swiss mnt network
micro & nanotechnology

EMPA
Materials Science & Technology

Composants de haute précision en acier inox par électrodéposition

Trends in Micro and Nano

Fribourg, 27 juin 2013

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Research Focus Areas (RFA)

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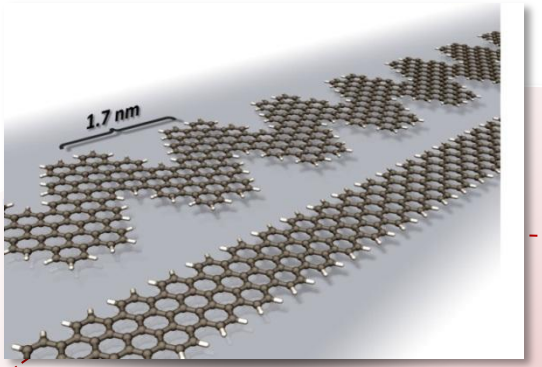

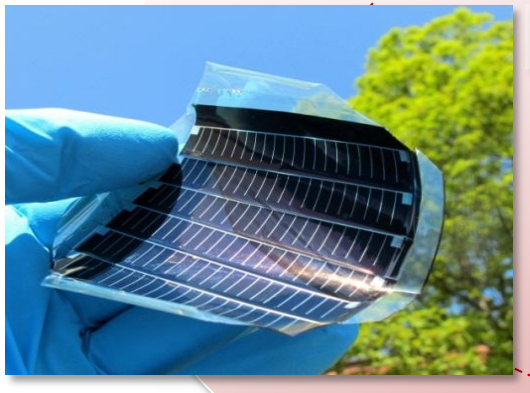

Instruments & Tools

Sustainability
Reliability and Safety

Computational
Simulation & Modelling

Adaptive
Systems

RFA: "Nanostructured Materials"

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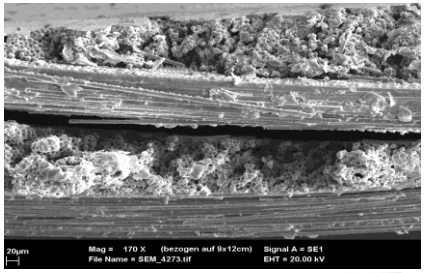
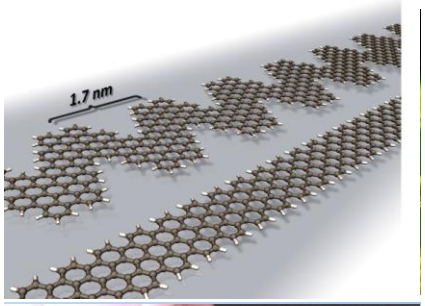
Module 1
Nanoparticles & Nanocomposites

Structural



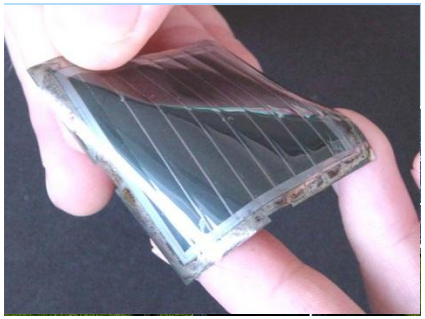
Module 2
Nano-Structured Thin Films

Functional



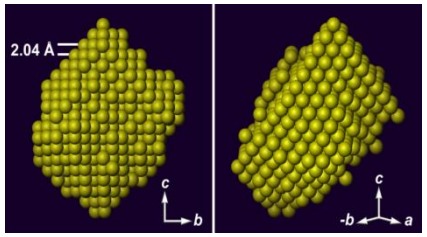
Module 3
Micro- and Nano-Fabrication

Efficient



Module 4
Micro- and Nano-Characterization

Unique



Industrial Partners

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Companies from the
Watch Industry

Electroplating

A well known industrial process for single elements

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Cu, Ag, Au, Ni Pt, Ni, Zn, Sn …. plating

Hard Chrome plating

Stainless steel electroplating – why?

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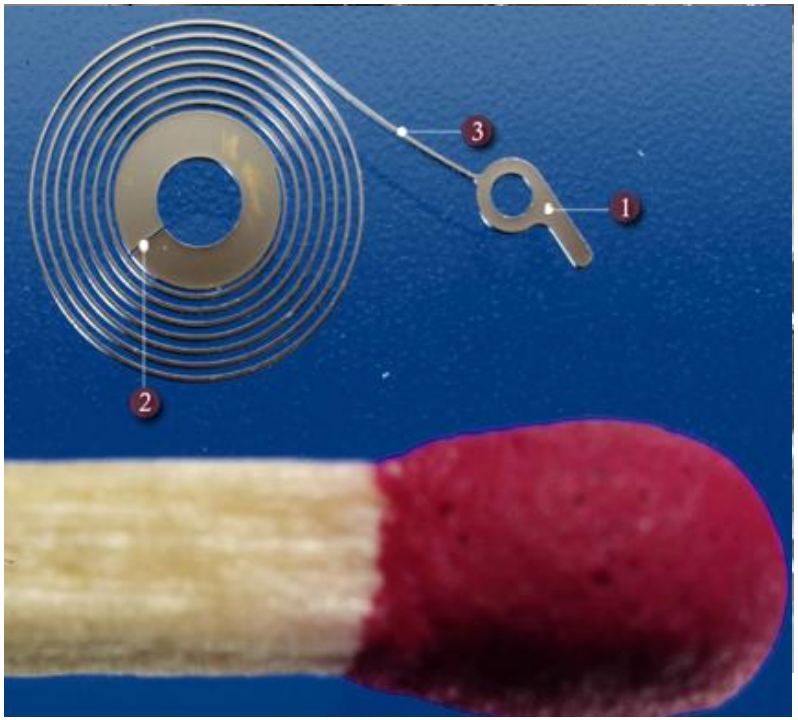
Stainless steels combine good mechanical and excellent anticorrosive properties as no other material or alloy!

Application:

- Micro-components by LIGA



Problem of Hard Chrome:

- Formation of cracks!

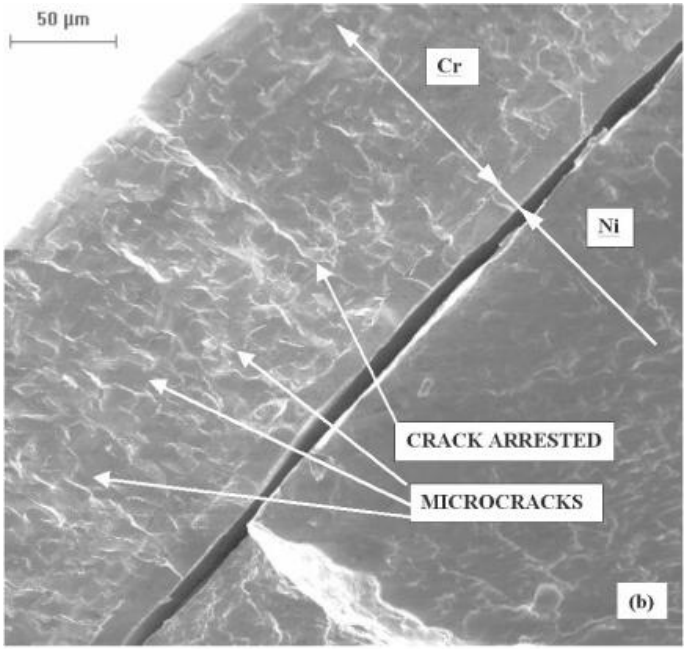


Figure 5b. Fracture surface of accelerated hard chromium (145 µm) over electroless nickel (15 µm) plated specimen submitted to shot peening pre treatment.

MEMS for Mechanical Watches

Escapement Oscillomax™ Patek Philippe

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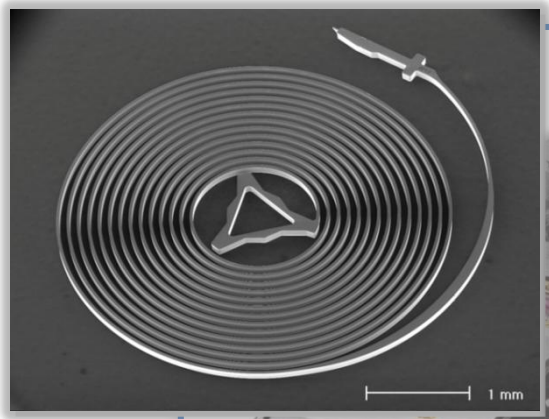

Challenges in Stainless steel electroplating

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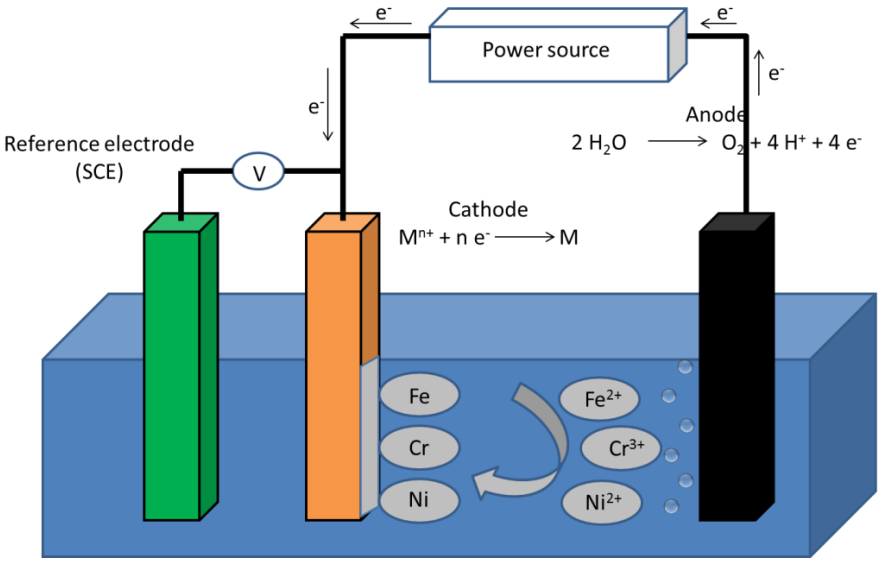
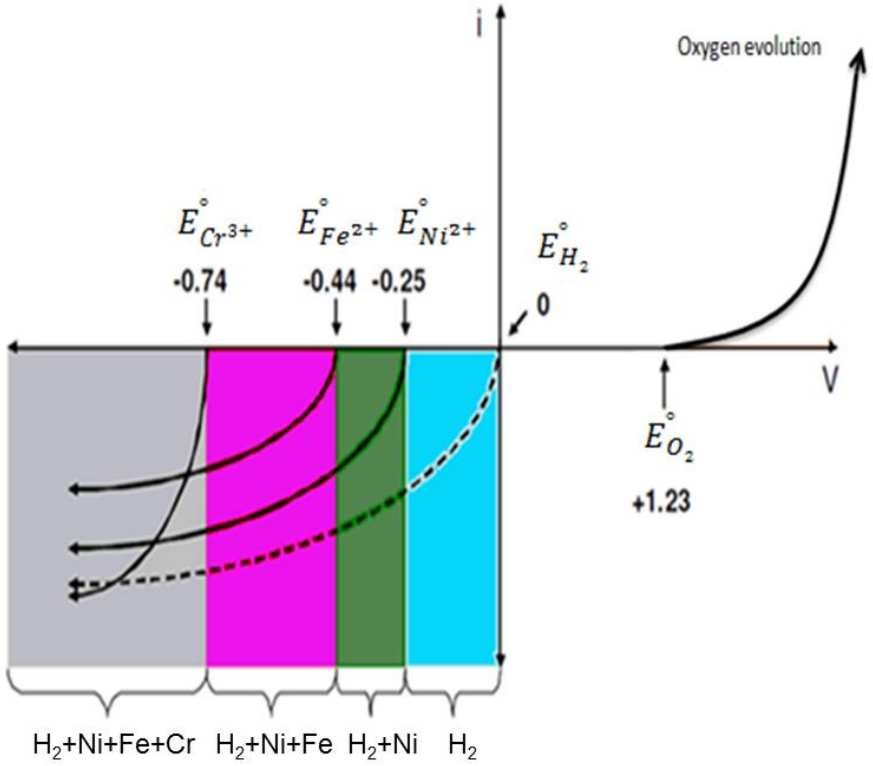


electrolyte composition	quantity (mol/L)
$CrCl_3 \cdot 6H_2O$	0.4
$NiCl_2 \cdot 6H_2O$	0.2
$FeCl_2 \cdot 4H_2O$	0.03
NH_4Cl	0.5
NaCl	0.5
H_3BO_3	0.15



The three major alloy elements (Fe, Ni, Cr) have very different electrochemical properties

Electroplating of stainless steel (Fe-Cr-Ni)

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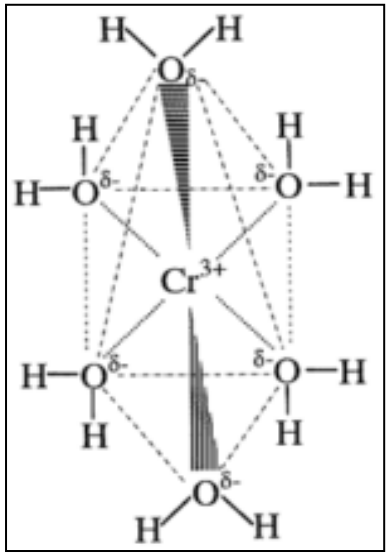
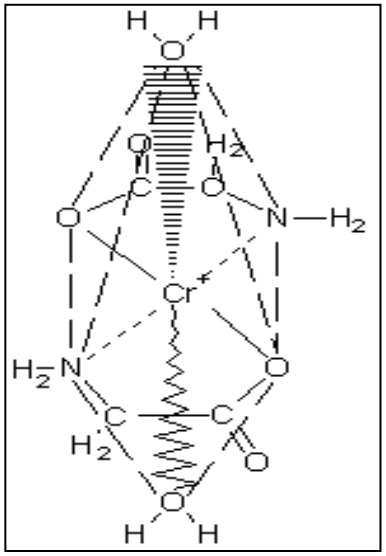
Chromium deposition:

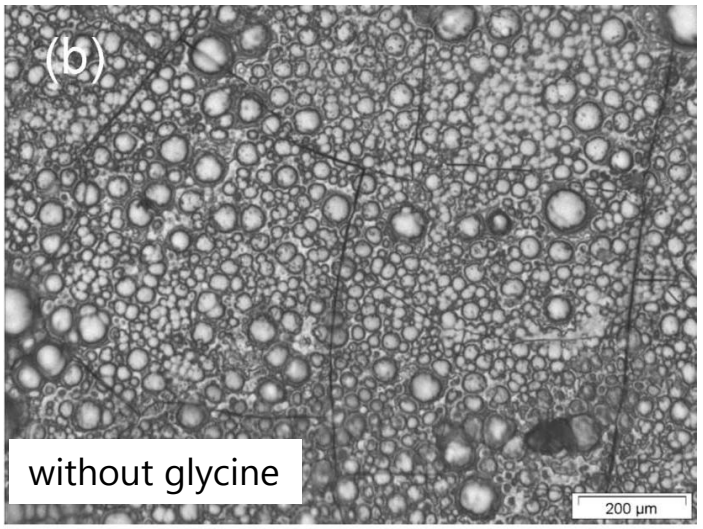
- $Cr^{3+} + 1e^- \rightarrow Cr^{2+}$ E°= -0.407 V/ESH
- $Cr^{3+} + 3e^- \rightarrow Cr$ E°= -0.744 V/ESH
- $Cr^{2+} + 2e^- \rightarrow Cr$ E°= -0.913 V/ESH



water complex



glycine complex



Production of Micro-Parts by LIGA

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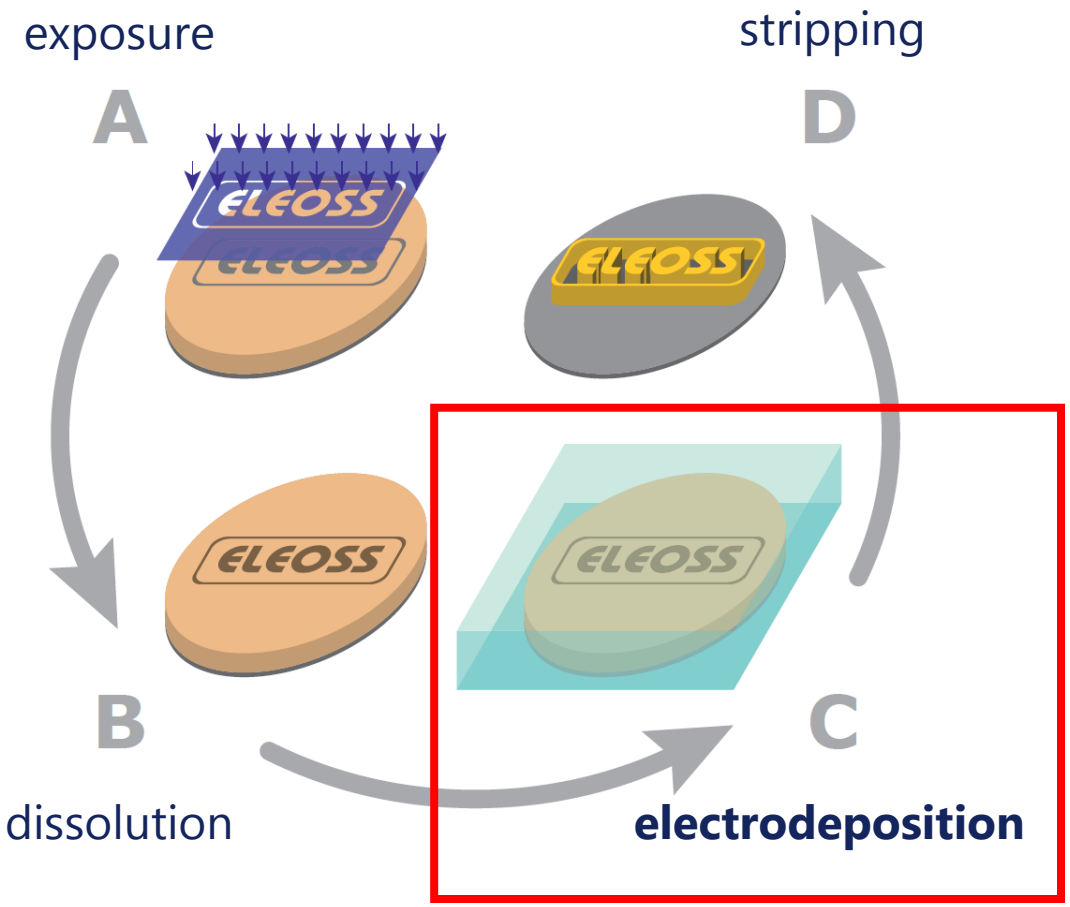
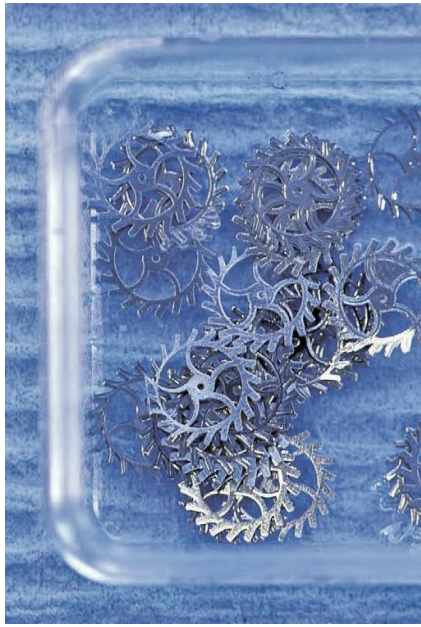
LIGA: Lithographie, Galvanik und Abformung





Composition of the Fe-Cr-Ni Plating

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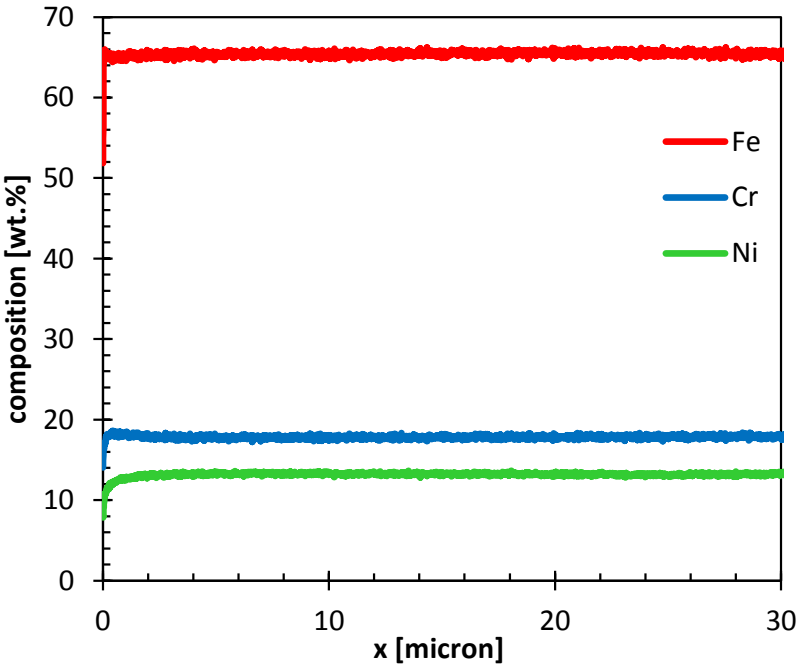
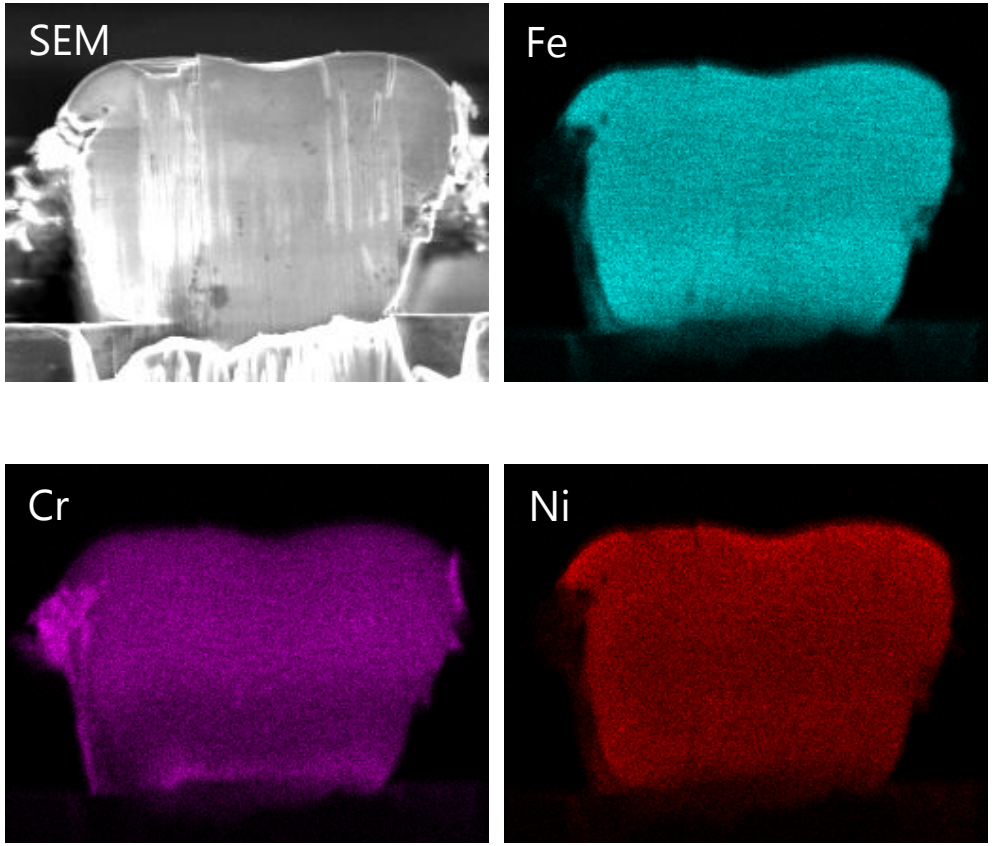
Chemical Analysis
by
Glow Discharge Optical Emission Spectroscopy (GDOES)



Focused Ion Beam (FIB) Analysis



mapping size: 180 x 230 µm

Microstructure of the Fe-Cr-Ni Plating

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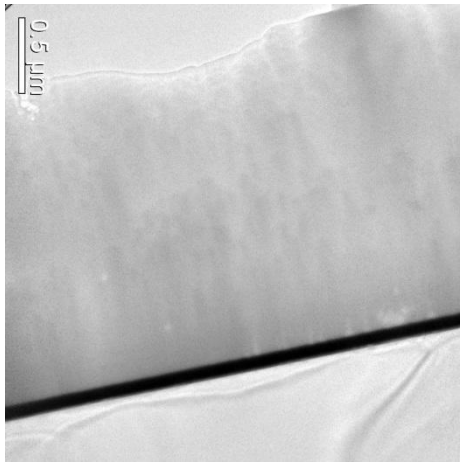
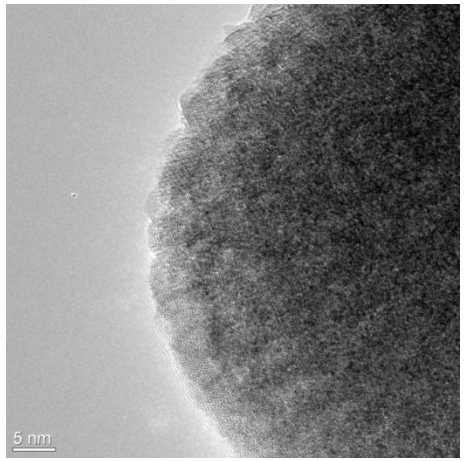
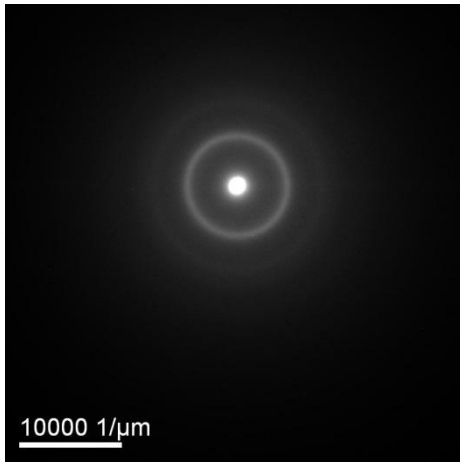
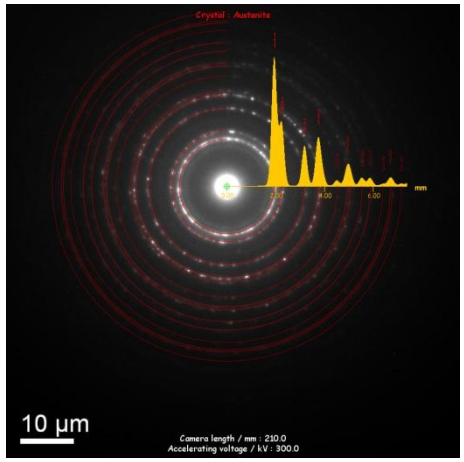


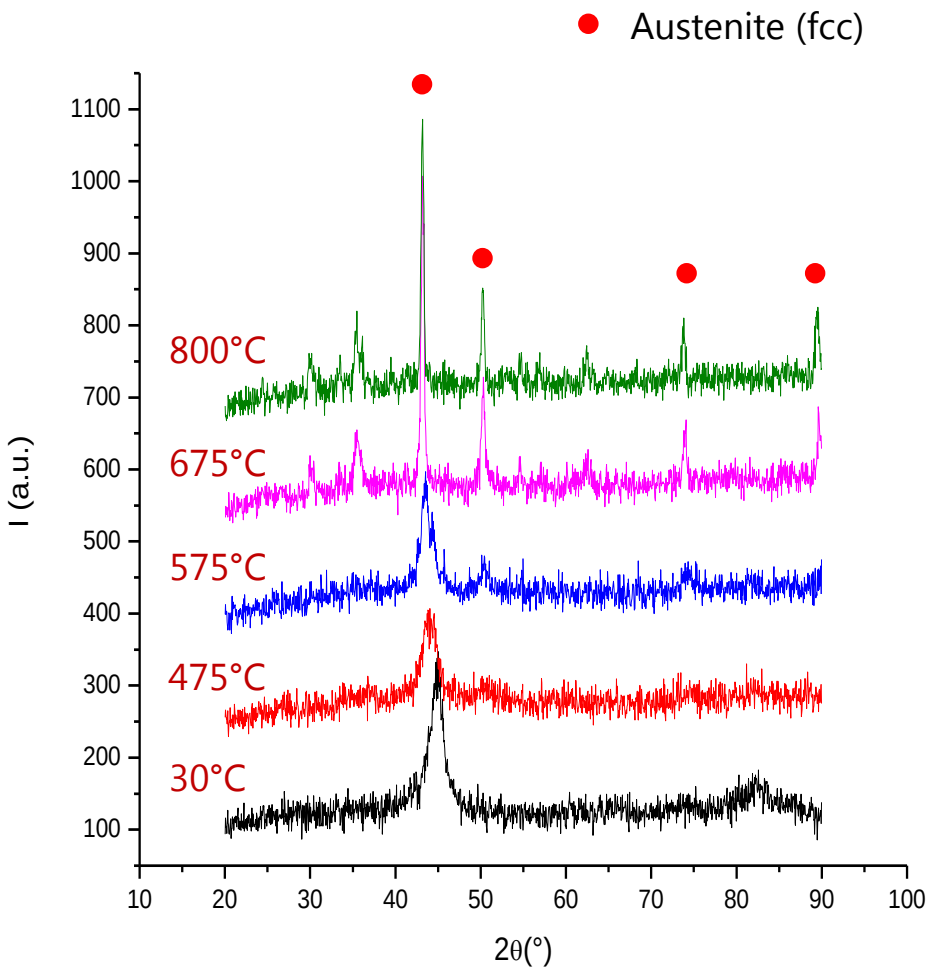






Predominantly amorphous

Some austenitic nano-crystalline areas



Properties of the Fe-Cr-Ni Plating

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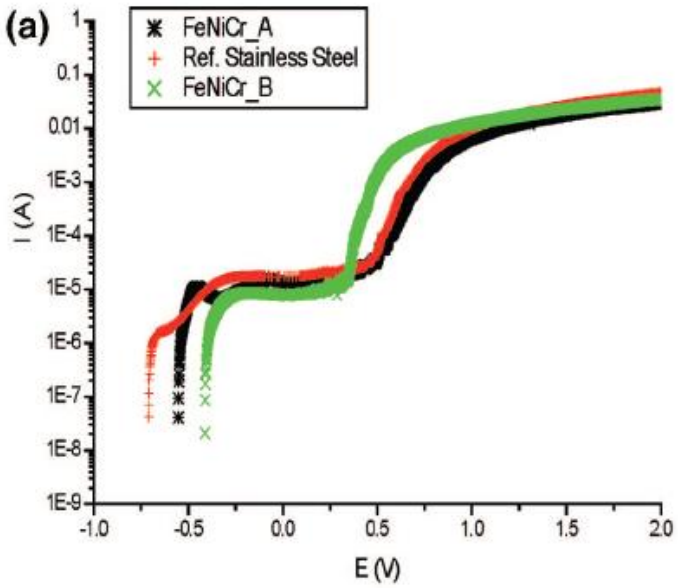

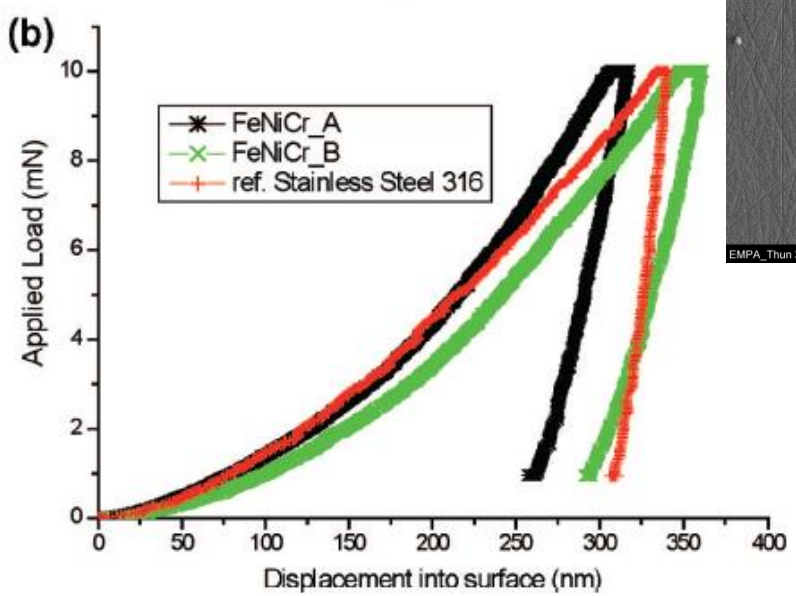

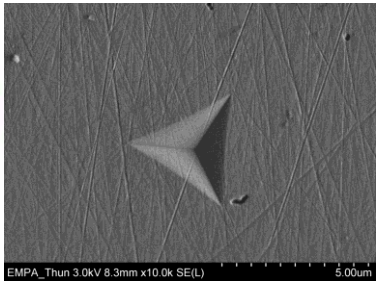

	FeNiCr_A (complexed with glycine)	FeNiCr_B (complexed with DMF)	AISI 316
Young's modulus (GPa)	123	107	198
Hardness (Gpa)	5.1	5.0	3.7
$I_{corrosion}$ (A/cm^2)	1.657×10^{-5}	5.668×10^{-6}	3.572×10^{-6}
$E_{corrosion}$ (V)	-0.414	-0.554	-0.623

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Merci pour votre attention