CORROSION BEHAVIOR OF STAINLESS STEEL IN OXIDE FUEL CELL SIMULATED GASEOUS ENVIRONMENTS

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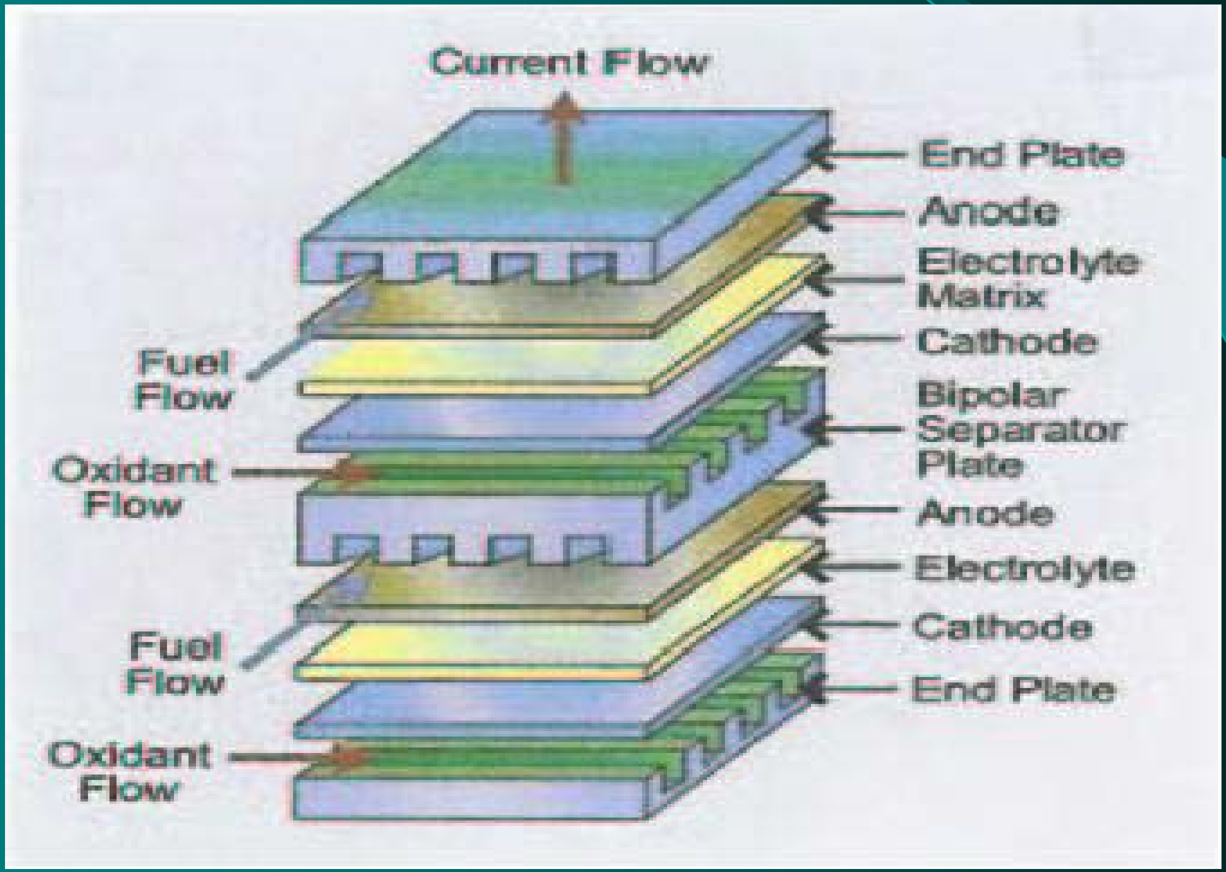
Scheme of Planar Solid Oxide Fuel Cell (SOFC) Stack



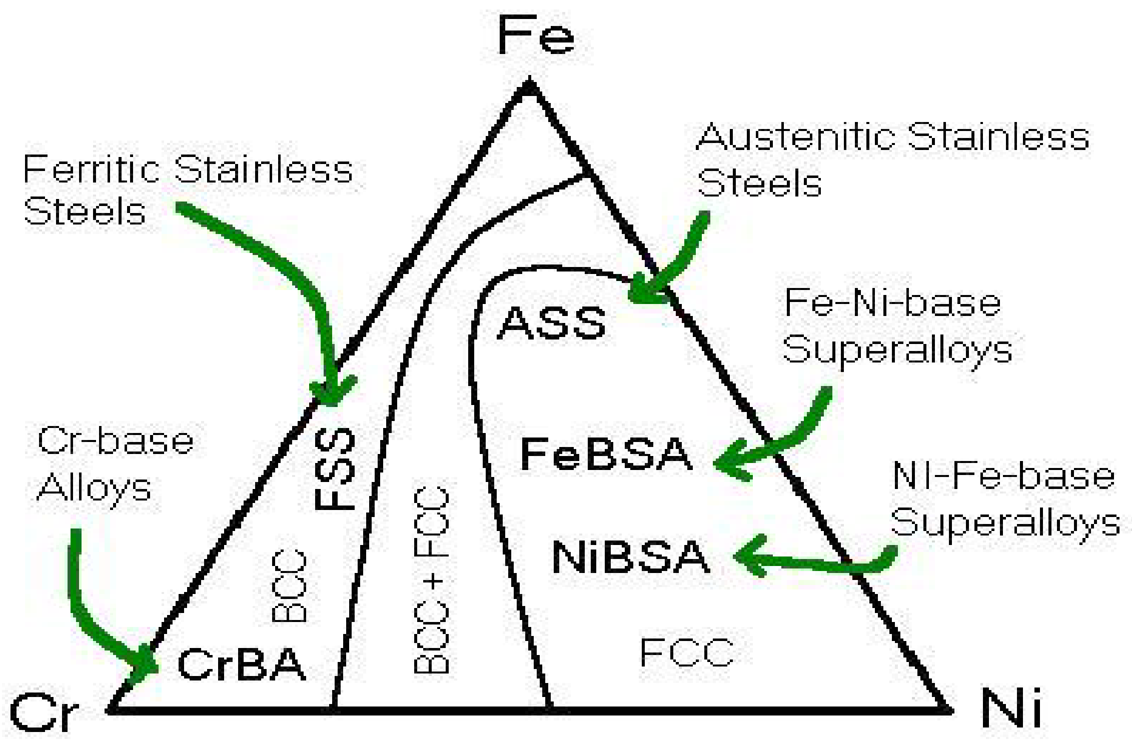
Reactions in SOFC

- **Electrochemical reactions :**
  - **Cathode:** $\frac{1}{2} O_2 + 2e^- = O^{2-}$
  - **Anode:** $H_2 + O^{2-} = H_2O + 2e^-$
  - **Cell:** $H_2 + \frac{1}{2} O_2 = H_2O$
- **Steam Reforming:**
  - $CH_4 + H_2O = CO + 3 H_2$
- **Shift Reaction:**
  - $CO + H_2O = CO_2 + H_2$

SOFC Stack Material Costs at 0.6 W/cm^2 for 5 kW module

SOFC Component	Material Cost for Current SOFC	Material Cost for Lower Temp SOFC
Electrode stack	$22.60/kW	$22.60/kW
Interconnects	$206.25/kW	$10.00/kW
Total	$228.85/kW	$32.60/kW

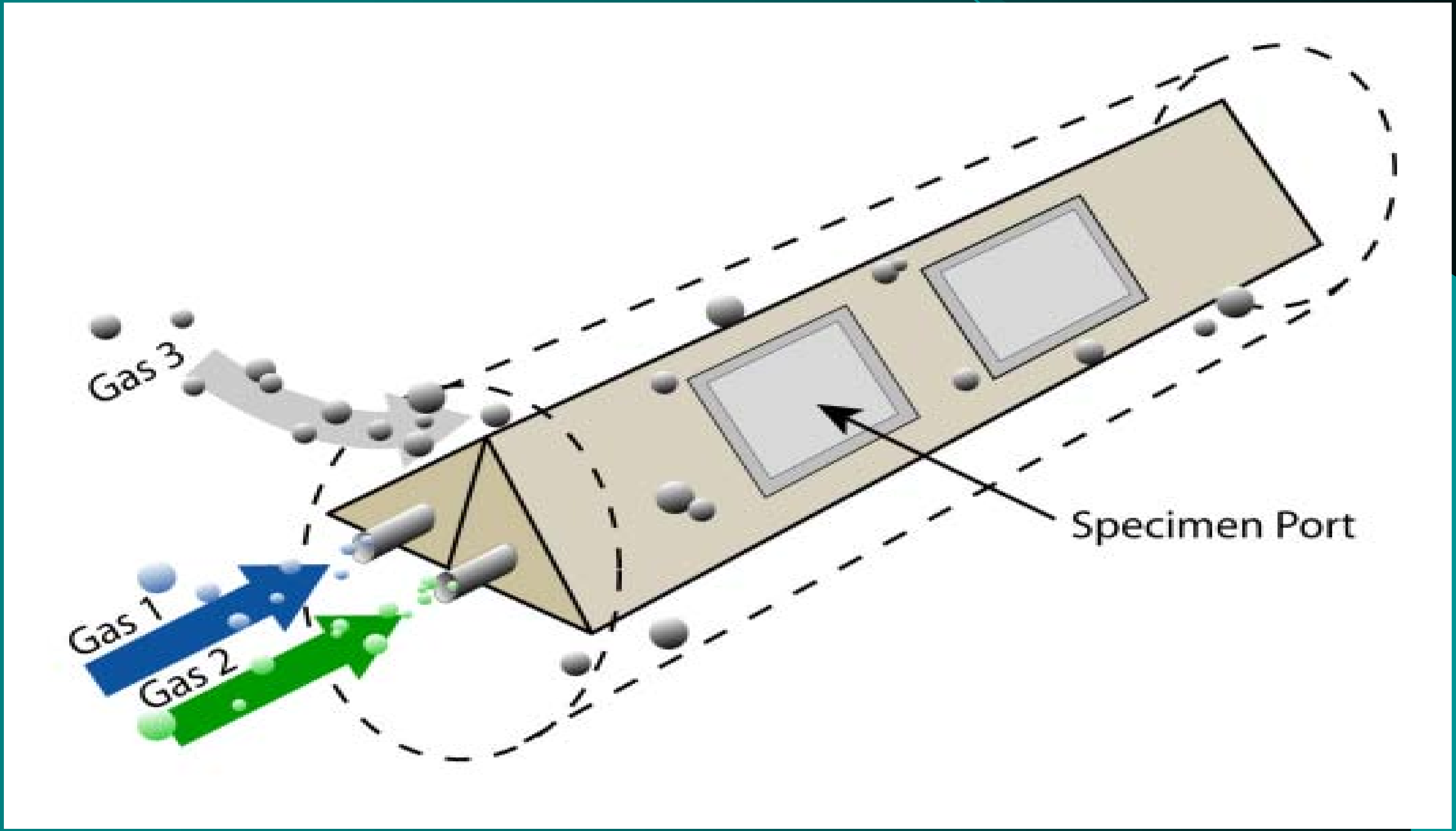
Schematic Alloy Design for SOFC Applications



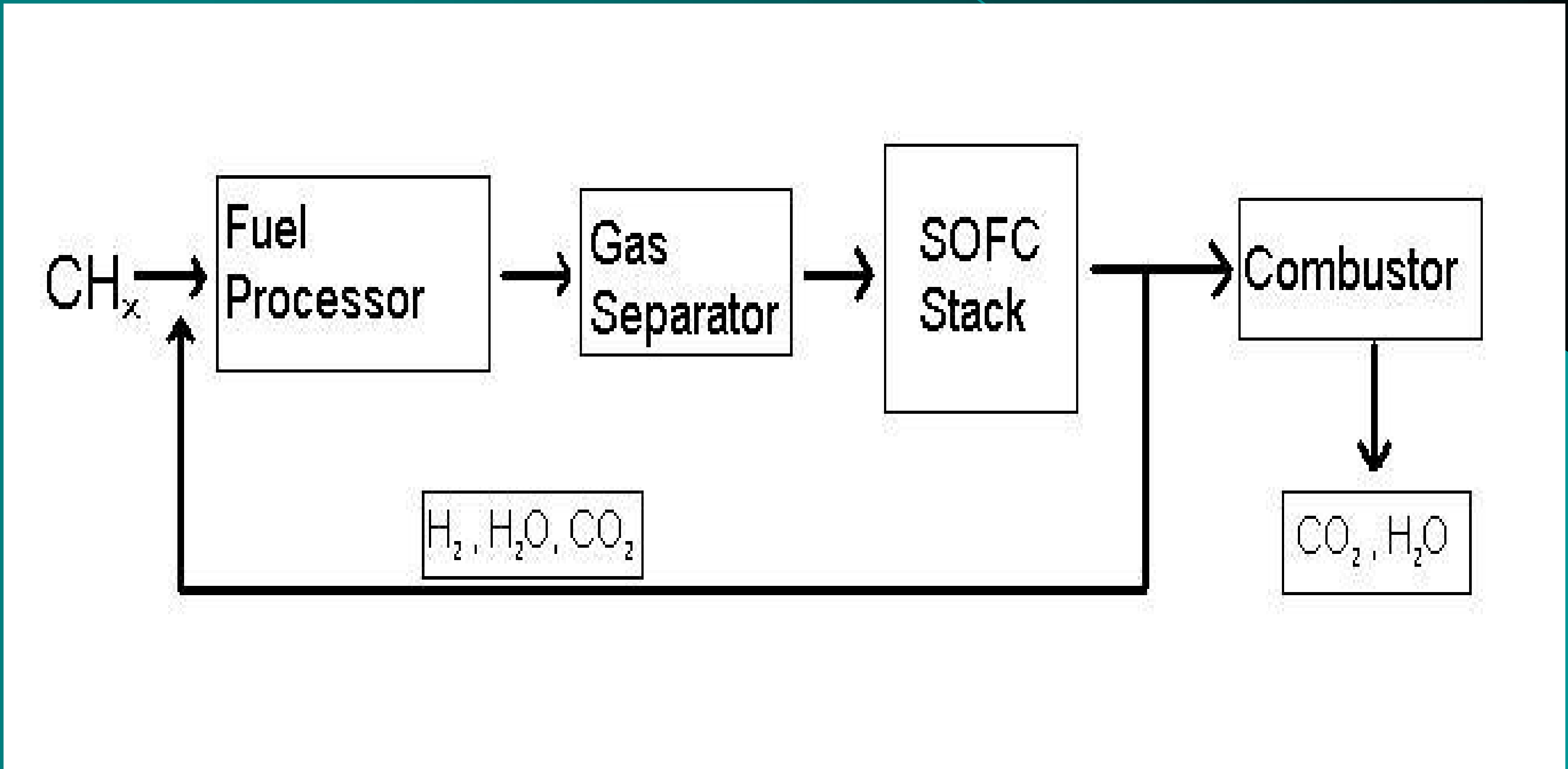
Adopted from Z.G. Yang, K.S. Weil, D.M. Paxton, and J.W. Stevenson. 2002 Fuel Cell Seminar p. 552

Laboratory Setup for Performing Experiments in Simulated Environments Using Tubular Specimens

Laboratory Setup for Performing Experiments in Simulated Environments Using Flat Specimens



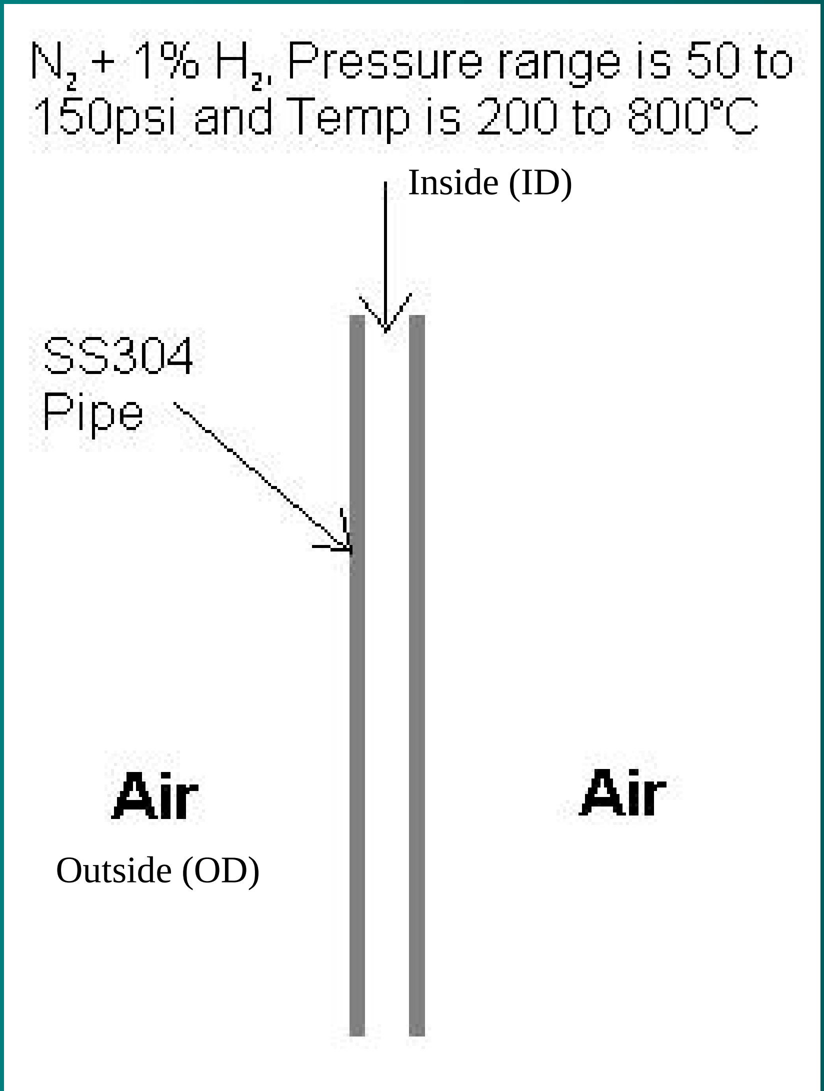
Example of SOFC Power Generation System



Functional Requirements

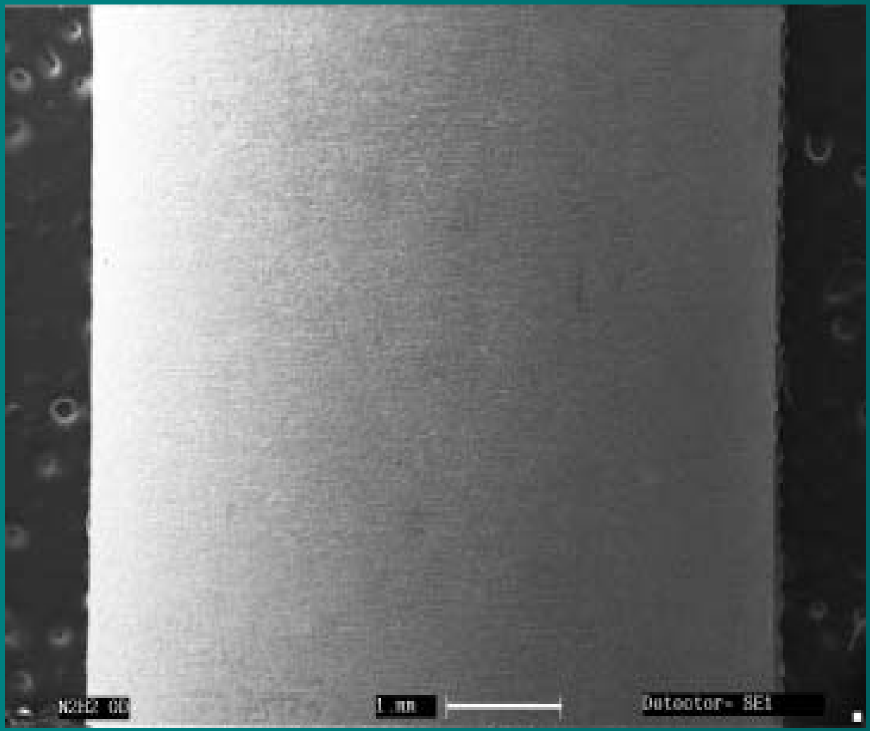
- Long Term Chemical Stability
  - **High-Temperature Corrosion / Oxidation Resistance**
  - **Compatibility with Cell Components**
- Electrical Performance Stability
  - **Formation of Conductive Scale**
  - **Oxide Stability**
- Mechanical / Structural Stability
  - **Thermal Expansion Coefficient Match**
  - **Weld / Joint Stability**

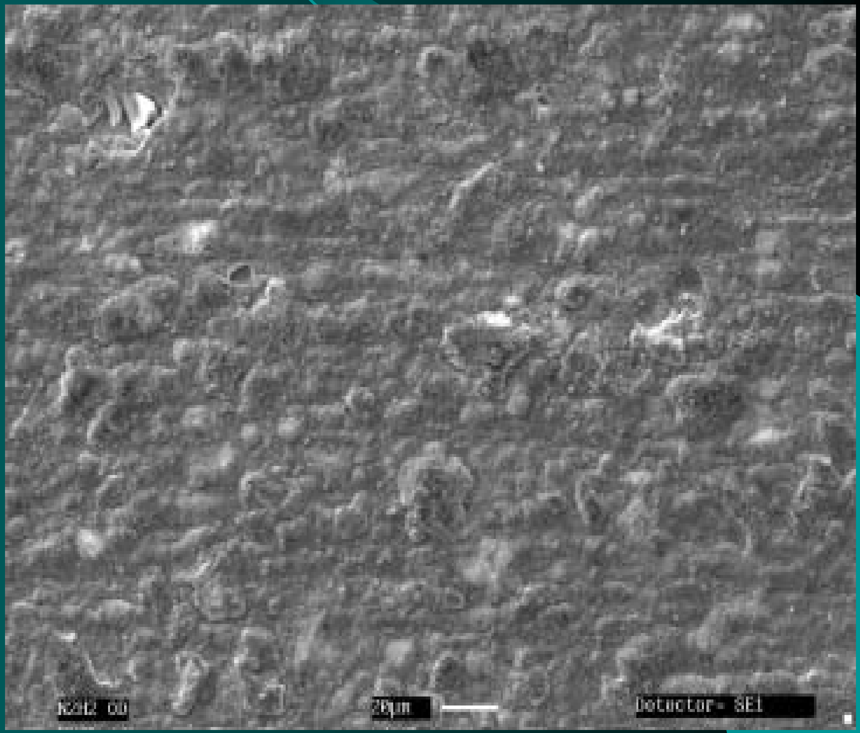
Experimental Conditions



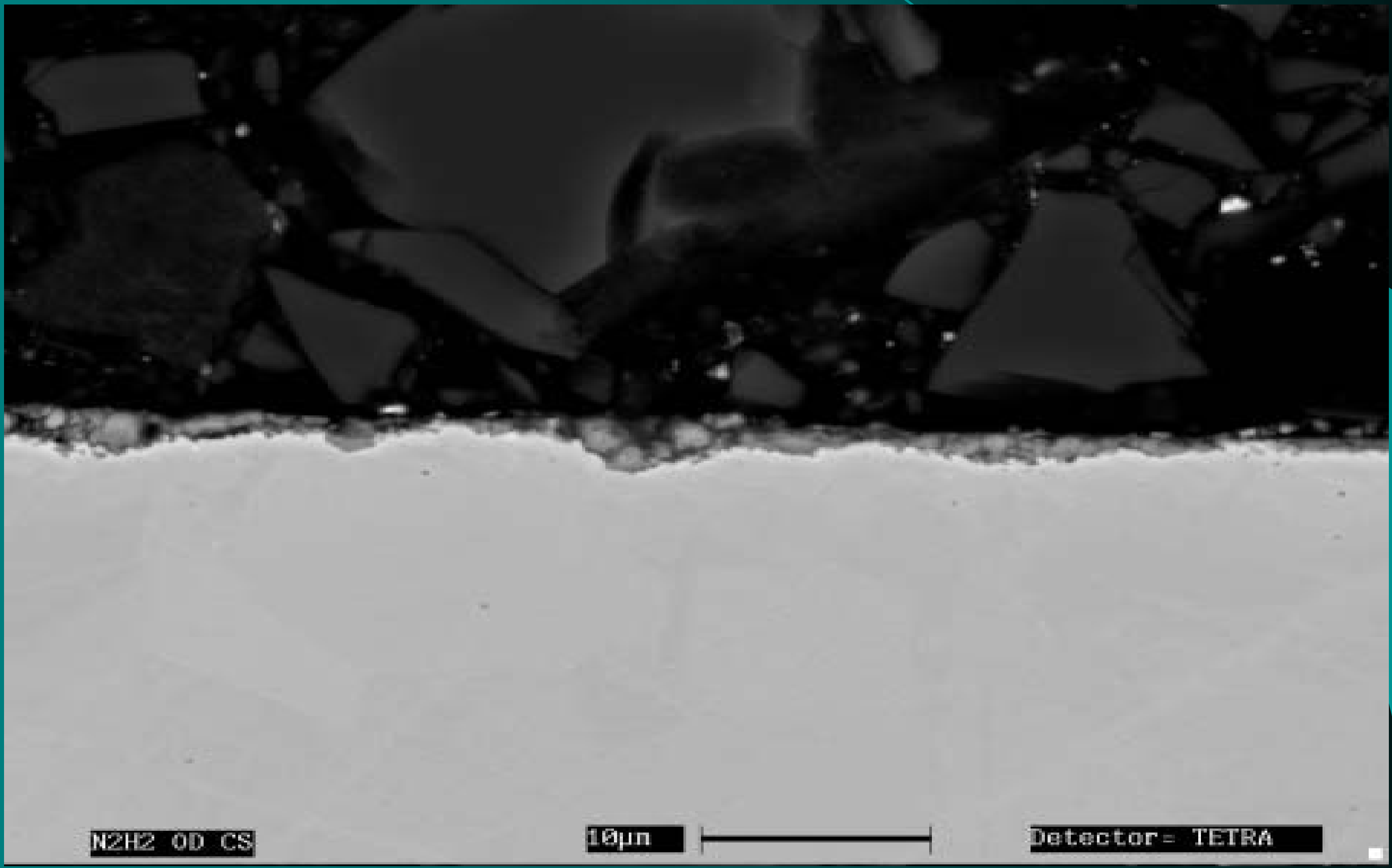
Cyclic heating and pressurization to a maximum of 800ºC and 150psi over a period of one year

SEM Micrographs of Longitudinal Outer Surface of Tube (Air)

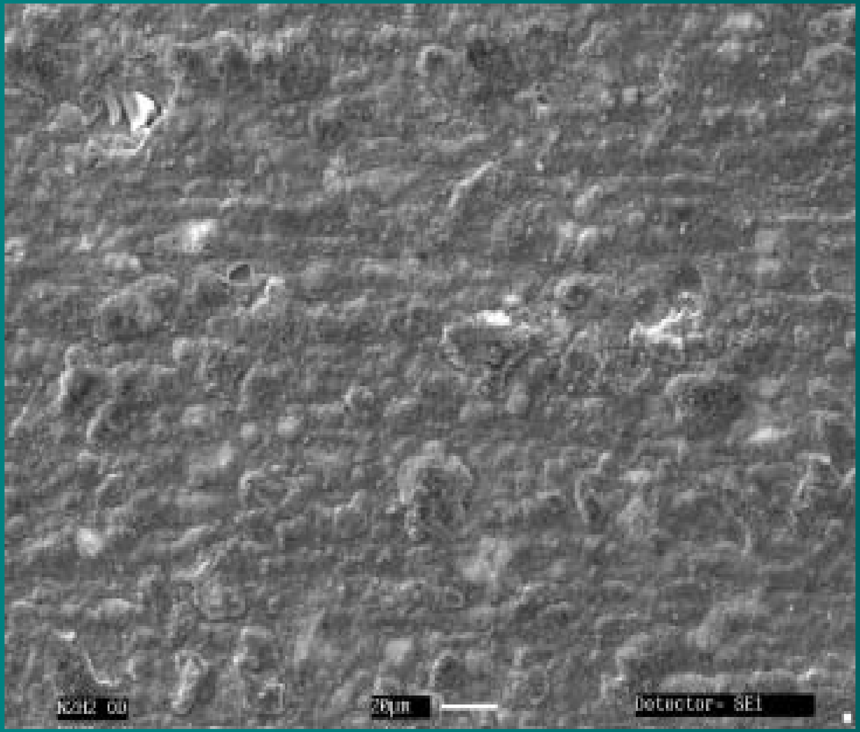


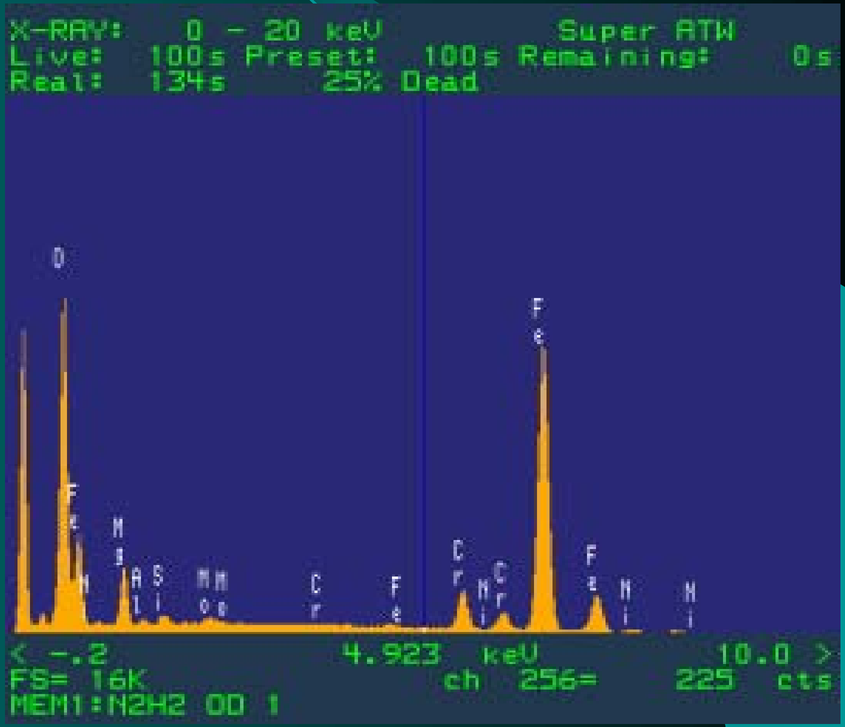


SEM Micrographs of Cross-section of Outer Surface of Tube (Air)

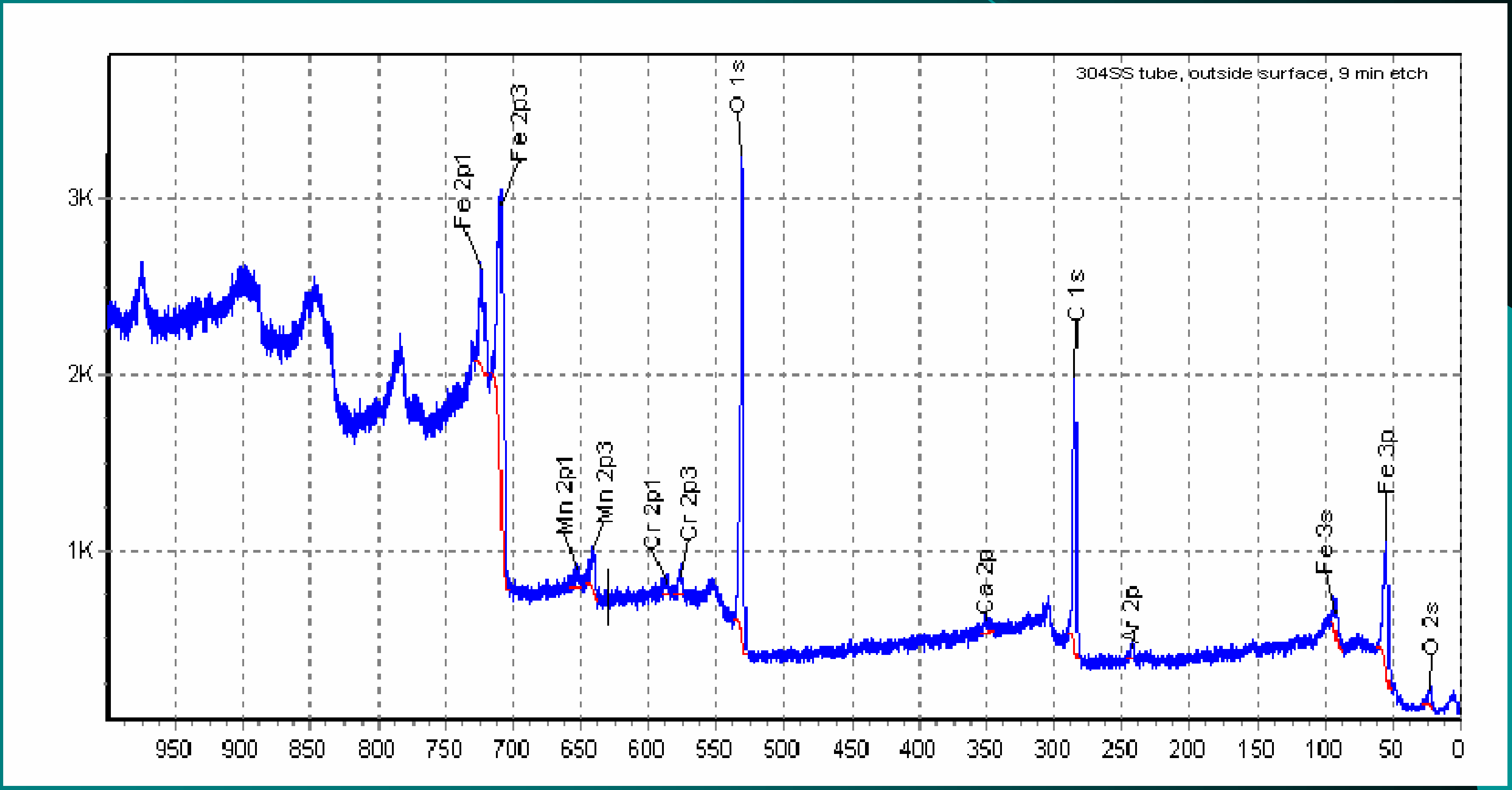


EDX Analysis of Longitudinal Outer Surface of Tube (Air)

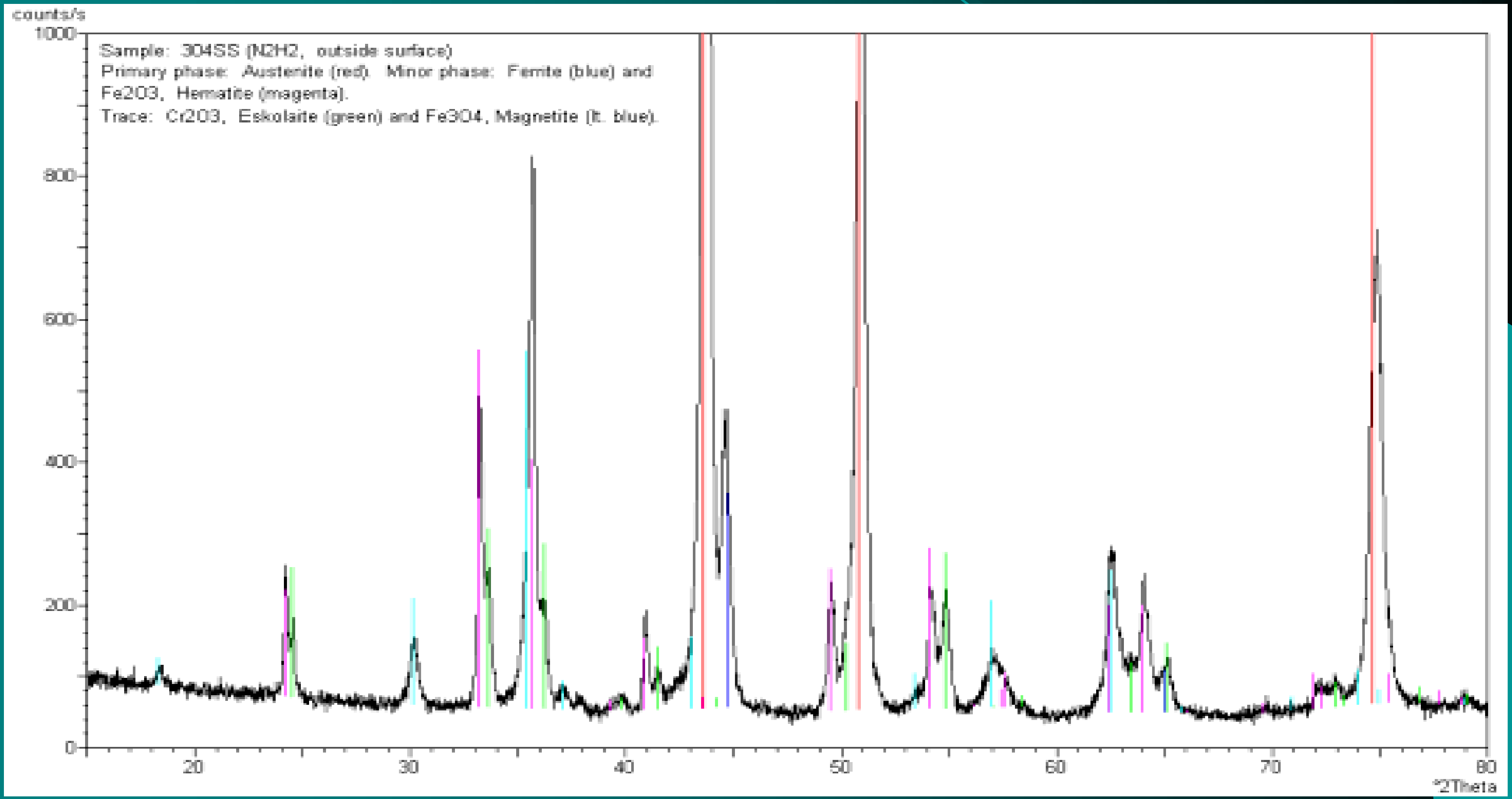




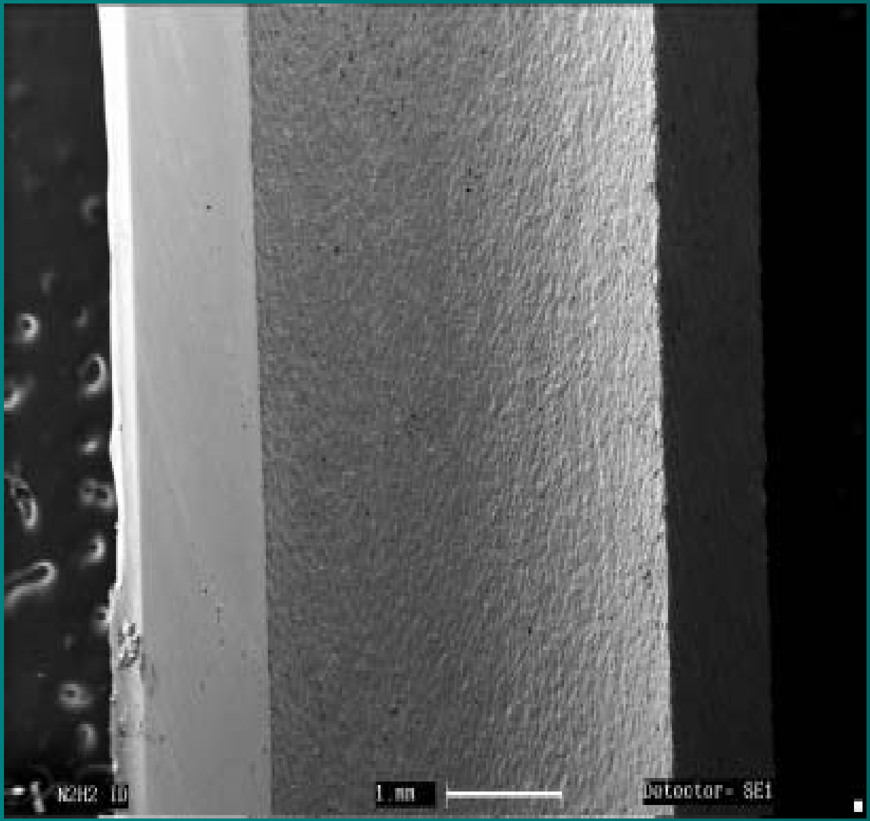
XPS Analysis of Longitudinal Outer Surface of Tube (Air)

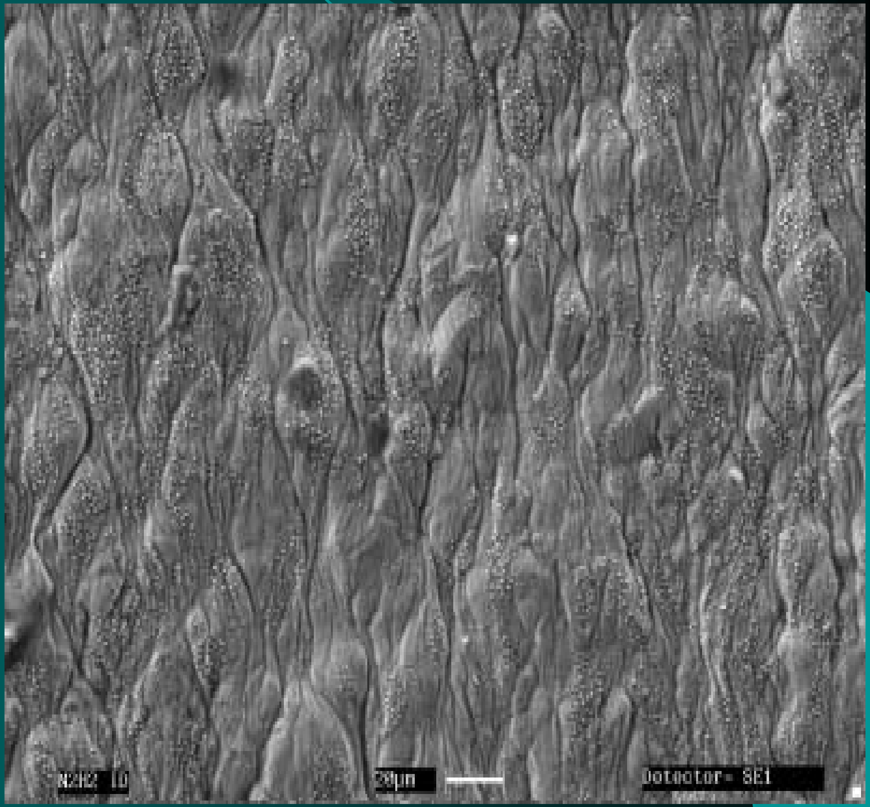


XRD Analysis of Longitudinal Outer Surface of Tube (Air)

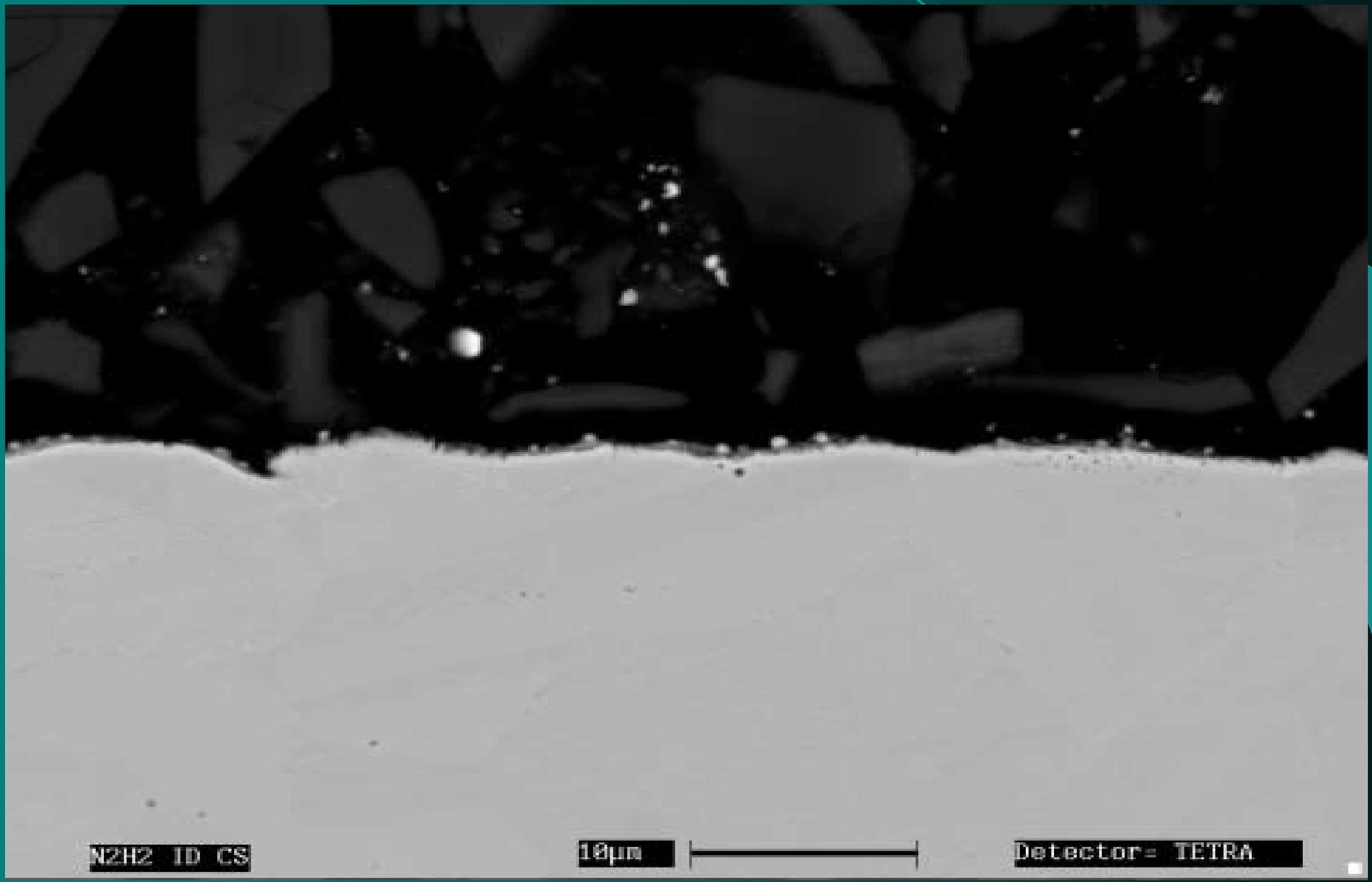


SEM Micrographs of Longitudinal Inner Surface of Tube (N_2 + 1% H_2)

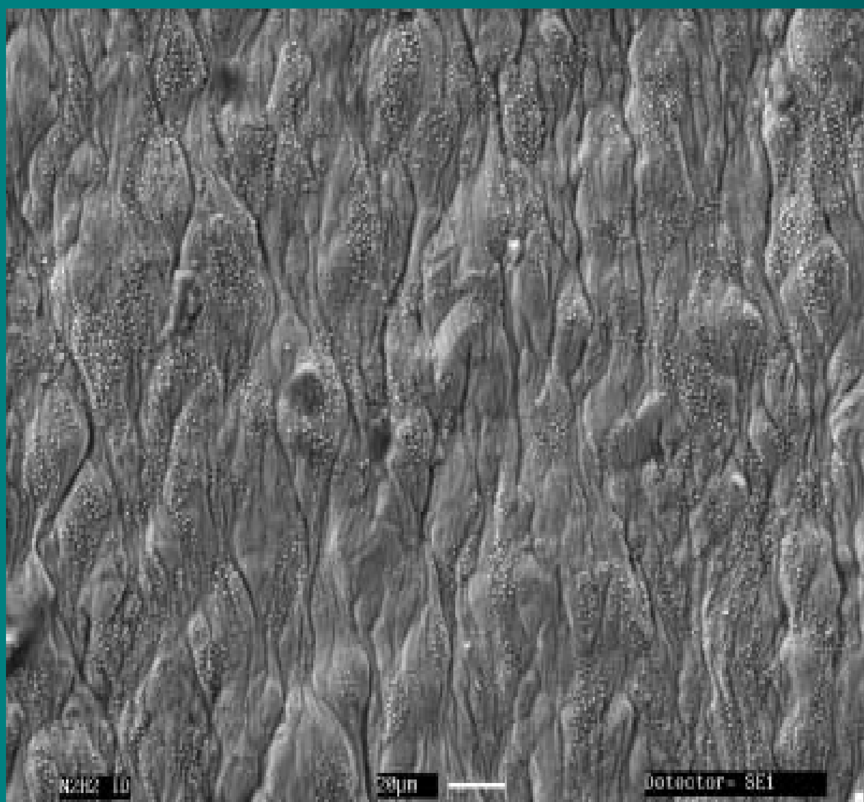


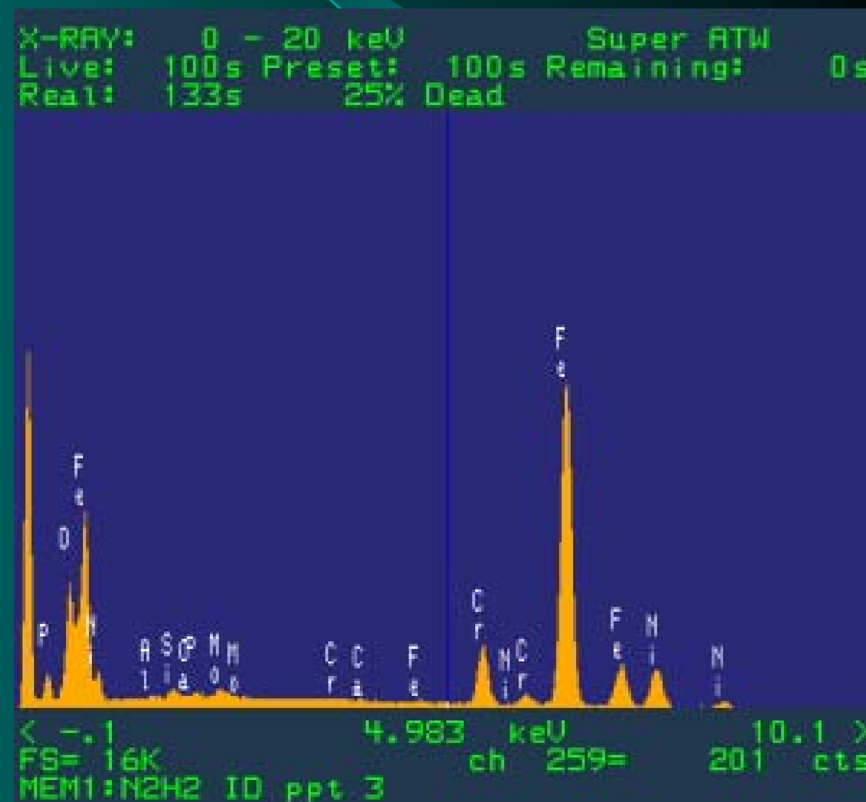


SEM Micrographs of Longitudinal Inner Surface of Tube (N_2 + 1% H_2)



EDX Analysis of Longitudinal Inner Surface of Tube (N_2 + 1% H_2)





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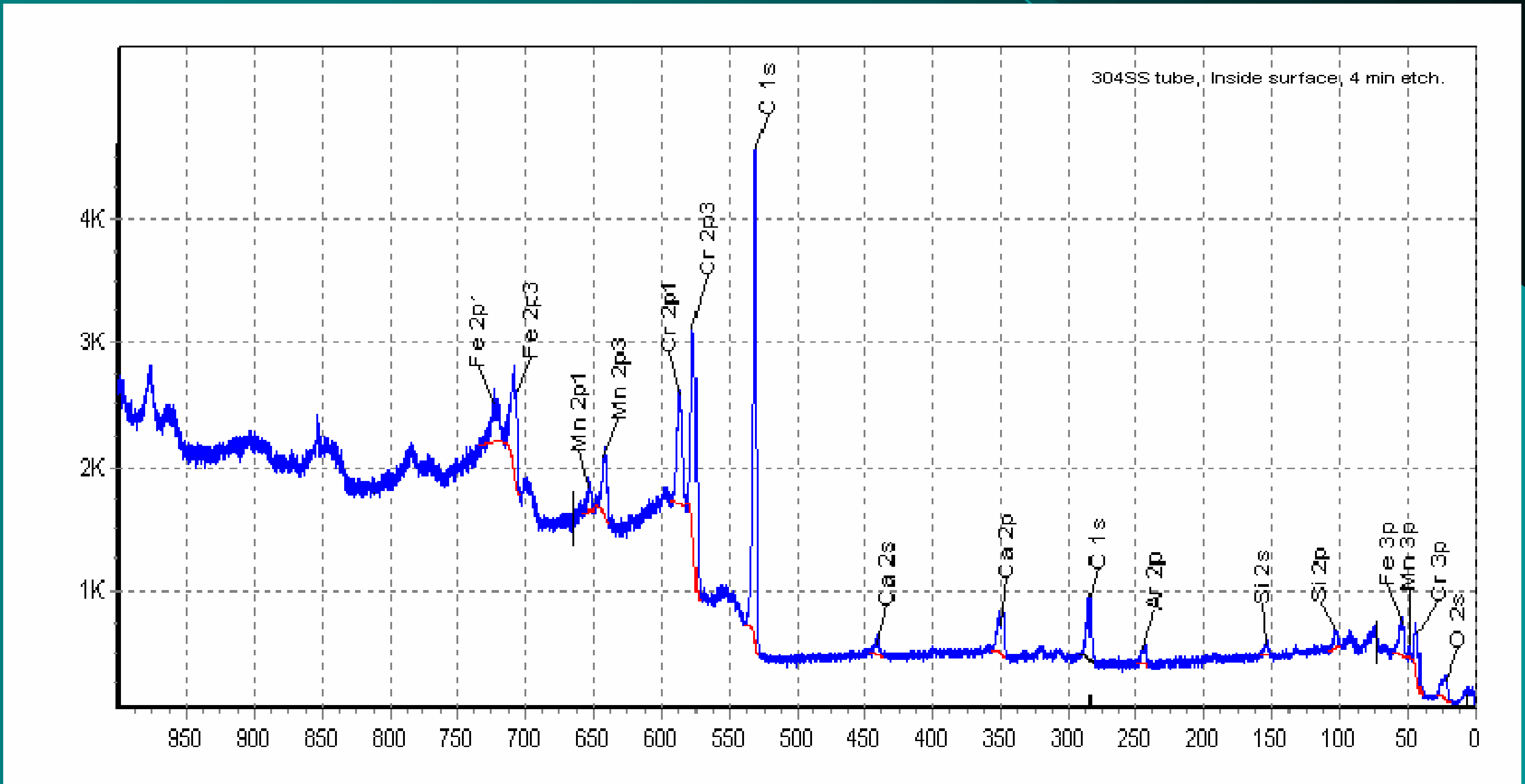
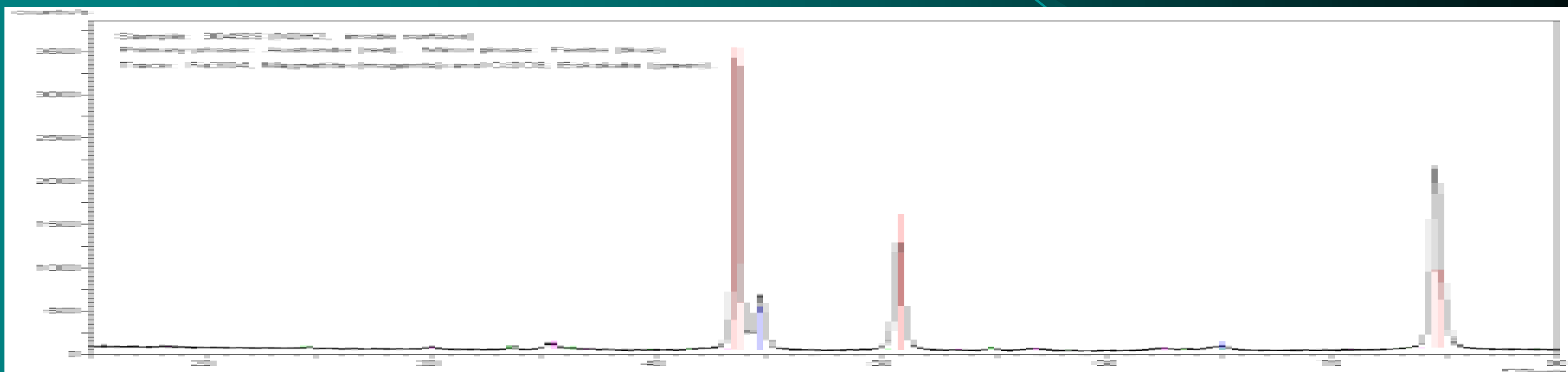
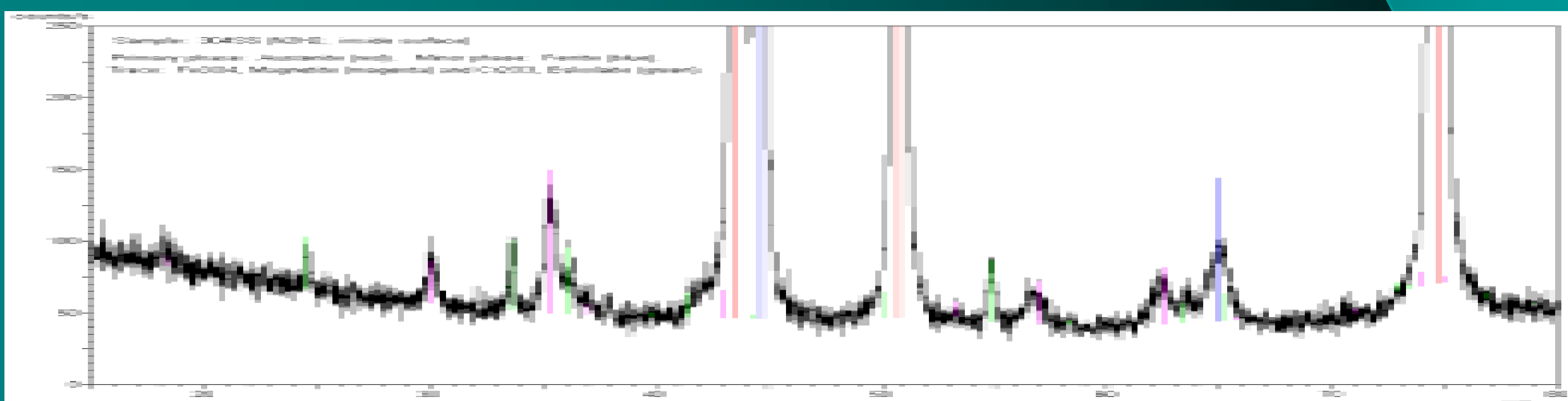
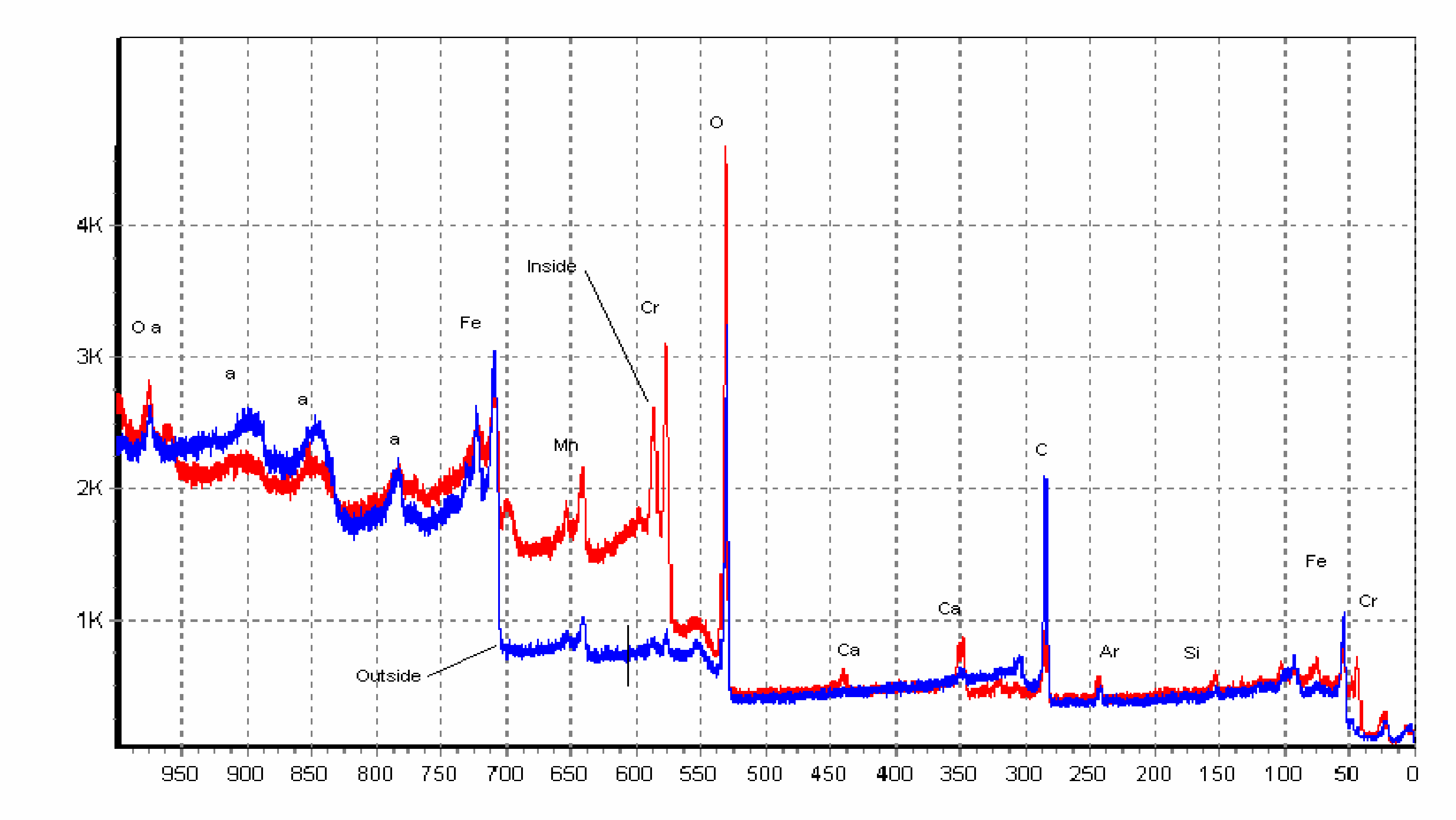


XRD Analysis of Longitudinal Inner Surface of Tube (N_2 + 1% H_2)





Comparison of XPS Spectra for Inner and Outer Surface



Conclusions

- SEM surface analysis indicates uniform formation of scales in air and N_2 + 1% H_2 mixture
- XRD results show the presence of the following crystalline oxides on both sides: Fe_3O_4 and Cr_2O_3. Fe_2O_3 was found on the outer surface.

Conclusions (Cont.)

- Fe_3O_4 and Cr_2O_3 were the predominant oxides formed on the inner surface; Fe_2O_3 with traces of Cr_2O_3 and Fe_3O_4 were the oxides formed on the outer surface.
- XPS results show the presence of Cr on the inner surface, and its significant reduction on the outer surface. This may indicate Cr evaporation from the outer surface.

Conclusions (Cont.)

- Oxide scales on the inner surface were formed due to exposure of the material to air during experiment setup.

Acknowledgements

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