

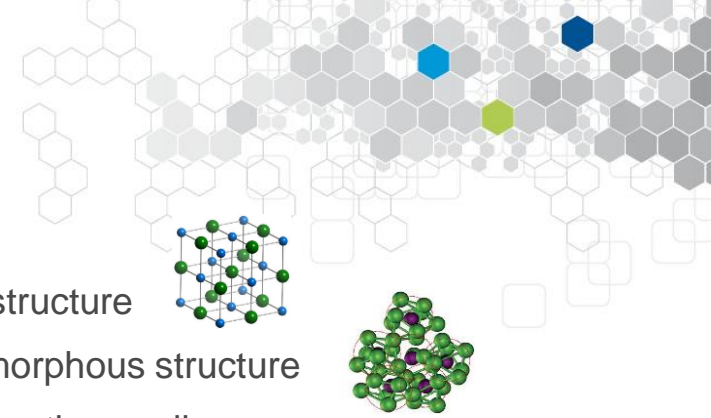
# Effects of relative humidity on the tribological behavior of Cu-Zr-based bulk metallic glasses

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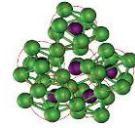
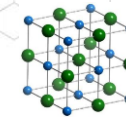
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# Introduction : Bulk Metallic Glasses



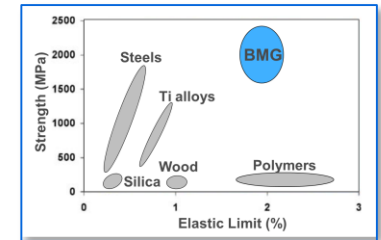
## Microstructure

- Usual metallic alloys → cristalline structure
- Bulk Metallic Glasses (BMG) → amorphous structure
- Since the 1980s : thanks to an innovative cooling process + complex chemical composition



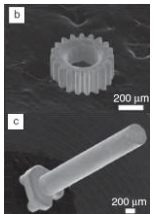
## Mechanical properties

- High hardness
- High elastic limit
- High strength
- Fatigue resistance
- Corrosion resistance
- Processability
- Surface net-shaped formability



## Industrial applications

- Sport
- Medical implants
- Sensor coatings
- Dry bearings
- Space application
- Micromechanics : gears



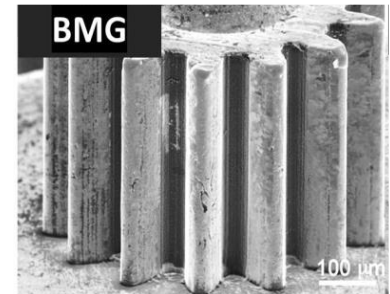
# Introduction : Bulk Metallic Glasses



High potential of BMGs for industrial applications



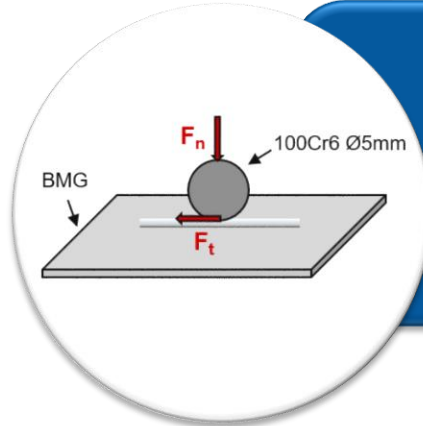
But tribological properties highly debated : unpredictable and misunderstood behavior



SEM observations of microgears after friction tests : wear of steel vs wear of a BMG



# Experimental Approach

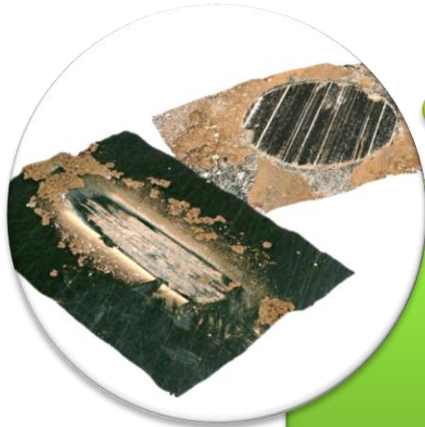


## Tribological testing :

With varying compositions,  
contact conditions,  
microstructure ...

### Measurements :

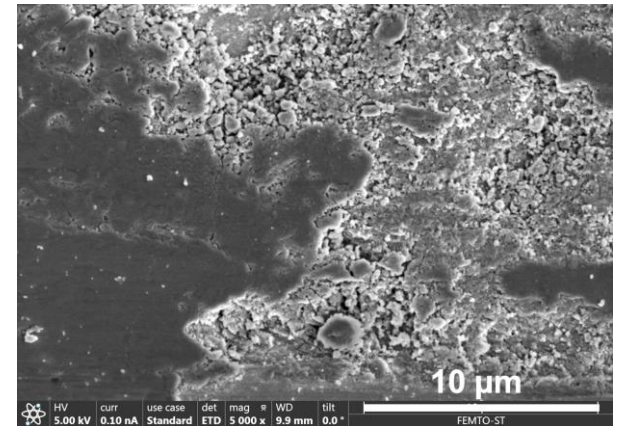
- Coefficient of Friction :  $\mu = F_t / F_n$
- Relative Humidity



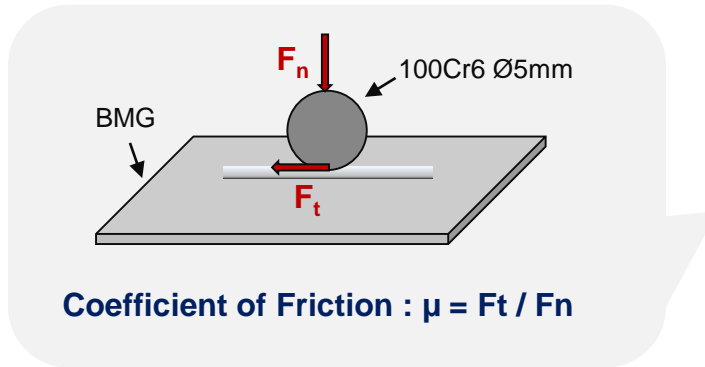
## Surface characterization :

SEM, EDX, 3D-roughness  
measurement, XRD, XPS

→ Which wear mechanism ?

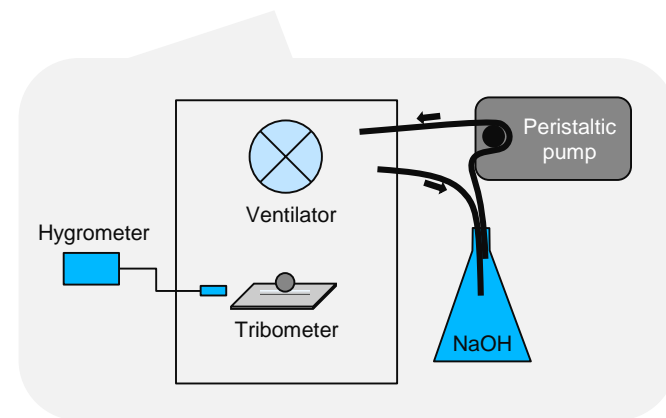
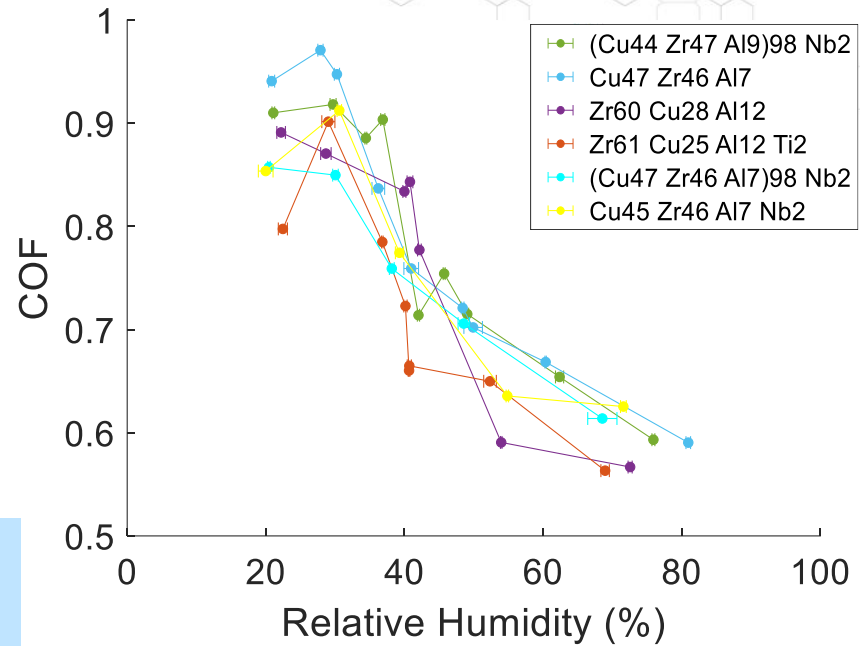


# Results and discussion

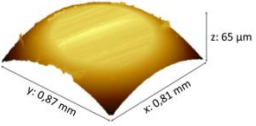
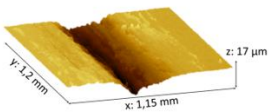
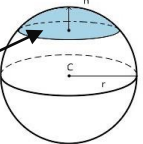
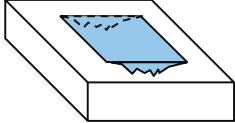


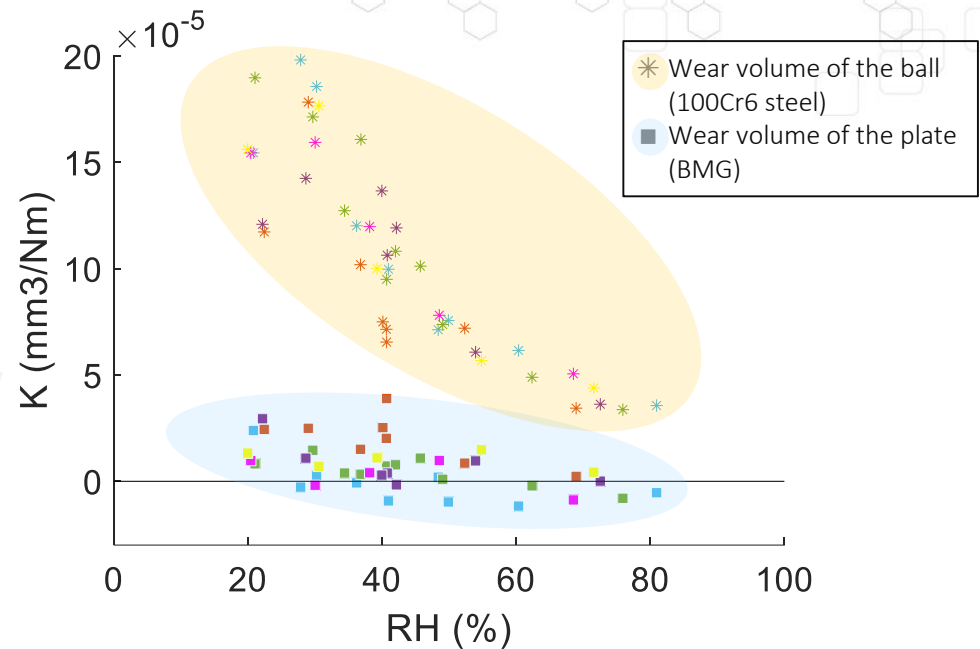
Friction tests carried out in enclosed area with humidity control :

- High dependency of the COF to Relative Humidity (RH)
- Same trend for all BMG compositions tested
- This means that in the contact area between steel ball and BMG plate, there are complex tribochemical reactions strongly correlated to the presence of water molecules in air

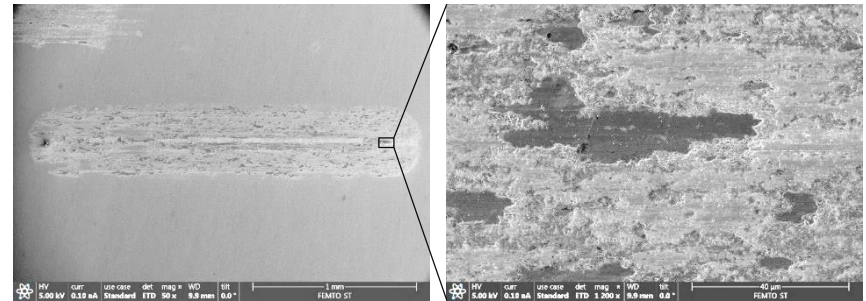


# Results and discussion

Steel ball	BMG plate
	
 Wear volume (mm <sup>3</sup> )	
Hardness : 800 HV	Hardness : 480 HV



- ➔ Wear rate of the steel ball  $\gg$  wear rate of the BMG plate
- ➔ Wear rate of the steel ball dependent to Relative Humidity (RH)
- ➔ Wear of the BMG extremely low  $\rightarrow$  due to the formation of a protective layer on the BMG friction track

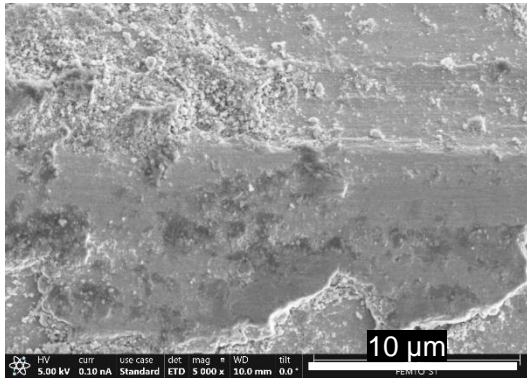


SEM pictures of a wear track on the BMG plate

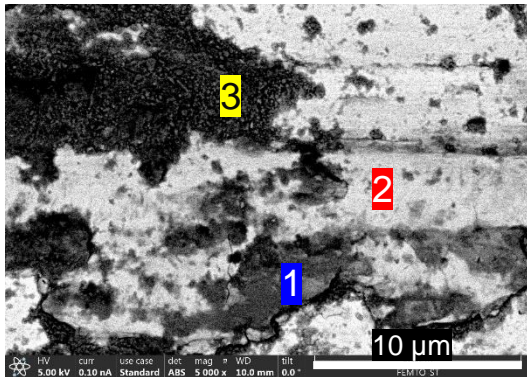
# Results and discussion



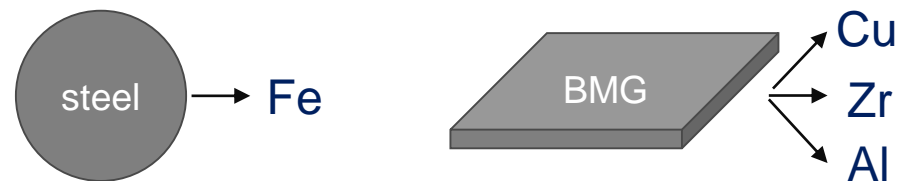
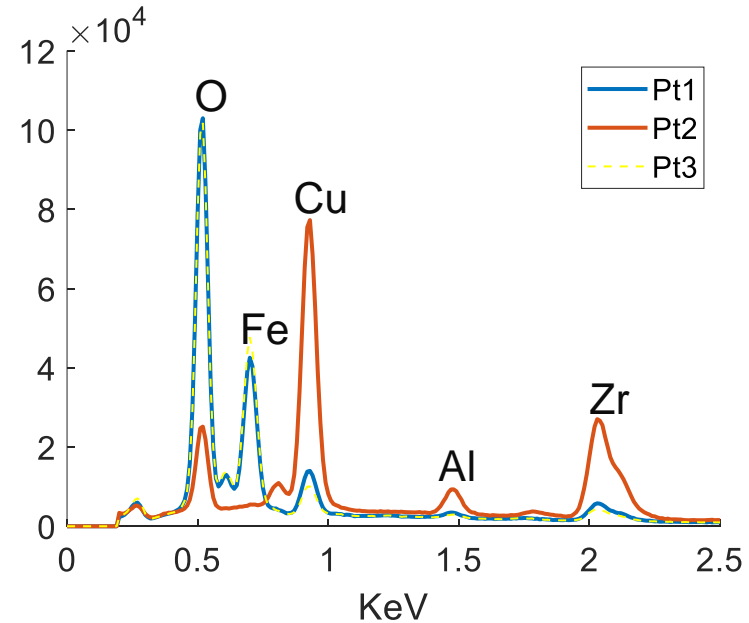
→ What is the nature of the 3<sup>rd</sup> body patches ?



SEM : ETD detector



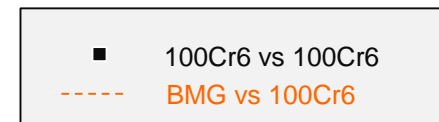
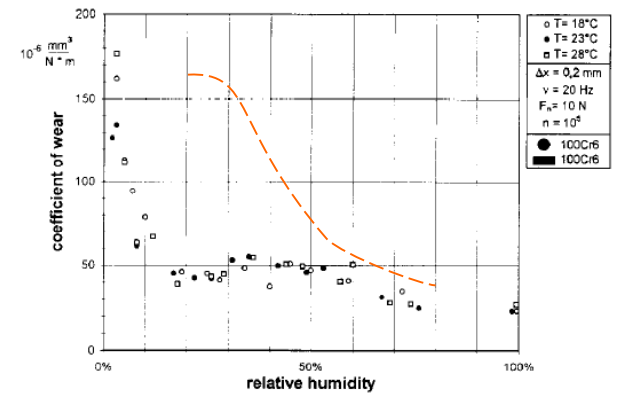
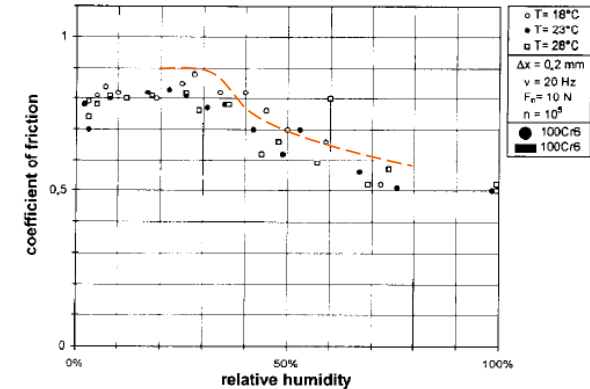
SEM : ABS detector



# Conclusion

- **Cu-Zr based BMG** have promising tribological behaviour : despite a high coefficient of friction (bet. 0,6 and 0,9), **its wear resistance is especially high**
- This is thanks to the formation of a **protective 3<sup>rd</sup> body** on the BMG surface, whose formation is dependant to **Humidity Rate**
- This is in agreement with literature : the dependence to humidity is probably linked to the **behaviour of the steel ball**
- This study also confirms that **hardness is not a decisive factor** to predict BMG's tribological behavior

A look at literature [1] :







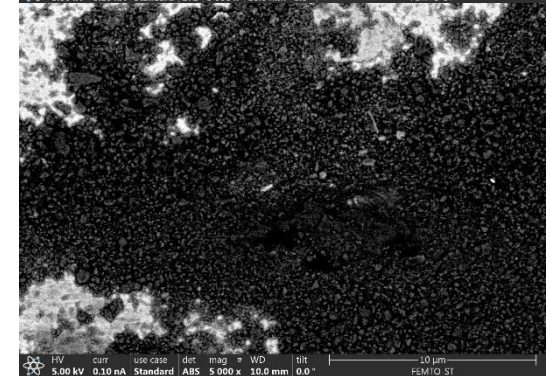
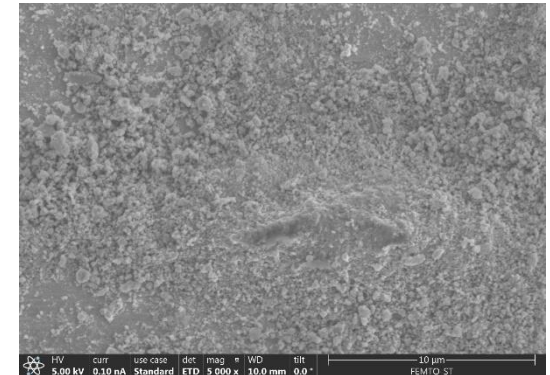
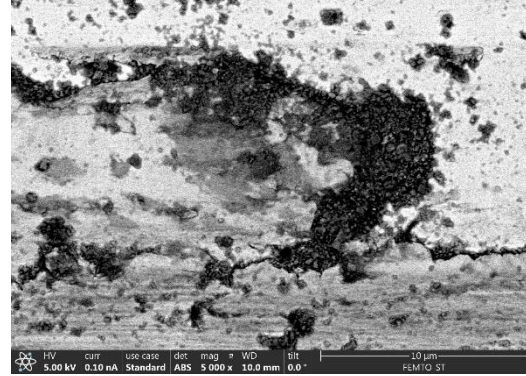
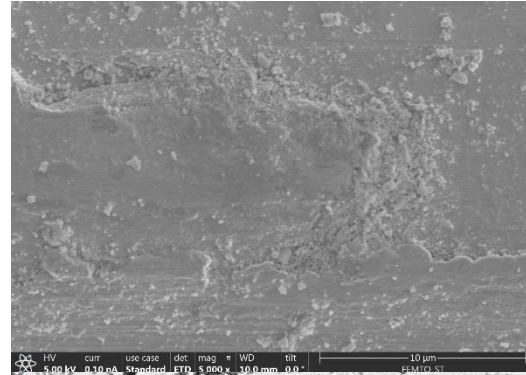
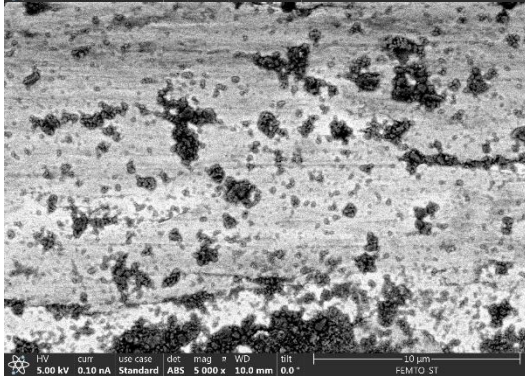
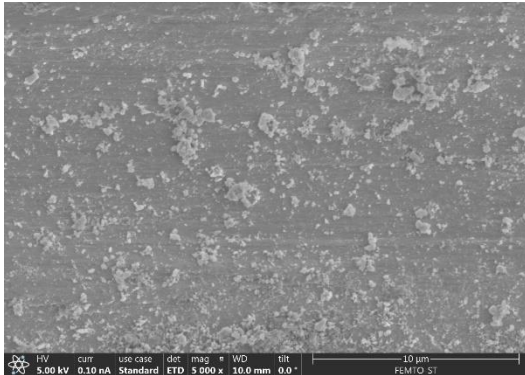
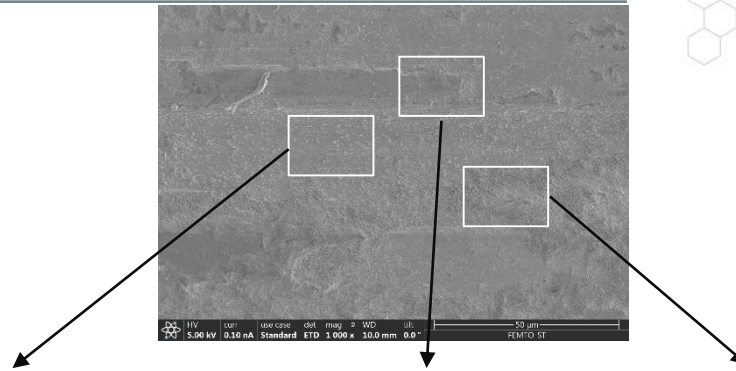
Thanks for your attention

## Contact

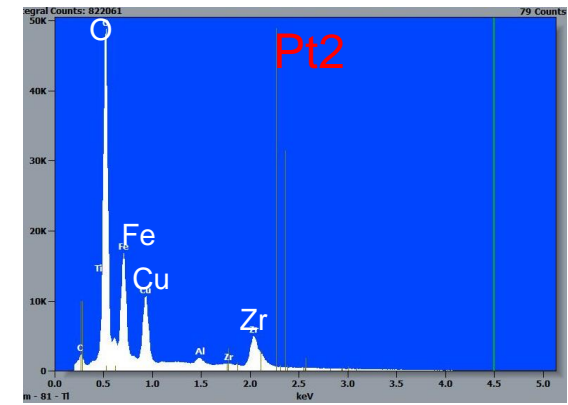
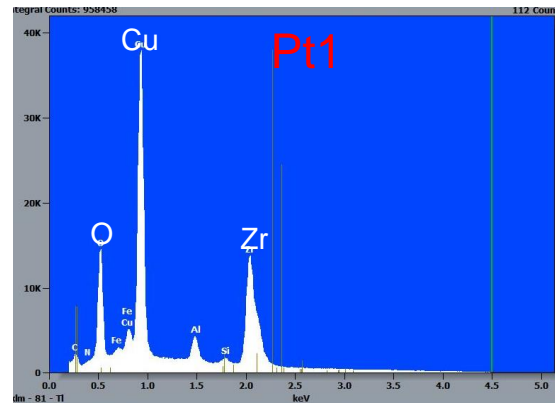
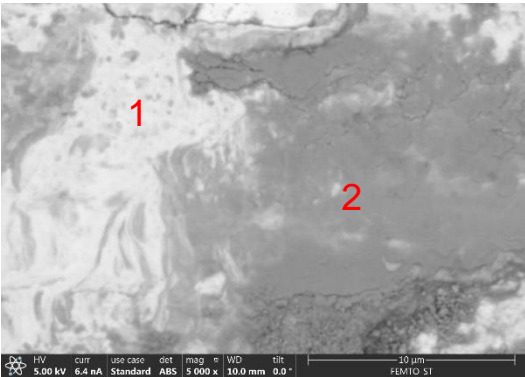
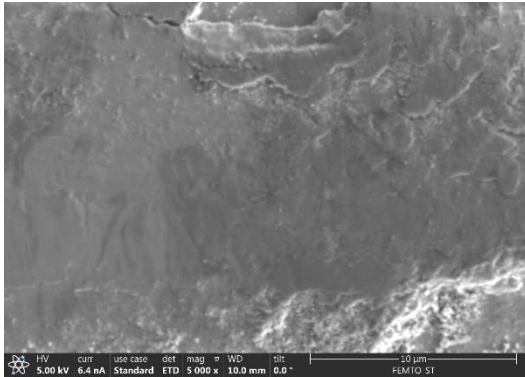
Nom : STOENS Solène

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# Annexes



# Annexes



# Annexes



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