Susceptibility of CuOFP to stress corrosion cracking in sulphide containing environments (SUCCESS)

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The research questions set forth in the SUCCESS-project were

1. Does Cu-OFP passivate sufficiently in sulphide containing environments to allow SCC to take place?
2. Is the passivation rate of fresh Cu-OFP surface in sulphide containing environments in such a range that SCC can occur?
3. Does hydrogen enter Cu-OFP to a detectable degree during exposure to sulphide containing environment and induce SCC?

Answer to research questions 1 and 2

(Does Cu-OFP passivate sufficiently in sulphide containing environments to allow SCC to take place? Is the passivation rate of fresh Cu-OFP surface in sulphide containing environments in such a range that SCC can occur?)

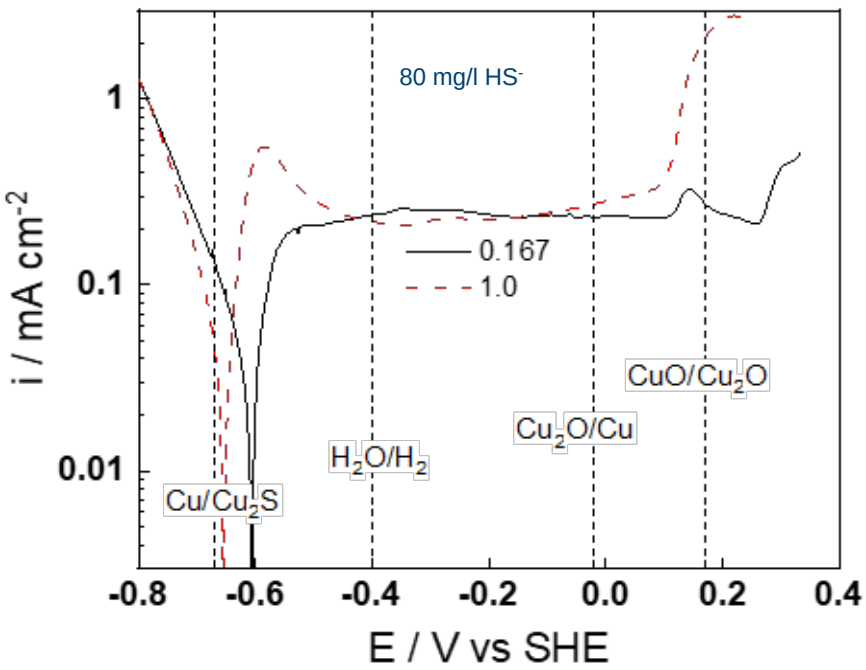
Journal paper proposed for publication in Corrosion Science:

"Effect of sulfide on de-passivation and re-passivation of copper in borate buffer solution", Martin Bojinov, Tiina Ikäläinen, Zaiqing Que, Timo Saario

Abstract – "The interaction of copper with sulfide-containing borate buffer solution either via direct immersion or by de-passivation following oxide film formation, is studied by electrochemical techniques (voltammetry, chrono-amperometry and electrochemical impedance spectroscopy, EIS) complemented with surface and cross-sectional microscopic observations and energy dispersive spectroscopic analyses. Both experimental findings and quantitative interpretation of EIS data using newly developed and previously published kinetic models indicate that no continuous adherent barrier-type layer is formed on Cu in sulfide solutions, thus **precluding the possibility of the development of localized corrosion modes**."

Sulphide (in concentrations from 20 to 80 mg/l) does not cause SCC in Cu-OFP base material.

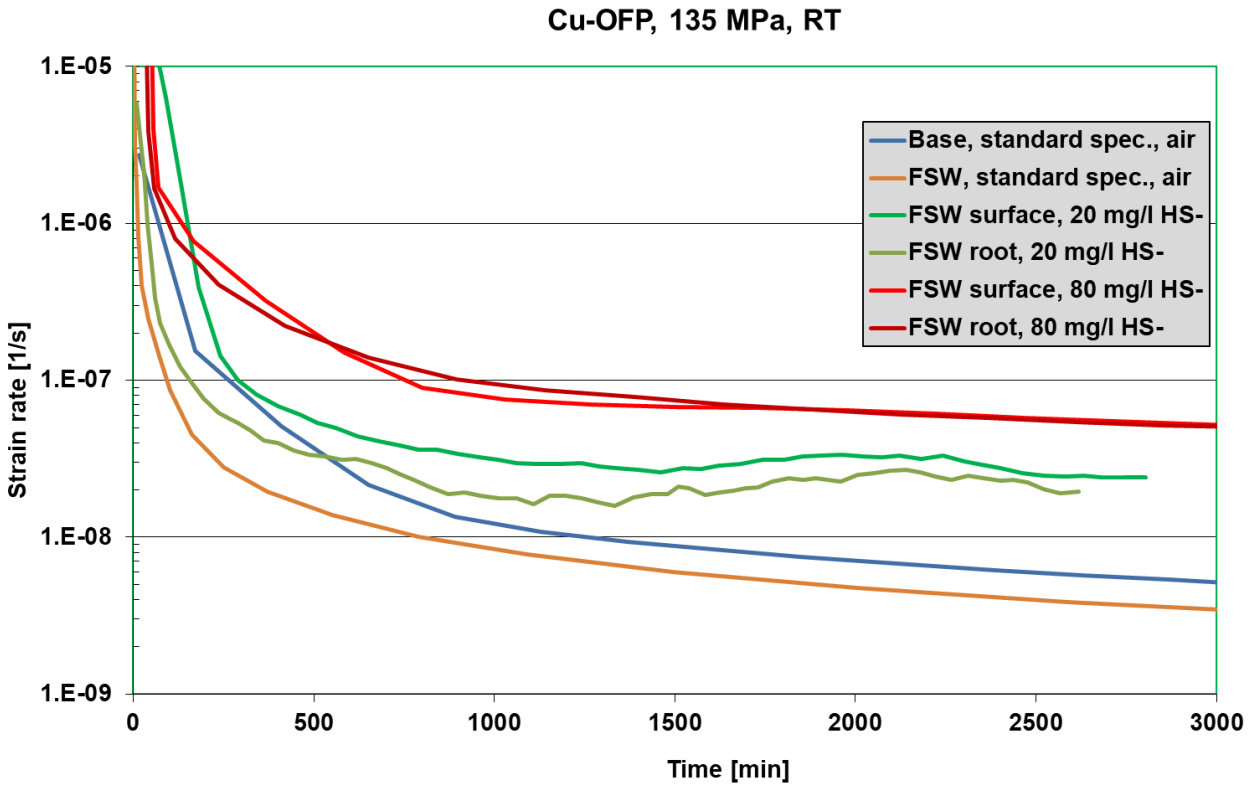
Current-voltage curves (general corrosion rate)



- Effect of sulphides
  - Very high current density (=corrosion rate > 1 mm/y)
  - High corrosion rate = Low level of passivity, i.e. inability of localised corrosion (i.e. SCC)
  - Results confirmed also by two other electrochemical methods as well as microscopy (SEM).

Answer to research question 3 – part 1

(Does hydrogen enter Cu-OFP to a detectable degree during exposure to sulphide containing environment and induce SCC?)



Creep tests of FSW Cu-OFP in a buffer solution of pH = 8 at 25ºC.

- the creep rate in water with sulphide is considerably higher than that of base material tested in air, water or water with sulphide or that of FSW Cu-OFP tested in air
- the creep rate of FSW increases as a function of sulphide concentration

VTT-R-00924-22, “Hydrogen analyses of FSW Cu-OFP tested under creep conditions in sulphide containing environment”, T. Ikäläinen et al.

Answer to research question 3 – part 2

(Does hydrogen enter Cu-OFP to a detectable degree during exposure to sulphide containing environment and induce SCC?)

Total hydrogen concentration measured with HME-MS		
Test number	**[HS^-] / mg/l**	**Hydrogen / C_H, wppm**
Creep test 3, 240 hrs	**80**	**1.53 to 3.30**
Creep test 4, 240 hrs	**80**	**2.20 to 3.42**
Reference	**0**	**5.28**

Conclusions:

1. The hydrogen content in FSW Cu-OFP is about ten times higher than that in the base material

2. **Sulphide exposure for 240 hrs does not increase the hydrogen concentration in FSW Cu-OFP**, quite the opposite, it decreases two about half of that in the reference sample.

VTT-R-00924-22, “Hydrogen analyses of FSW Cu-OFP tested under creep conditions in sulphide containing environment”, T. Ikäläinen et al.

Conclusions

- Corrosion tests of Cu-OFP base material indicate poor passivity in presence of 10 to 100 mg/l HS^-. Since good passivity is a pre-requisite for localised corrosion (e.g. pitting and SCC), the poor passivity found in this work indicates that sulphides are unable to initiate SCC in Cu-OFP.

- Sulphide exposure (20 to 80 mg/l HS^-) does not increase the hydrogen concentration in FSW Cu-OFP. Instead, a decrease in hydrogen concentration to about half of that of the reference sample was found.

- Sulphide exposure was found to increase the creep rate of FSW Cu-OFP, the more the higher the sulphide concentration.

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