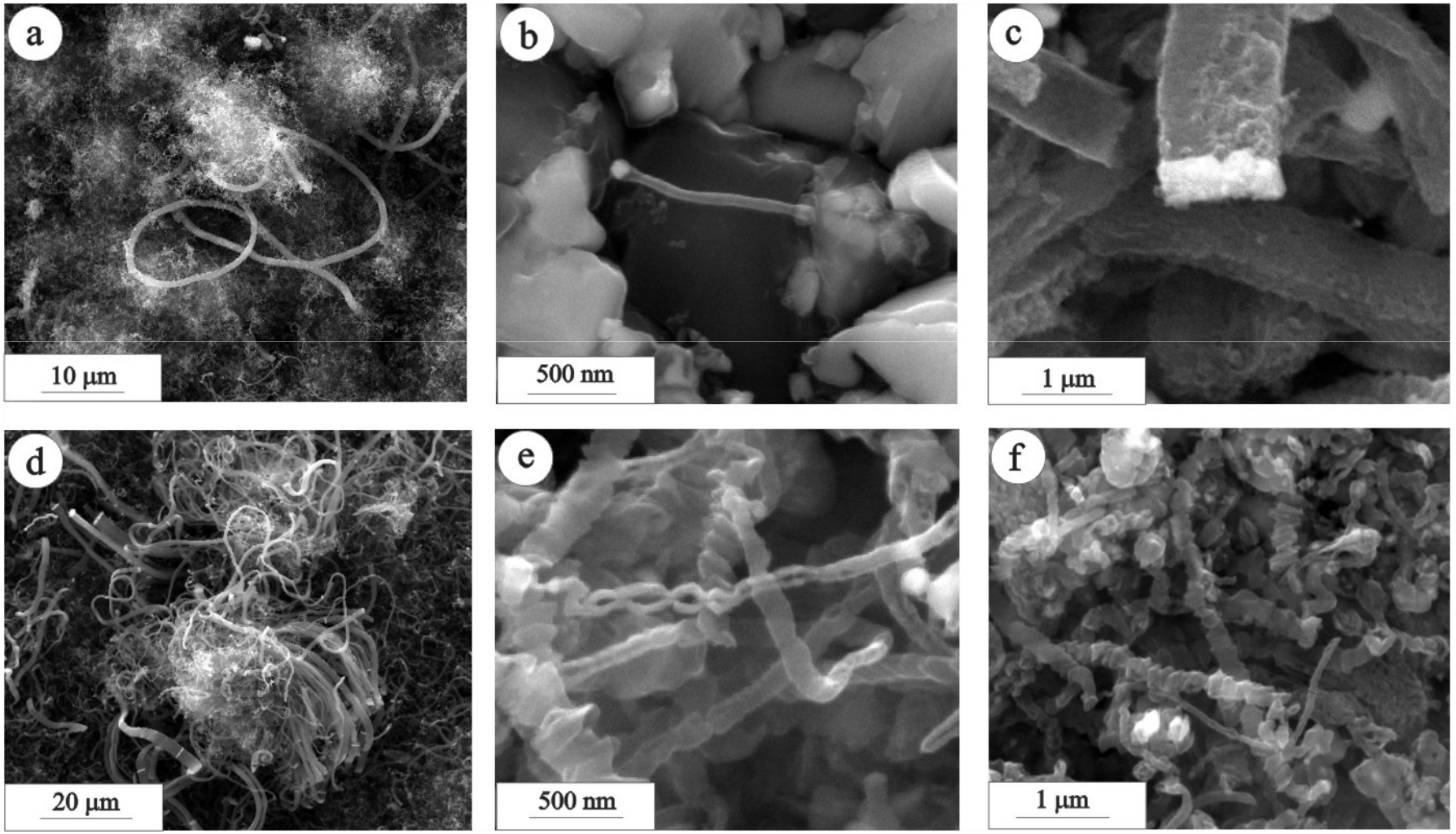


Stages of carbon steel corrosion at 1073 K in a propane-butane atmosphere

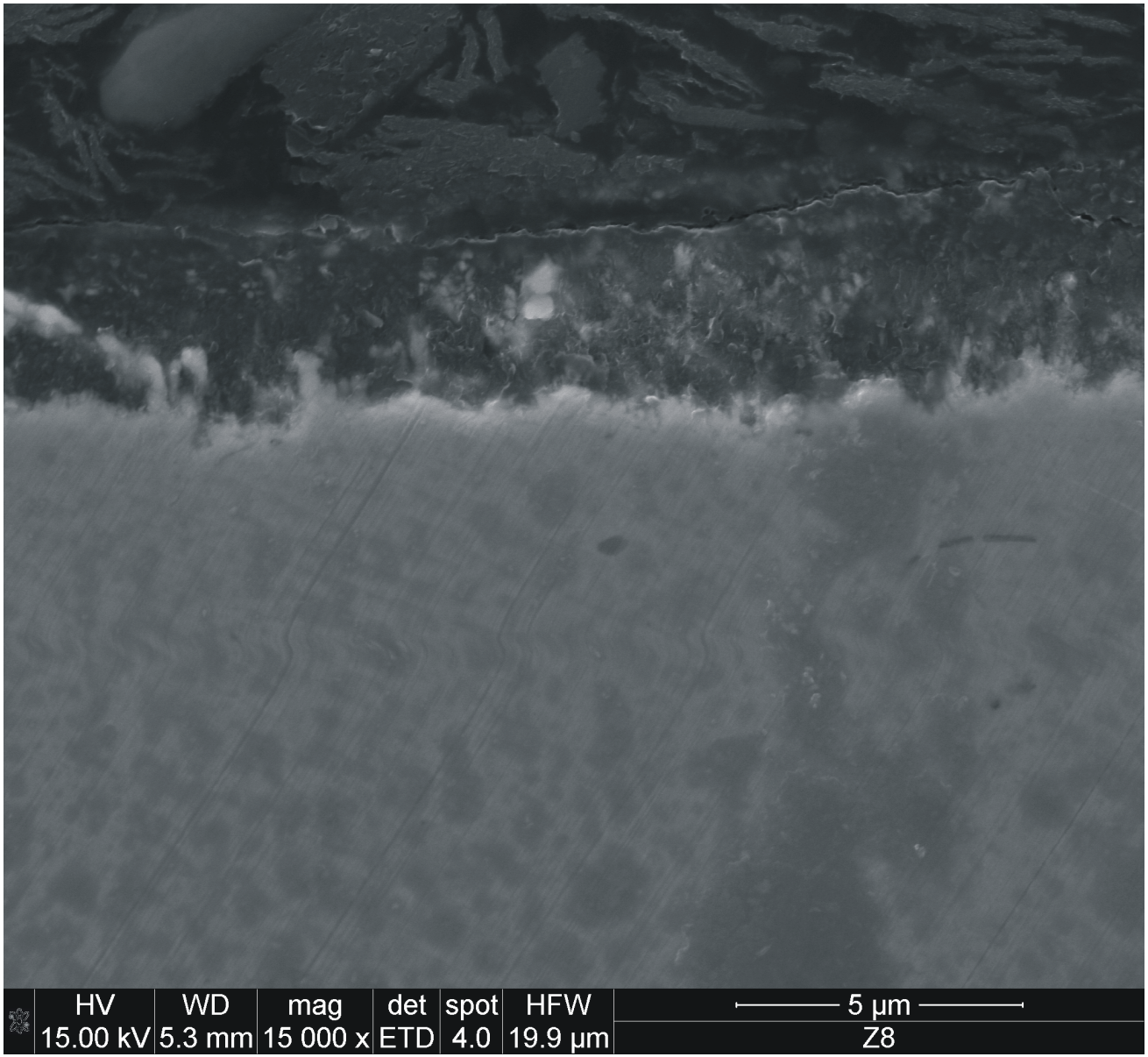


a) i b) 5 min; c) 15 min; d) 60 min; e) 90 min; f) 180 min

Forms of carbon steel corrosion products obtained at 1073 K in a propane-butane atmosphere



Cross-section of a carbon steel sample after *metal dusting* corrosion



SUMMARY

In spite of several years of investigations on *metal dusting* corrosion, a rational foundation for limiting this form of high-temperature corrosion has not yet been developed. Therefore, it is necessary to carry out further studies in order to gain control over this undesired phenomenon.

THE END