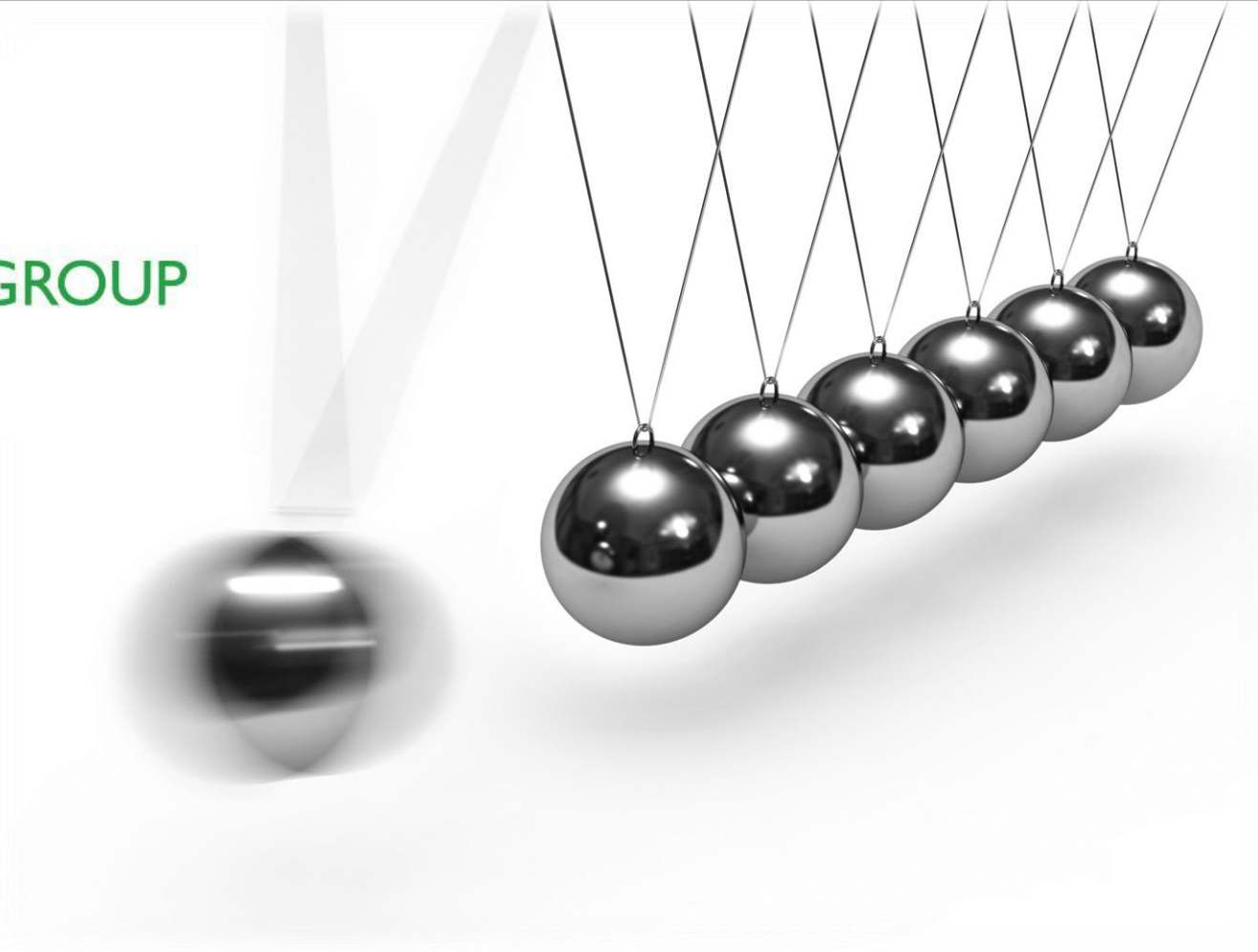




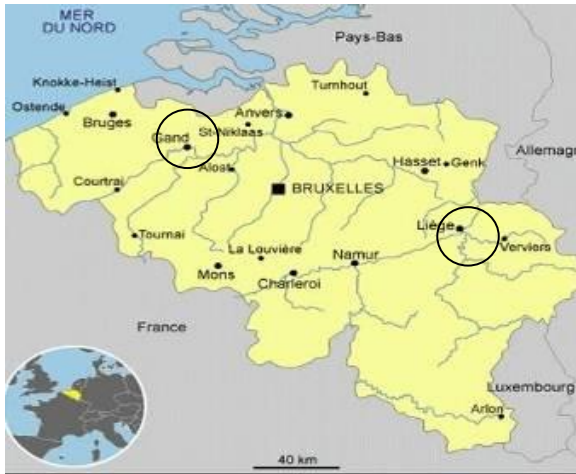
Smoothing of metallic thin films using advanced electropolishing technologies

Jean-François Vanhumbecq
D. Mercier - C. Le Pen - S. Hertel - A. Jobke



«Bridge between science & market»

CRM Group : Key figures



- CRM Group is the reference expertise centre for metal in Wallonia.
- The Centre was founded in **1948**
- CRM Group integrates the talents and the assets of **265** researchers, PHD's, technicians & employees
- Budget (2016) **>34 Mio €**



Steel industry

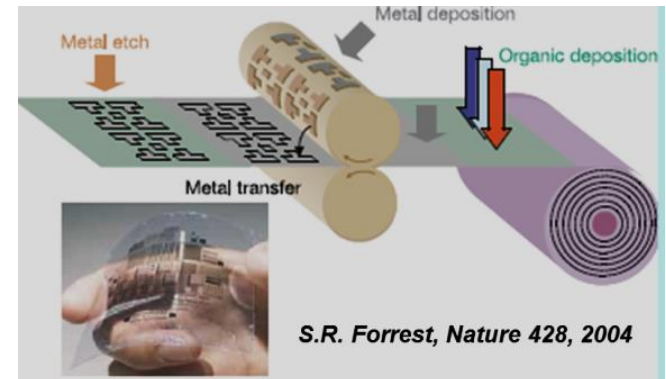
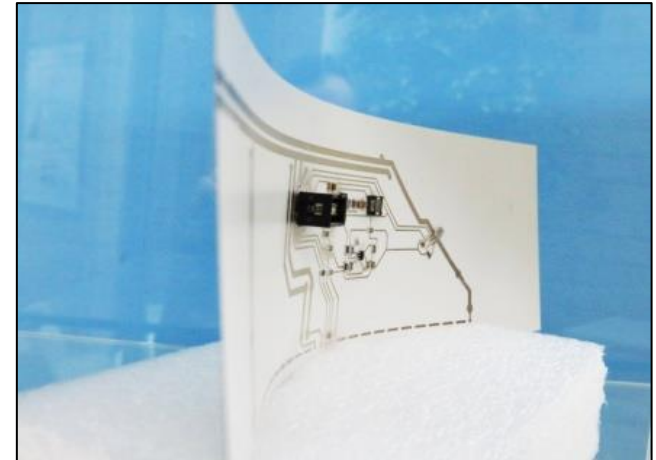
Outline

- ⌘ Steel and electronics : a common bright future?
- ⌘ Electropolishing
 - ⌘ Presentation of AdEPT project

Steel and electronics : a bright future ?

Printed electronics on metallic materials attracts growing interest

	Metal	Glass	Plastic
Flexibility/ formability	✓	(x)	✓
Heat dissipation	✓	x	x
Robustness	✓	x	x
Extreme condition (heat resistance, pressure, high temperature ...) !	✓	(x)	x
Electrical conductivity	✓	x	x
Scalable	✓	✓	✓
Roll to roll	✓	x	✓
Recycling	✓	✓	✓



Steel and electronics : a bright future ?

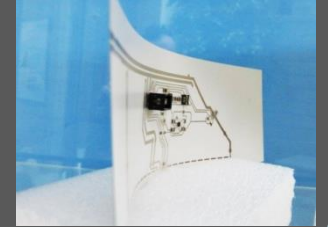
Lighting

OLED – LED sources
integration



Steel Printed circuit board

(metal core PCB)



RFID printed antennas

Wireless
communication



Coating / patterning
by printing
technologies in R2R

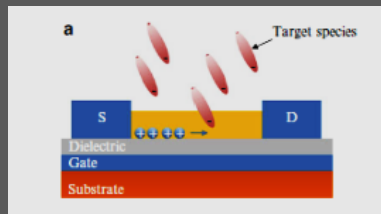
Heater foils

by printed
resistor



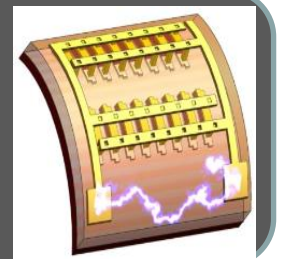
Sensors

Humidity / Gas /
Organic compounds



Energy harvesting

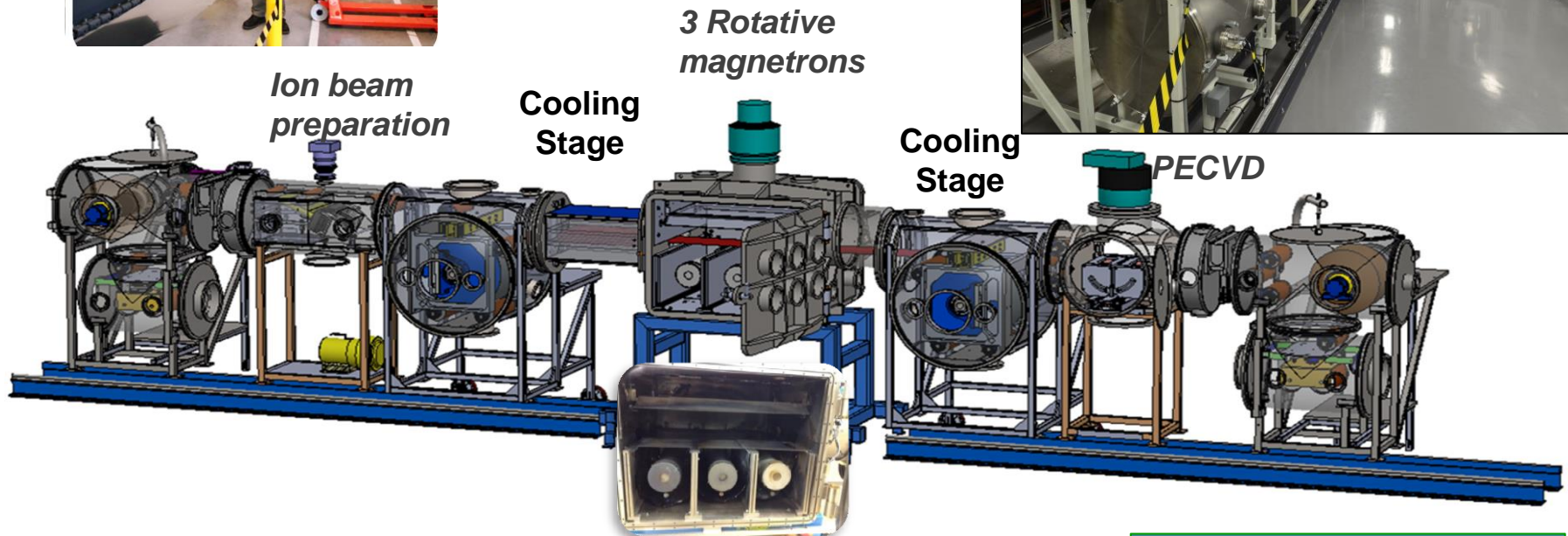
Energy conversion by
printed piezoelectric
thermoelectric



Steel and electronics : a bright future ?



Vacuum coating pilot line for steel foils in ISO 7 clean room at CRM



Ion beam preparation

3 Rotative magnetrons

Cooling Stage

Cooling Stage

PECVD

*250 mm width
 $t < 0.4$ mm
 $L = 1000$ m for 0.1 mm*

*Forward / Reverse mode
2 mm/min to 5 m/min
Managed with supervision system*

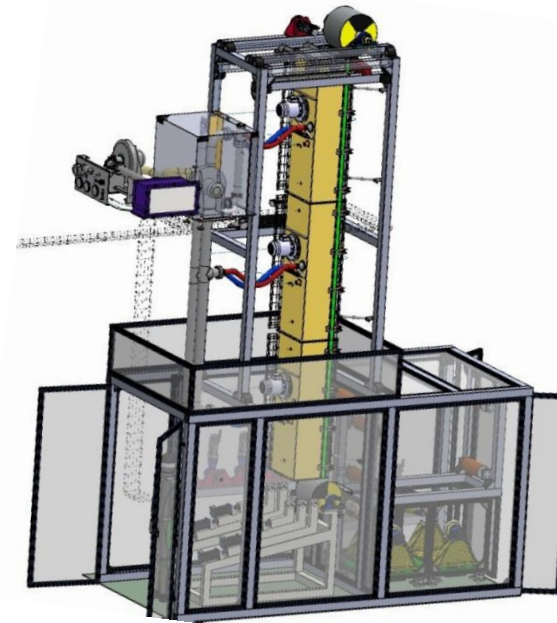
*Cleaning
Cooling
Heating - 25° C – 650° C*

Steel and electronics : a bright future ?



Winding

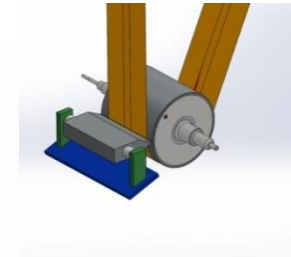
- Guiding unwind-rewind
- 50 μm - 0.4 mm : Tension 2500N
- Speed 0.5-20m/min



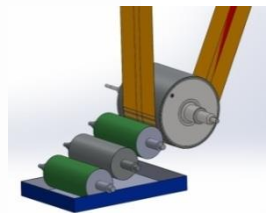
Modular R2R wet pilot line for steel foils in ISO 7 clean room

Heating - cooling

- Oven with own filtered air system
- Web Temperature 20 - 300°C
- 5 m length : 3 sections regulated
- Cooling top roll



Slot die



3 rolls

Outline

- ⌘ Steel and electronics : a common bright future?
- ⌘ Electropolishing
 - ⌘ Presentation of AdEPT project

This presentation takes place in the frame of :

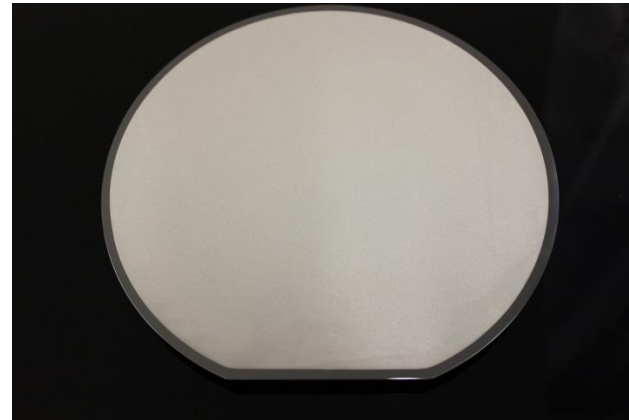
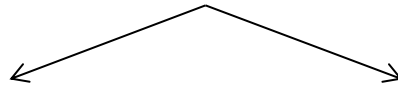


AdePT



AdEPT : ‘Advanced’ electropolishing

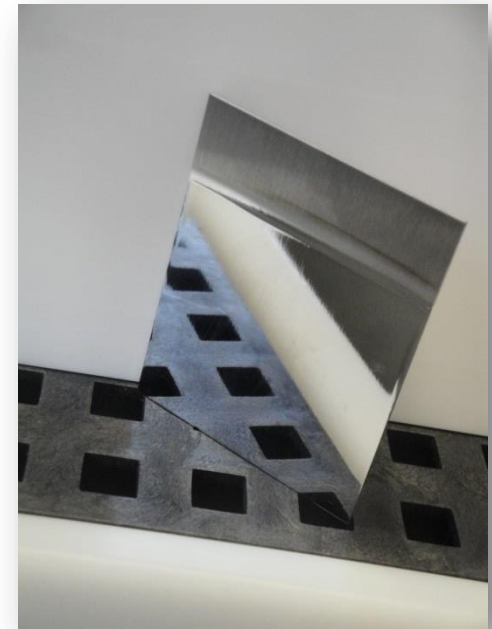
- ⌘ The innovative objective of AdEPT project is to ‘push further’ the limits of electropolishing technology to meet the increasingly stringent requirements of recent applications, such as high frequency, microfluidics, thin films, optical and other high-end applications.



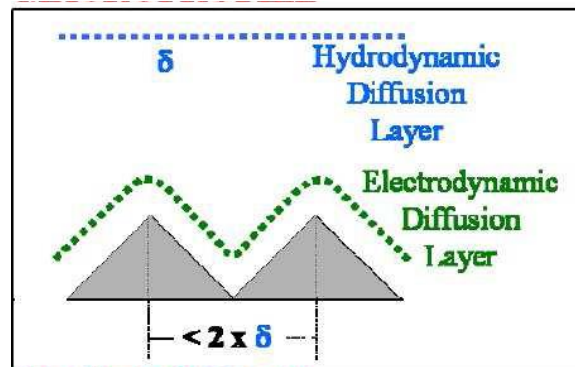
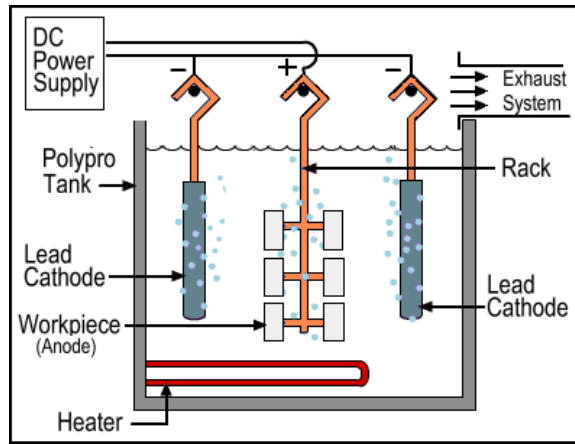
How to polish a metal surface ?

Different polishing technologies :

- ⌘ Mechanical
- ⌘ Chemical
- ⌘ Chemical-Mechanical (CMP)
- ⌘ **Electrochemical**



Introduction to Electropolishing



MICROPROFILE

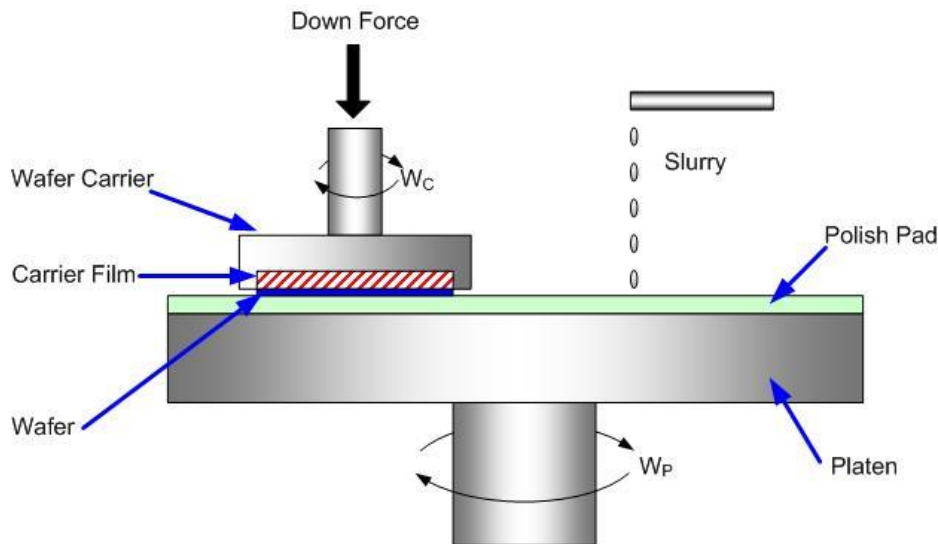
How does it work ?

- ⌘ Electrochemical dissolution of the metal



- ⌘ Formation of a 'viscous film' on the surface \rightarrow shorter diffusion path at surface peaks
- ⌘ Oxide films on the surface also play a role in the polishing mechanisms

AdEPT : target applications



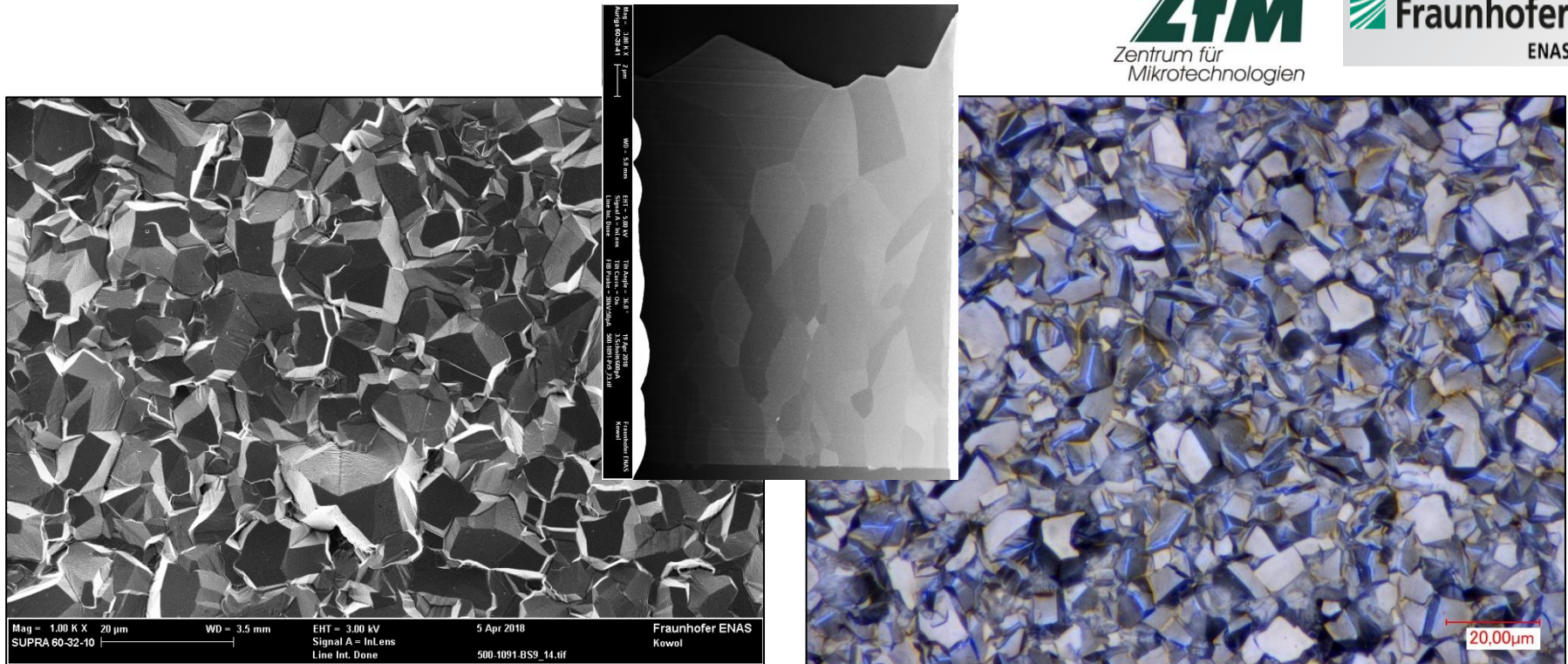
In microelectronics, **CMP** is the reference technique when thin films need to be polished down to nm-roughness

Main drawback : contamination by abrasive particles



Electropolishing could offer a non-contaminating polishing method more flexible than CMP for some materials.

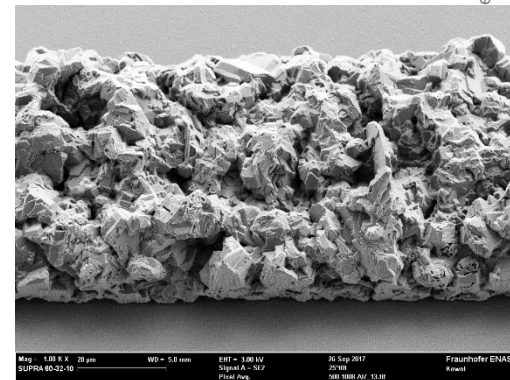
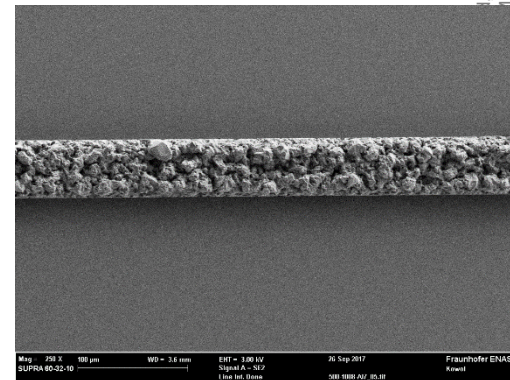
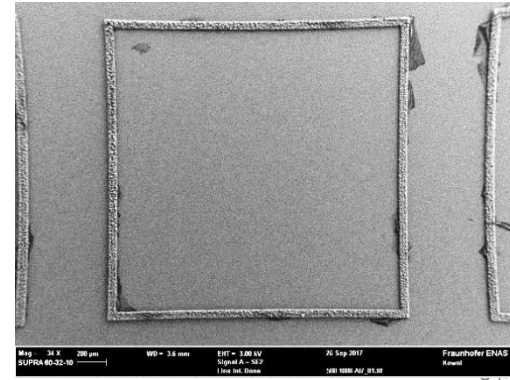
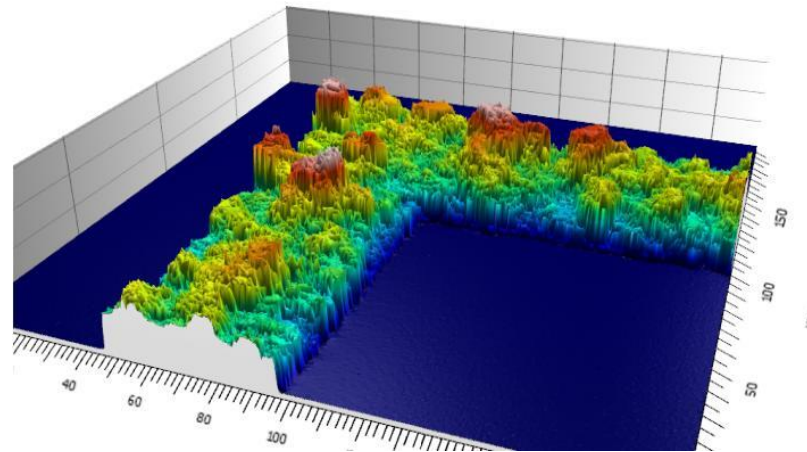
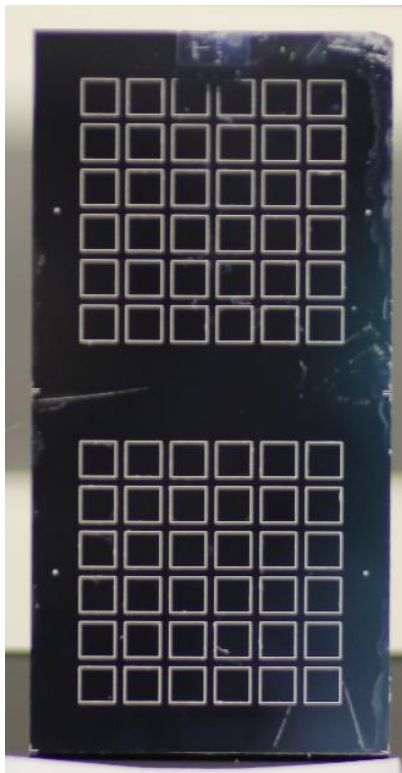
AdEPT : target applications



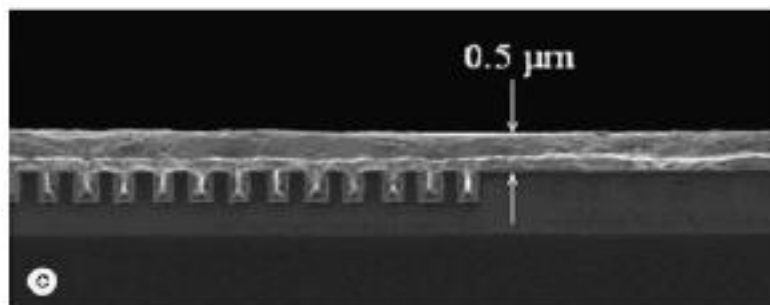
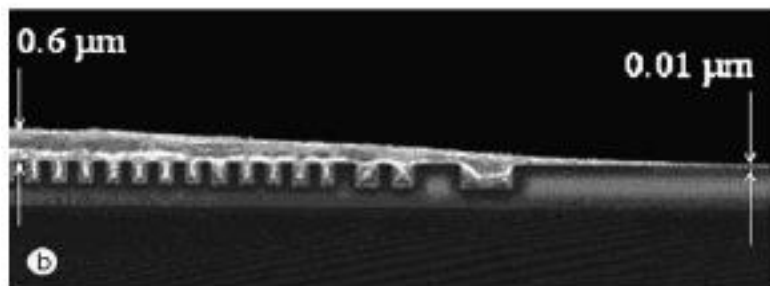
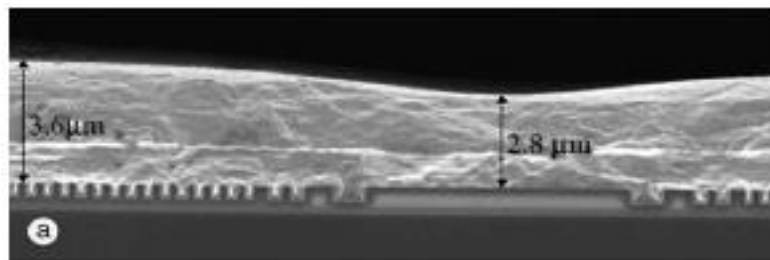
- Al layers thin films are electroplated from ionic liquids at ZfM
- Grain size and roughness of the film increase with its thickness

AdEPT : target applications

⌘ Samples with micro features : Al bonding frames



AdEPT : target applications



Electropolishing of thin films

Management of the current distribution is critical

Inhomogeneous thinning

Homogeneous thinning

Work on :

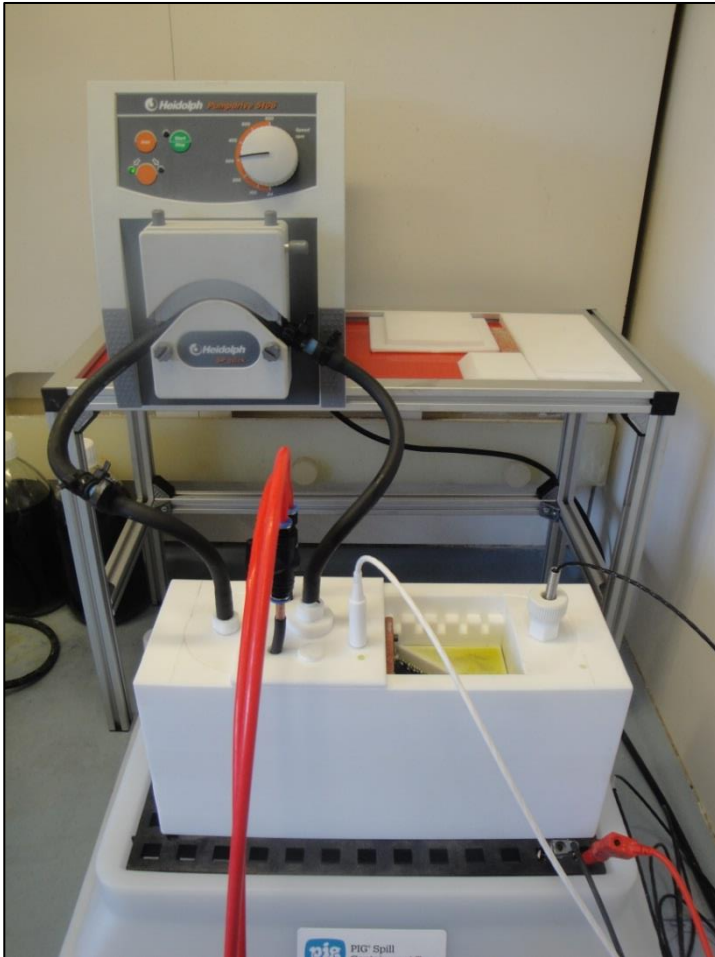
Bath chemistry

Electrical parameters

Cell configuration and tooling

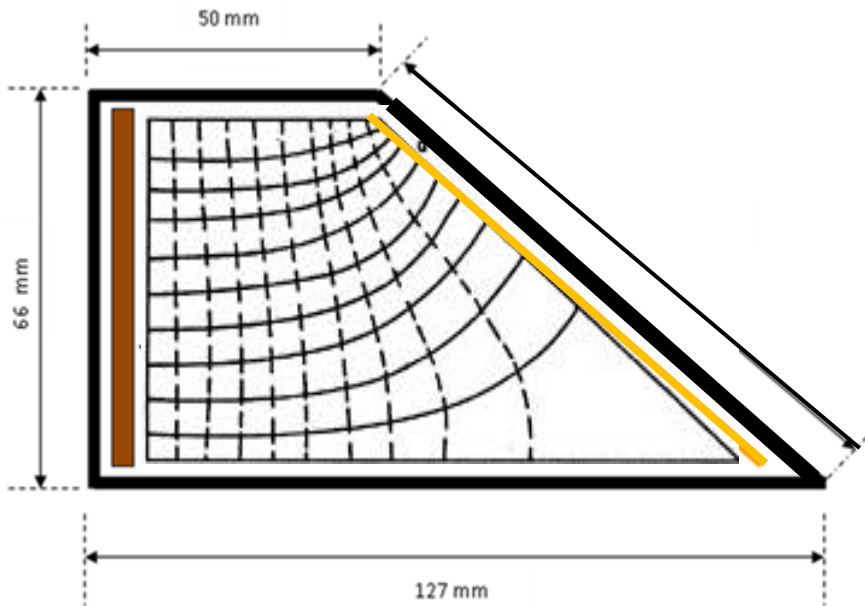
Journal of Applied Electrochemistry 34: 305–314, 2004.
© 2004 Kluwer Academic Publishers. Printed in the Netherlands.

AdEPT : Work strategy

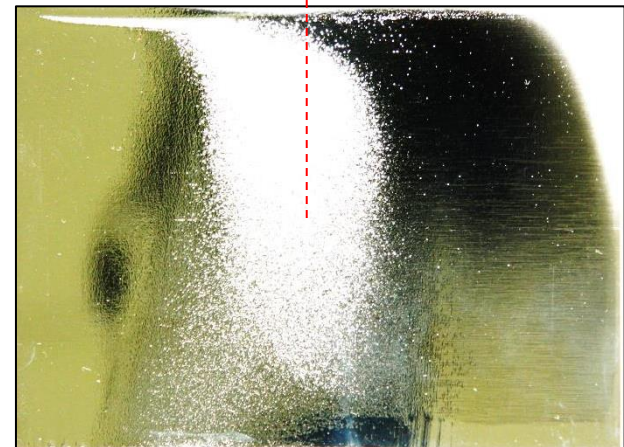
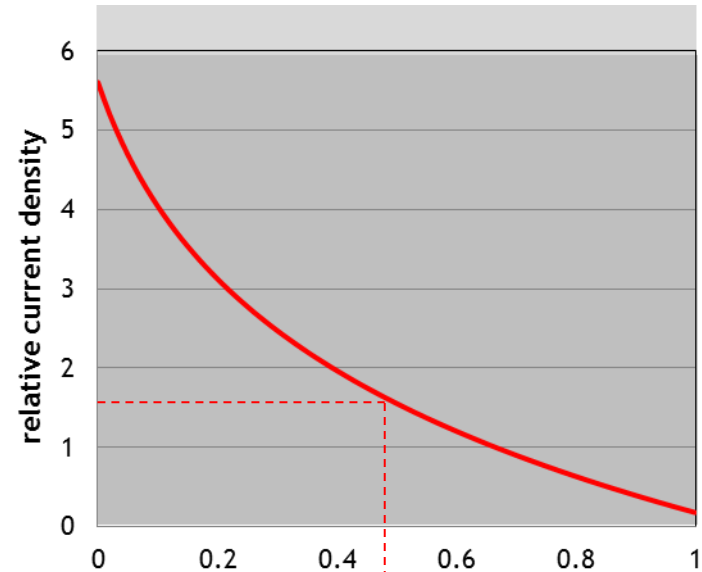


- Construction of an electroplating cell common to all partners
- Experimental procedures developed on stainless steel
- Transposition to Al thin films is in progress

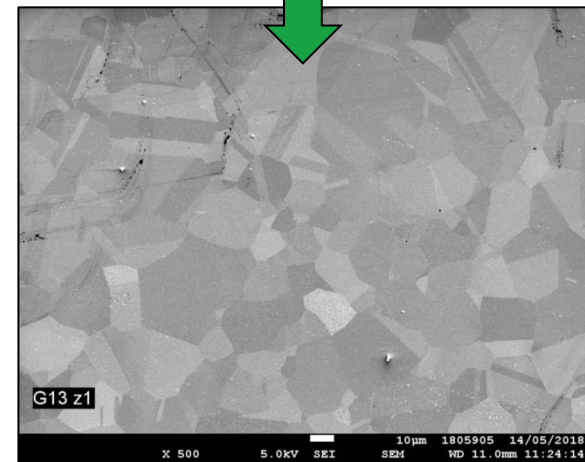
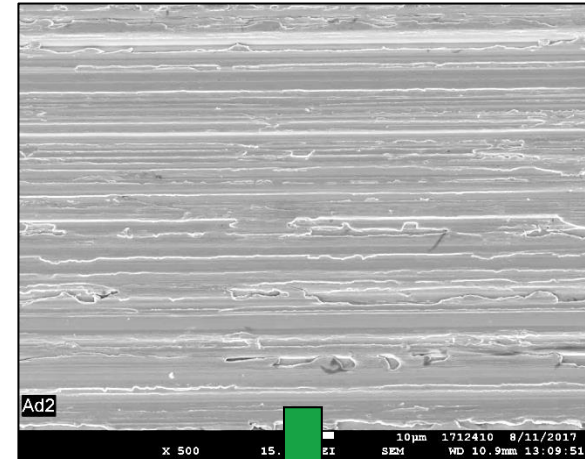
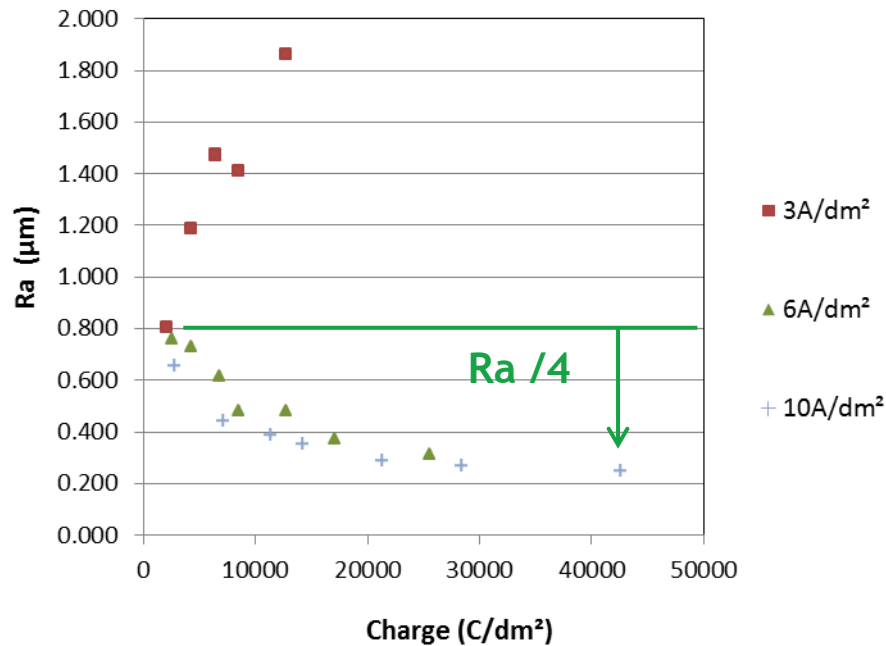
AdEPT : Work strategy



- Hull cell tests allow for fast screening of electropolishing bath performances and defectology studies



Electropolishing performances on AISI 316 stainless steel



Conclusions

- Steel might take an increasing importance as a substrate material for electronic devices
- Electropolishing could find applications in microfabrication processes if some technical challenges can be overcome

The support of DGO6 for AdEPT project is gratefully acknowledged

