# Application of GDOES to Study of Corrosion Protective Coatings

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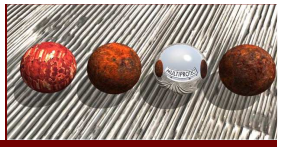
GD day 16th September 2016



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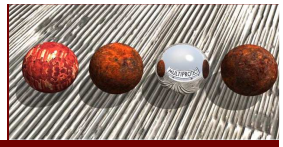
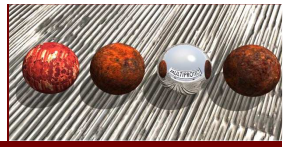


# Project background

MULTIPROTECT:

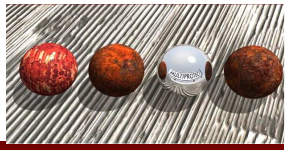
- An integrated project of the 6th framework programme of the European Commission.
- A collaboration between 31 academic and industrial researchers from 13 countries.
- Aim: to provide novel, heavy-metal free, multifunctional, economical and environmentally friendly corrosion protecting surface treatments based on nanocomposite materials.

http://www.multiprotect.org/

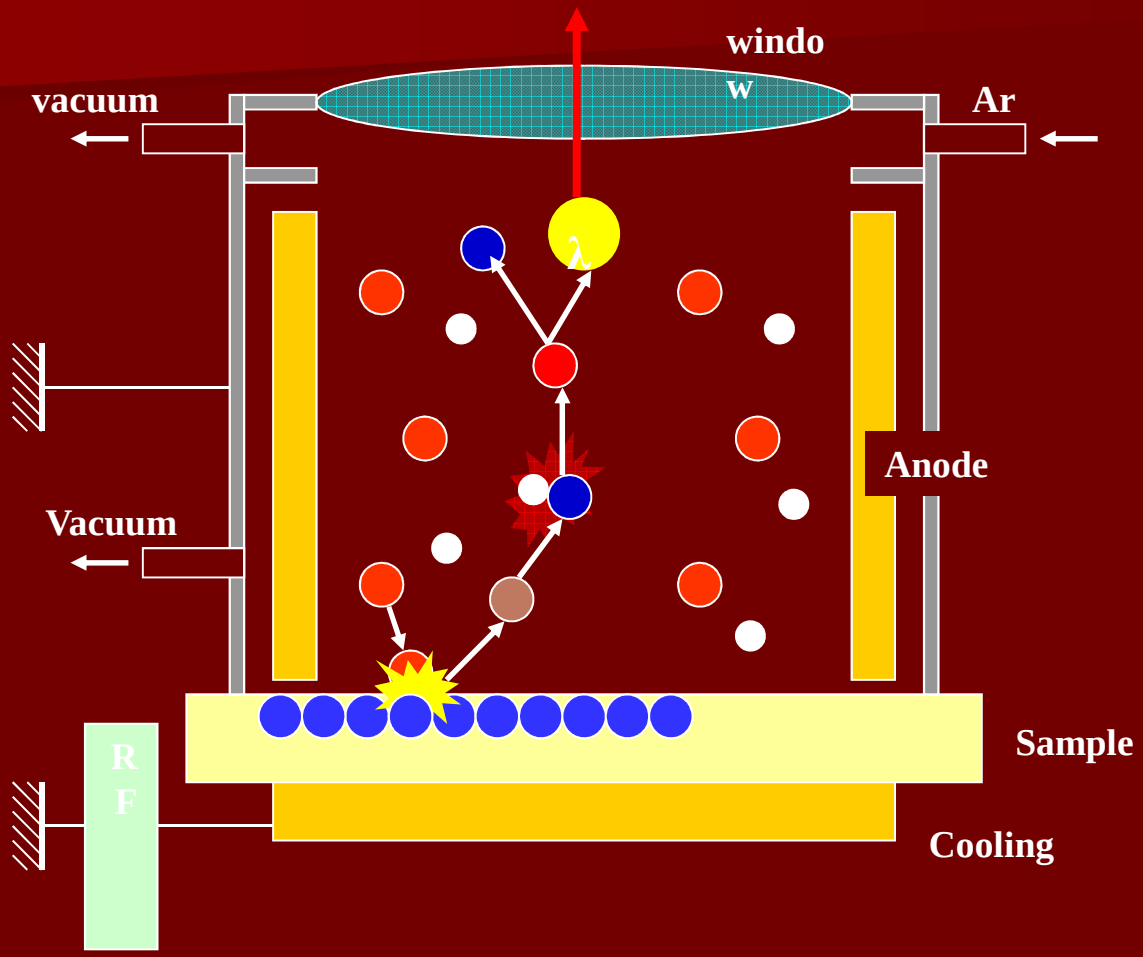


# Specimens: AA2024 T3

- EPOXY-Al sol-gel coatings (INM)
  - Non-inhibited
  - Inhibited: BZT or BZT in AluOx;
- Methacryloxy-based sol-gel coatings (EADS)
  - Non-inhibited
  - SAPP-inhibitor in sol-gel,
  - Inhibitors in primer: BZT, MBT, MBI, $SrCrO_4$.



# Experimental: RF-GDOES




- The sample is sputtered by Ar ions.
- Neutral species are accelerated in the plasma.
- Light is emitted by the atoms when excited by collisions.

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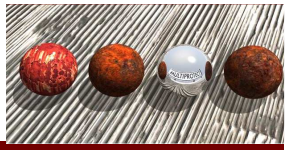
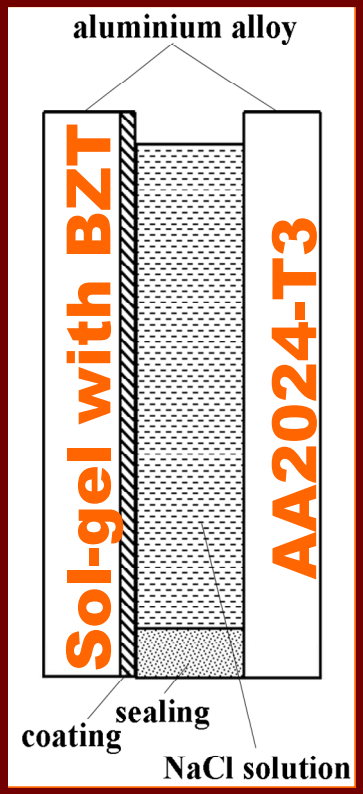
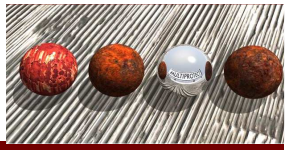


# Experimental: Artificial Cells

- Cells consisted of coated specimens fixed in close proximity to the bare alloy:

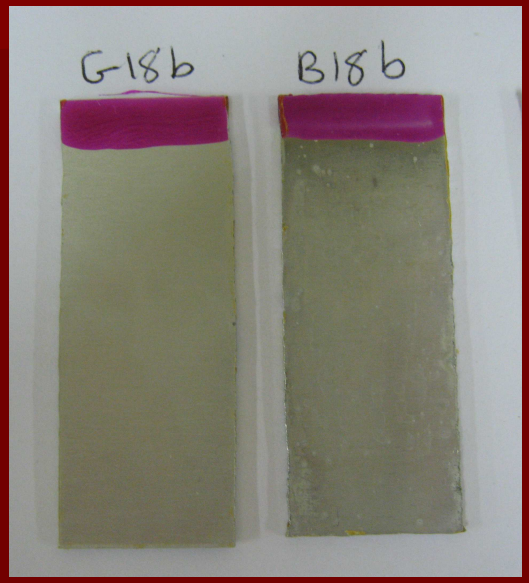



- Cells were filled with 35 g $l^{-1}$ NaCl solution for (a) 5 h and (b) 200 h.
- Subsequent GDOES analysis of the **bare alloy** from each cell.
- Noted characteristics of elemental profiles.



# Experimental: Artificial Cells


^ Artificial cells during exposure





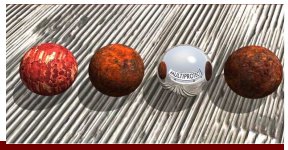
^ Artificial cells deconstructed after exposure

Bare alloy specimens were then sputtered. Raw data was imported to Excel and combined to compare profiles of individual elements.

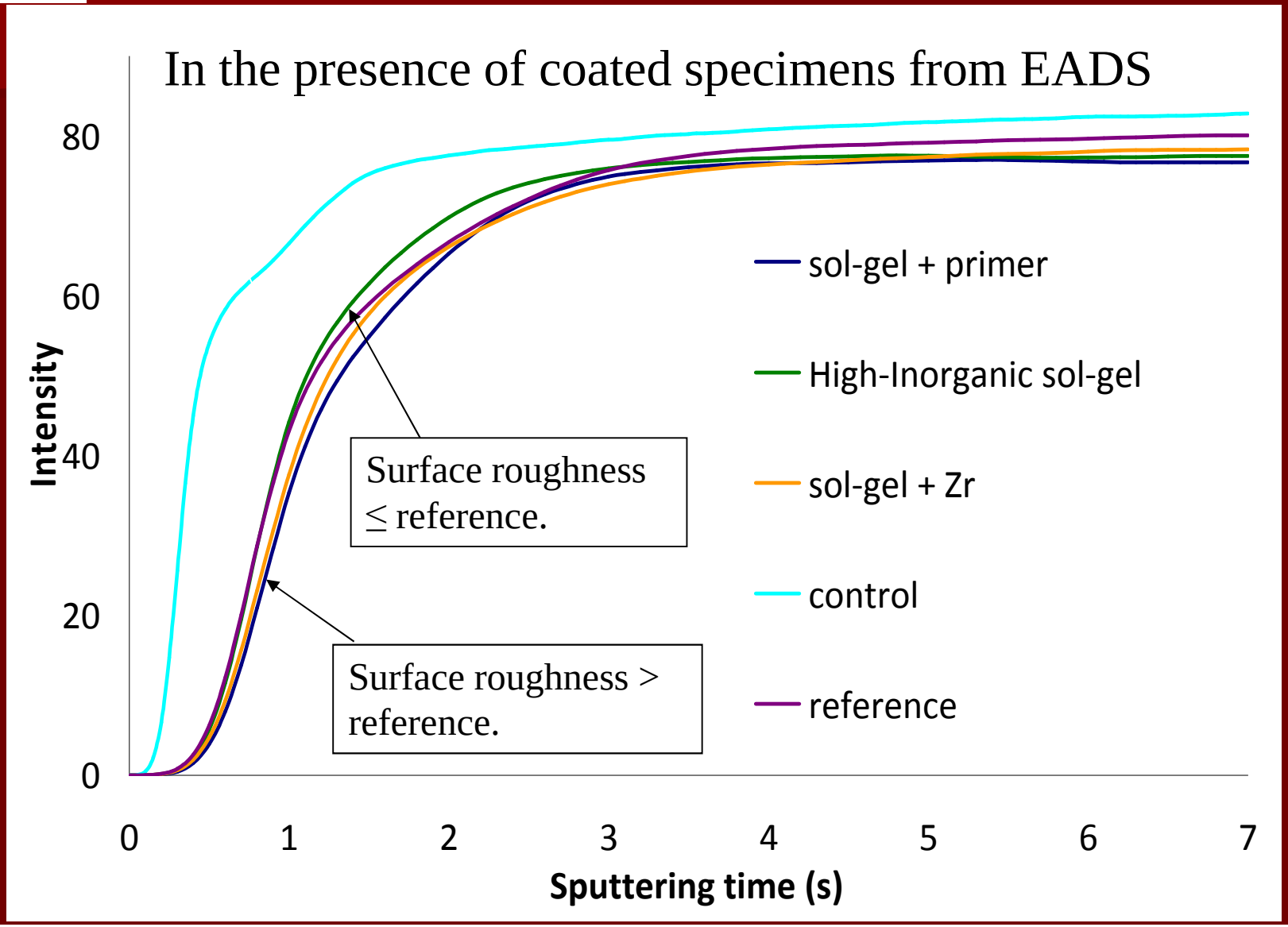
# Results and Discussion

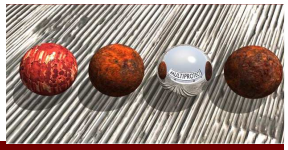
## Part 1:
## Elemental depth profiles of the bare alloy from cells incorporating uninhibited coatings

*Surf. Interface Anal.* **2015**, 47, 1009 – 1014



# Aluminium profiles of bare alloy





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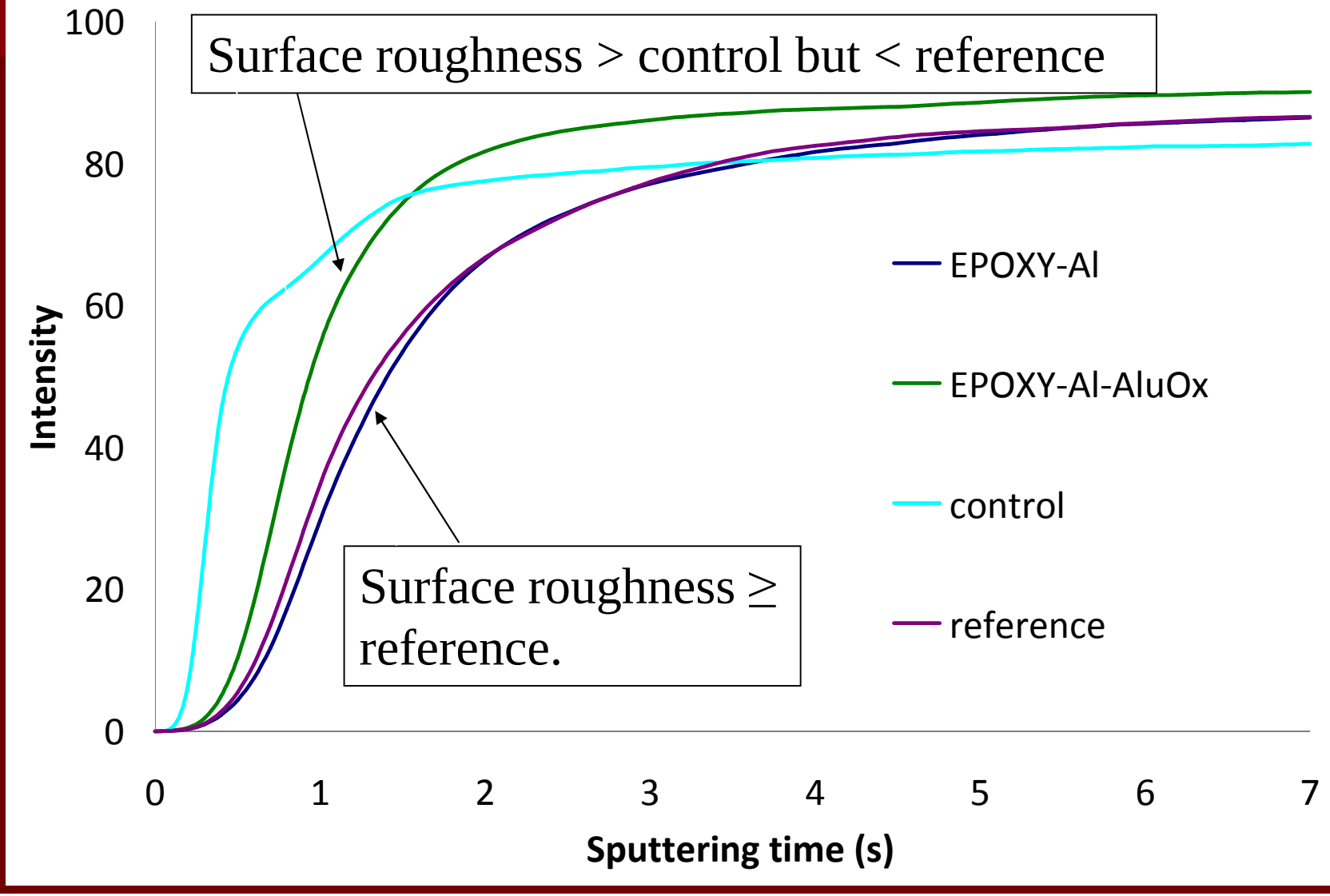
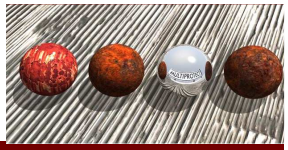
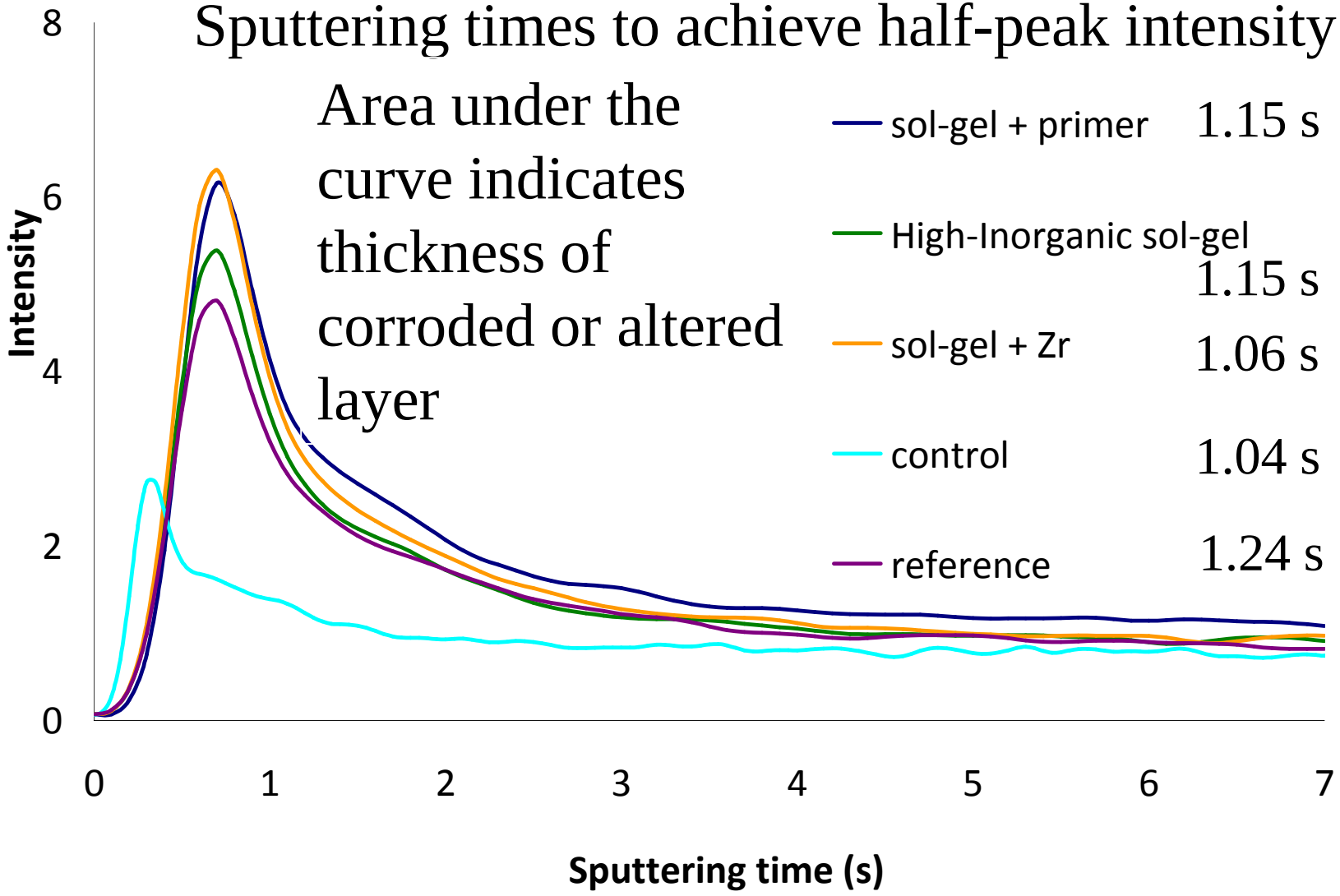


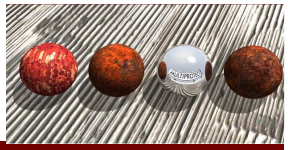


# Oxygen profiles of bare alloy

Sputtering times to achieve half-peak intensity:

Area under the curve indicates thickness of corroded or altered layer





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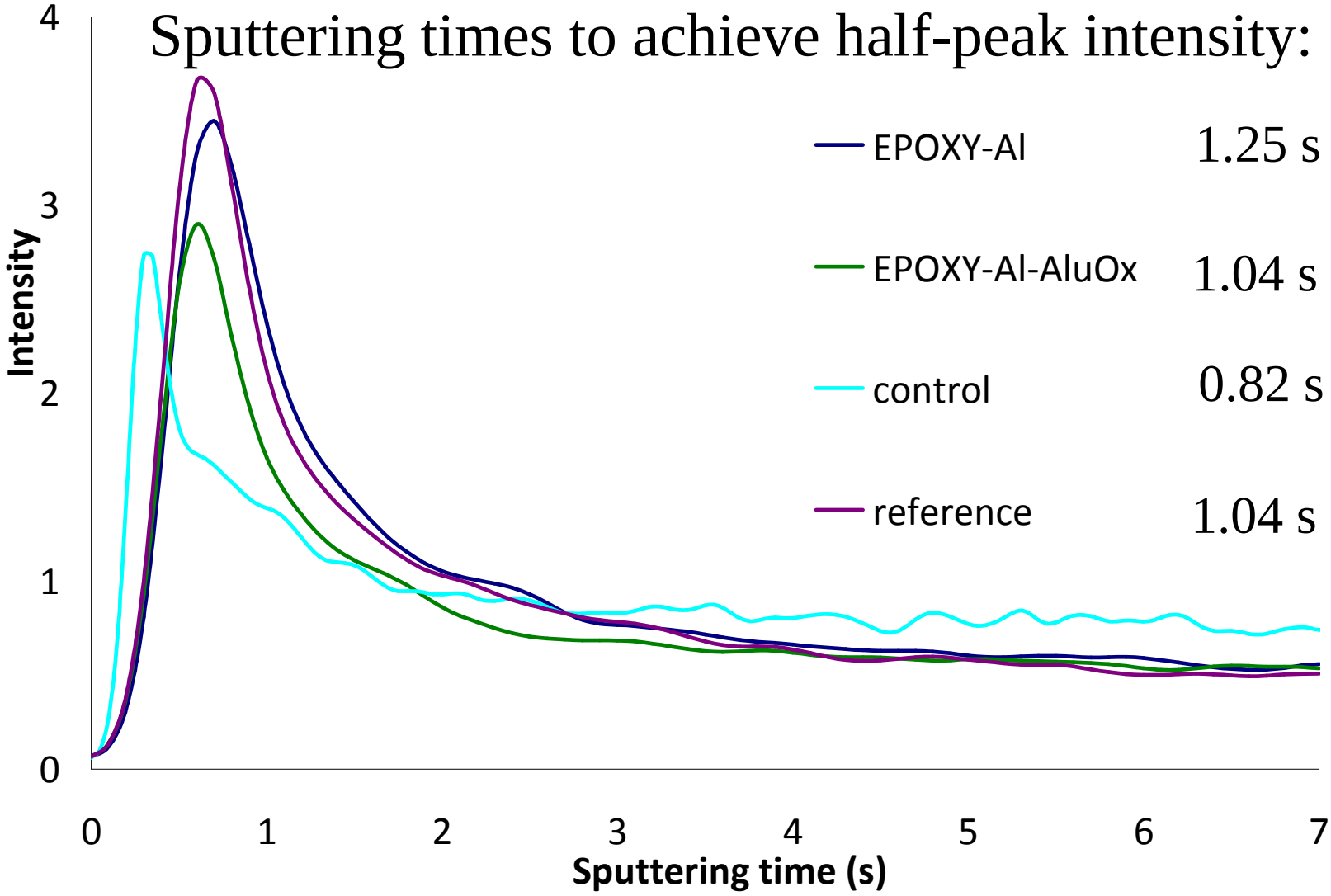
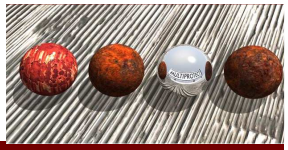
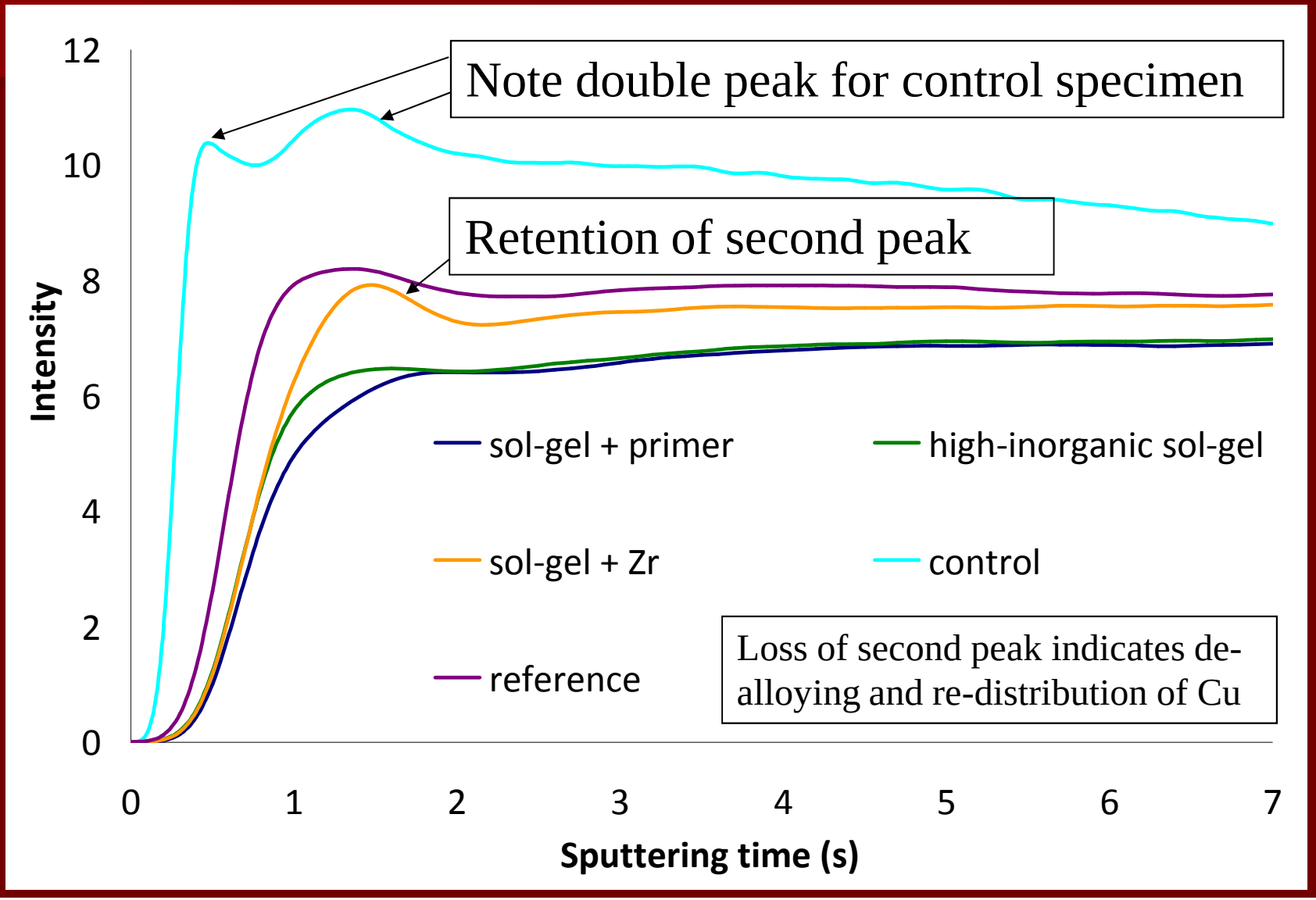
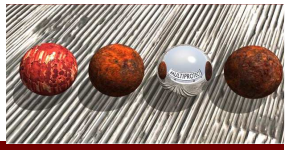


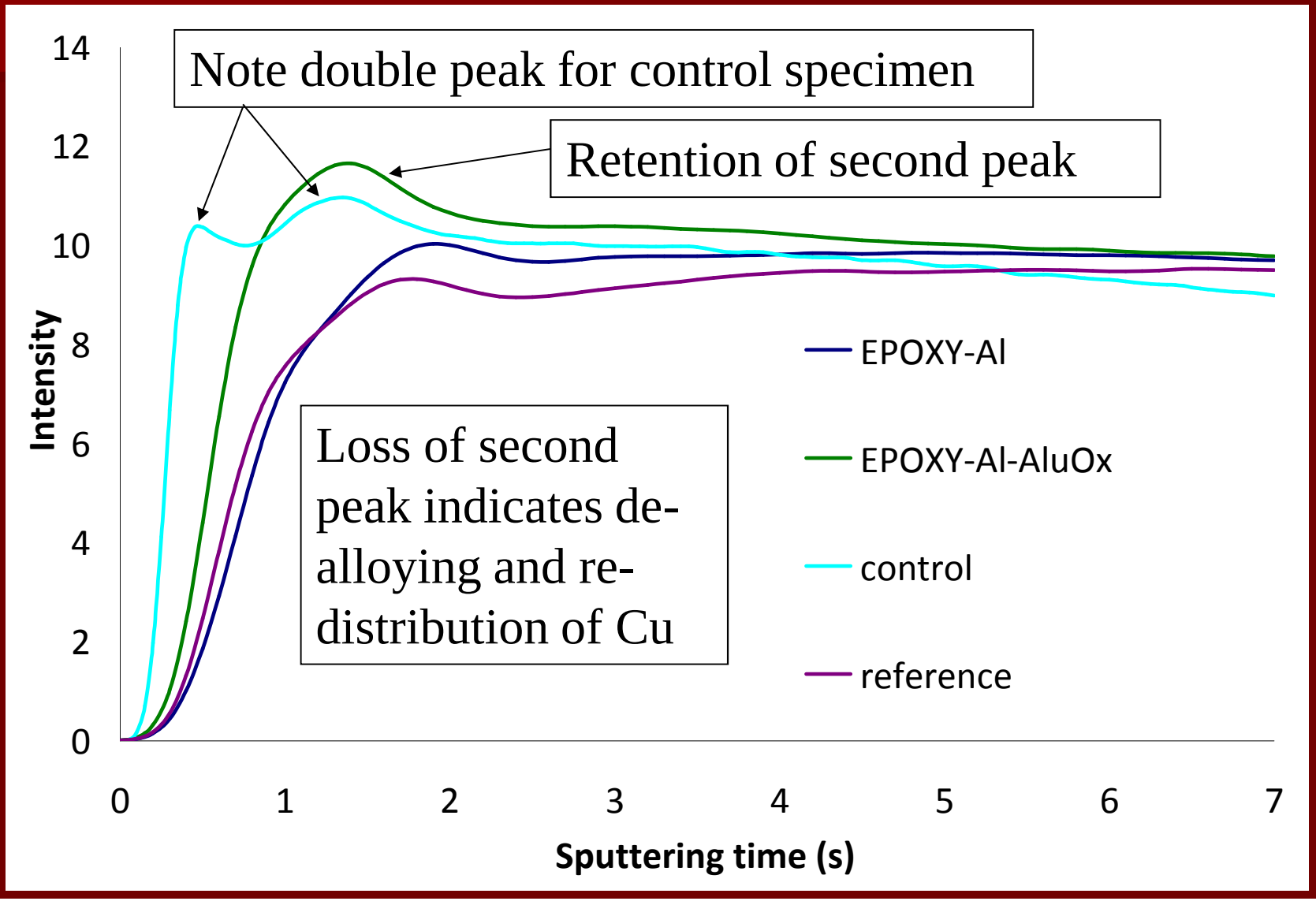


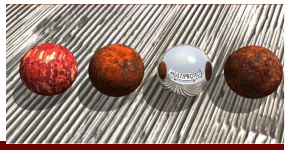
# Copper profiles of bare alloy





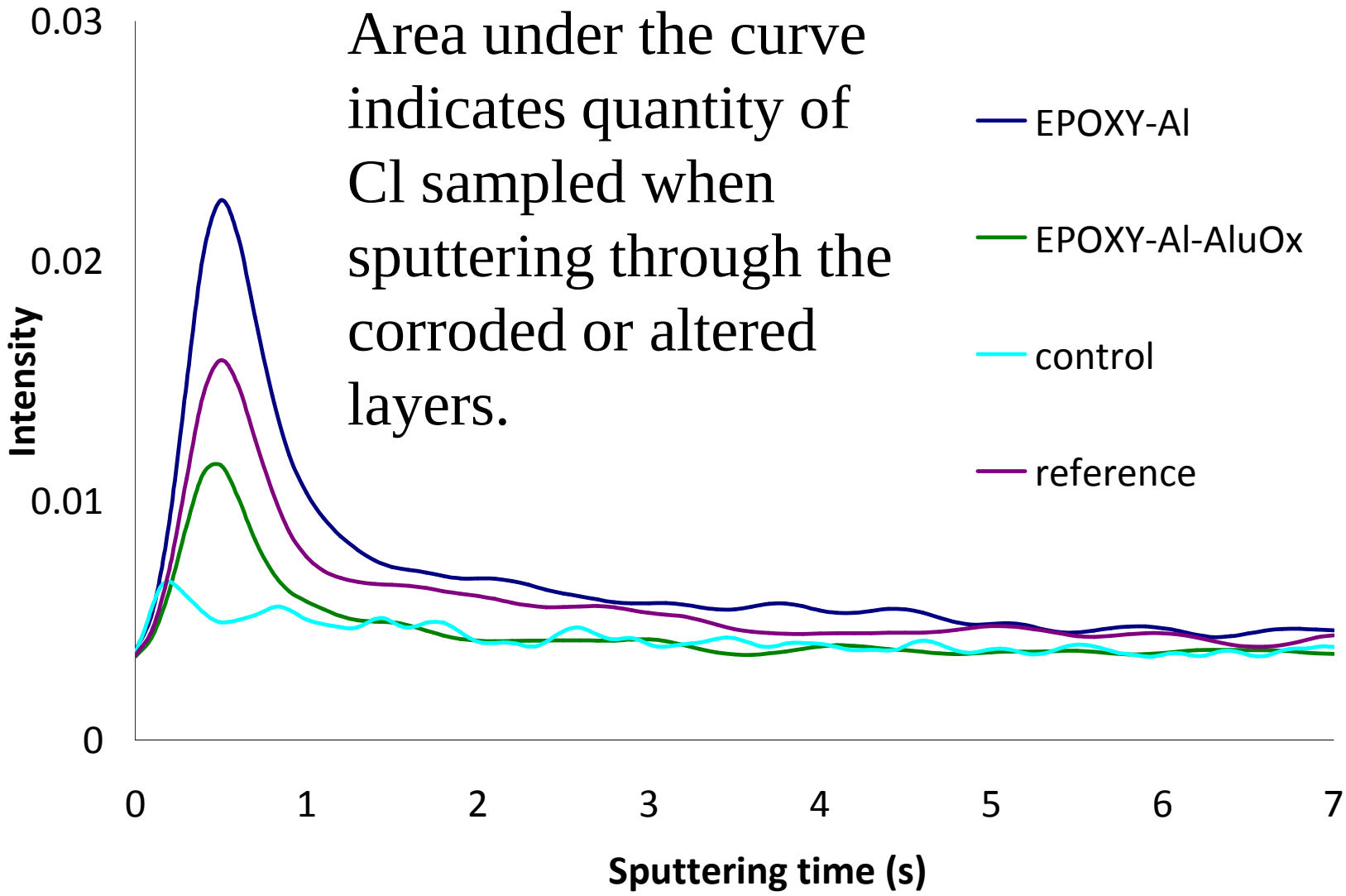
# Copper profiles of bare alloy





# Chlorine profiles of bare alloy

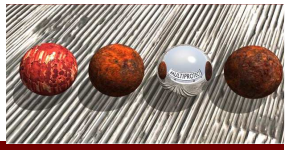
Area under the curve indicates quantity of Cl sampled when sputtering through the corroded or altered layers.



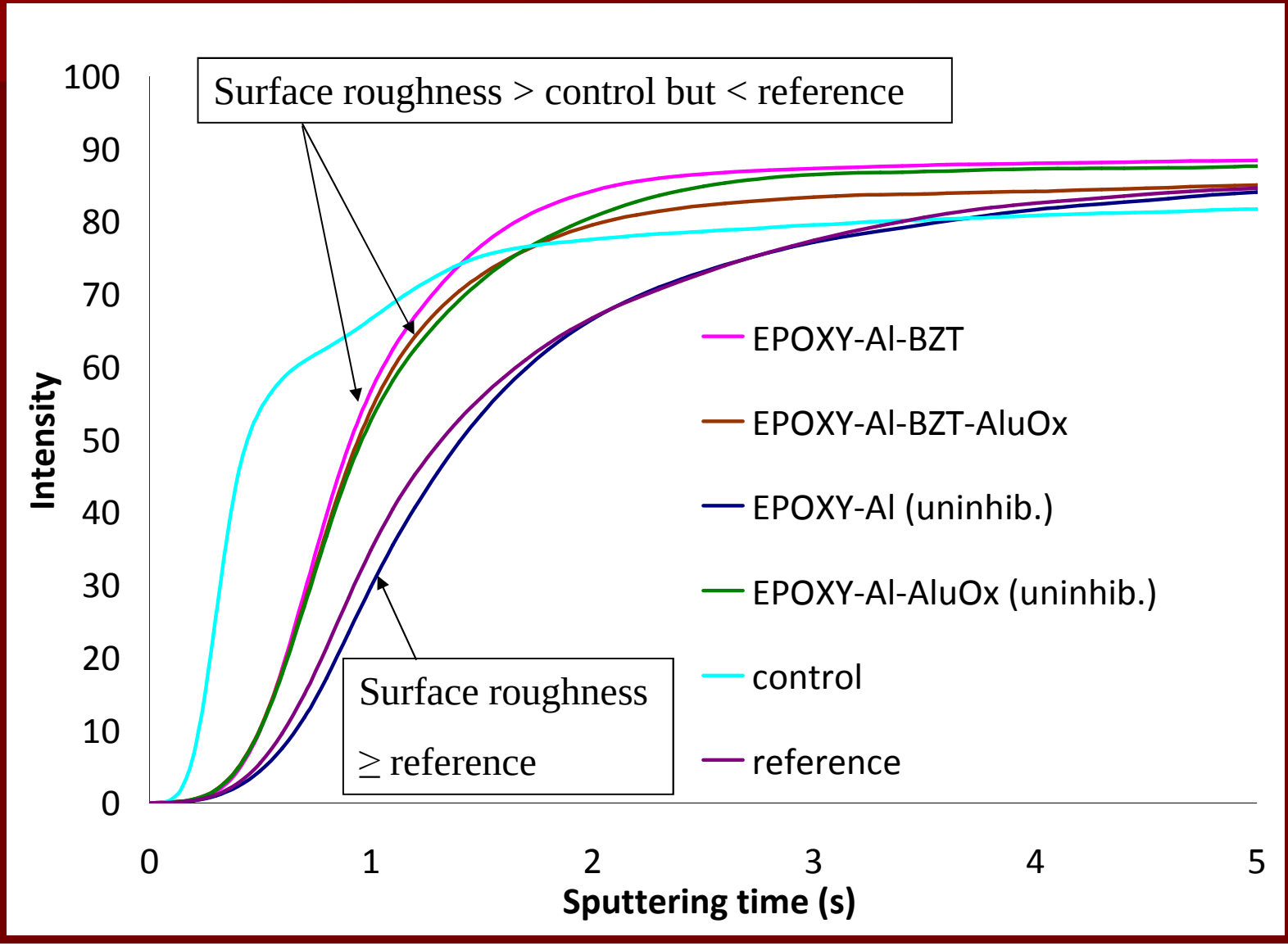
# Results and Discussion

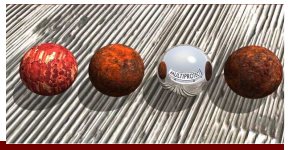
## Part 2:
## Elemental depth profiles of the bare alloy from cells incorporating BZT-inhibited coatings (INM)

*Surf. Interface Anal.* **2015**, 47, 1098 – 1108

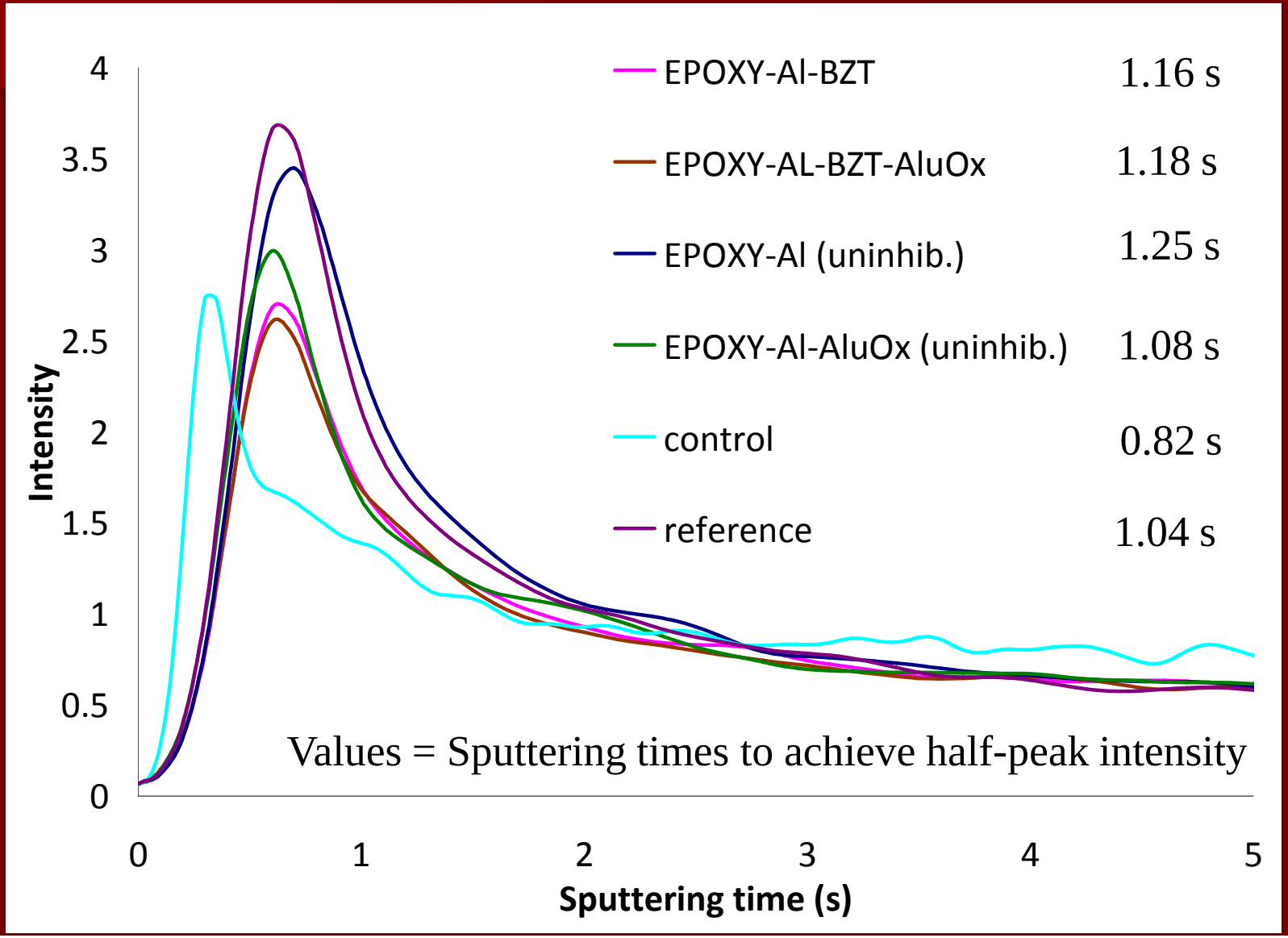


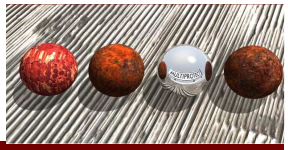
# Aluminium profiles of bare alloy



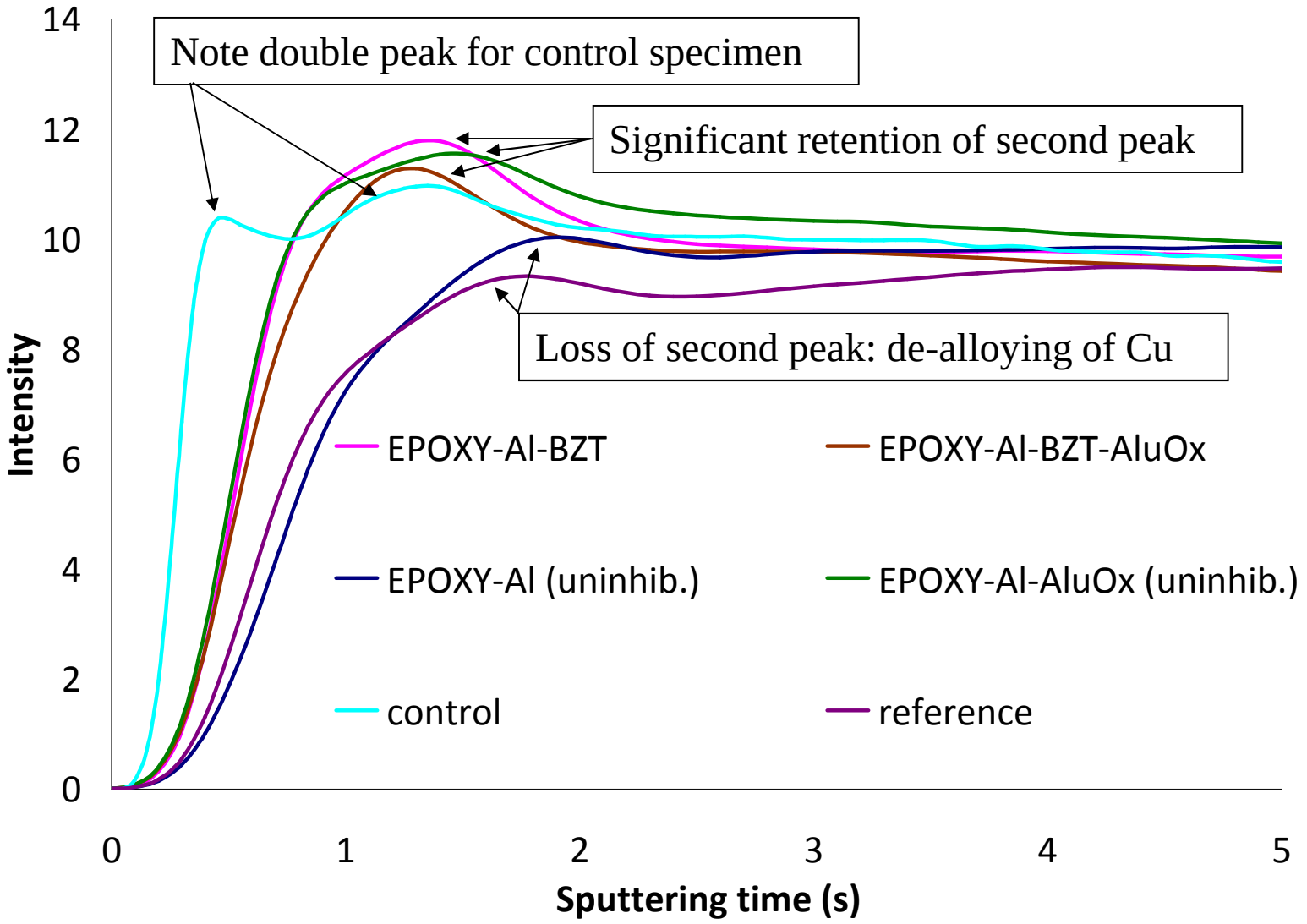


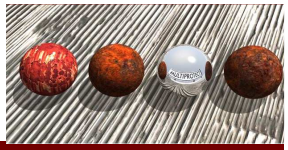
# Oxygen profiles of bare alloy





# Copper profiles of bare alloy





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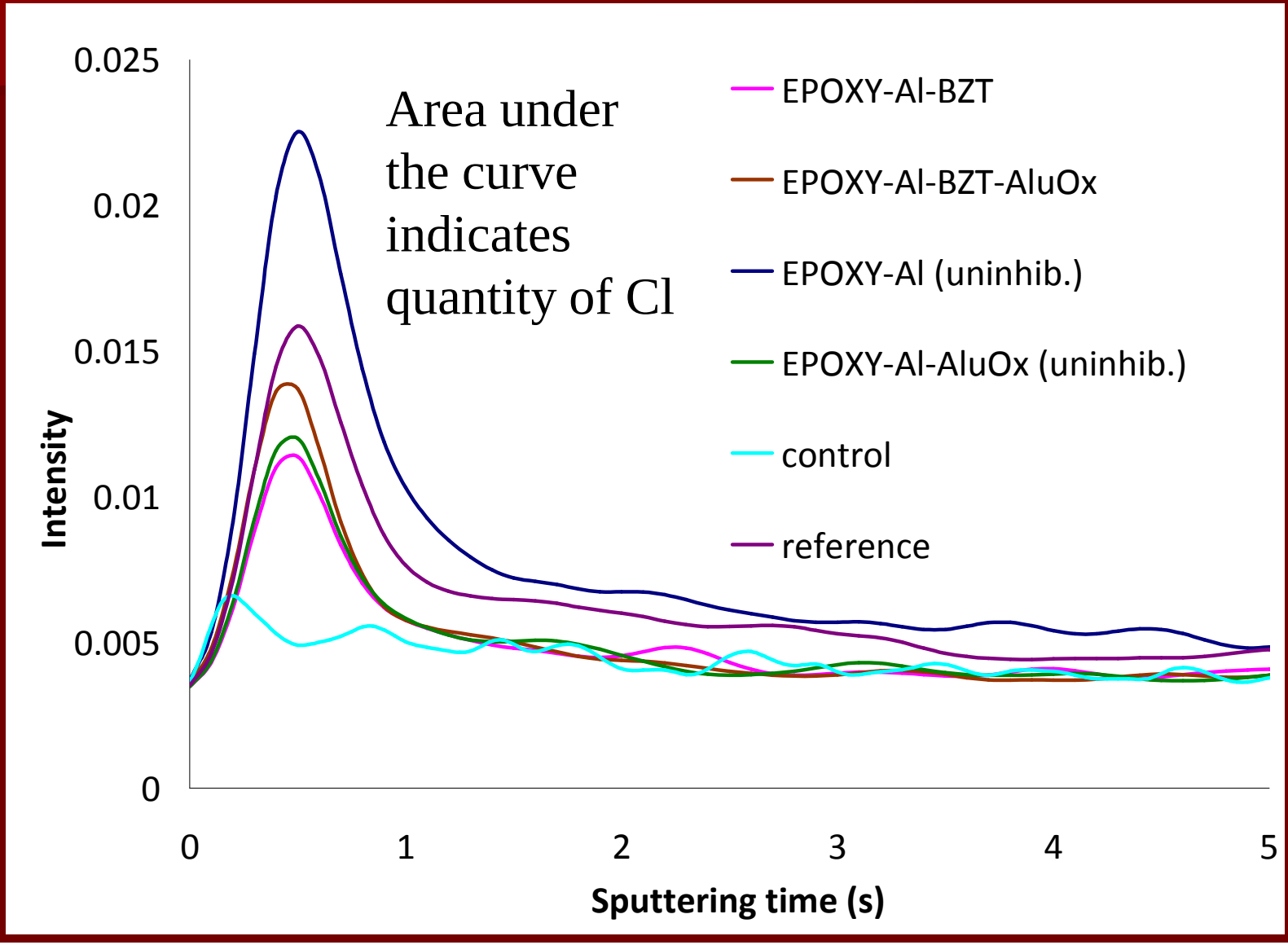
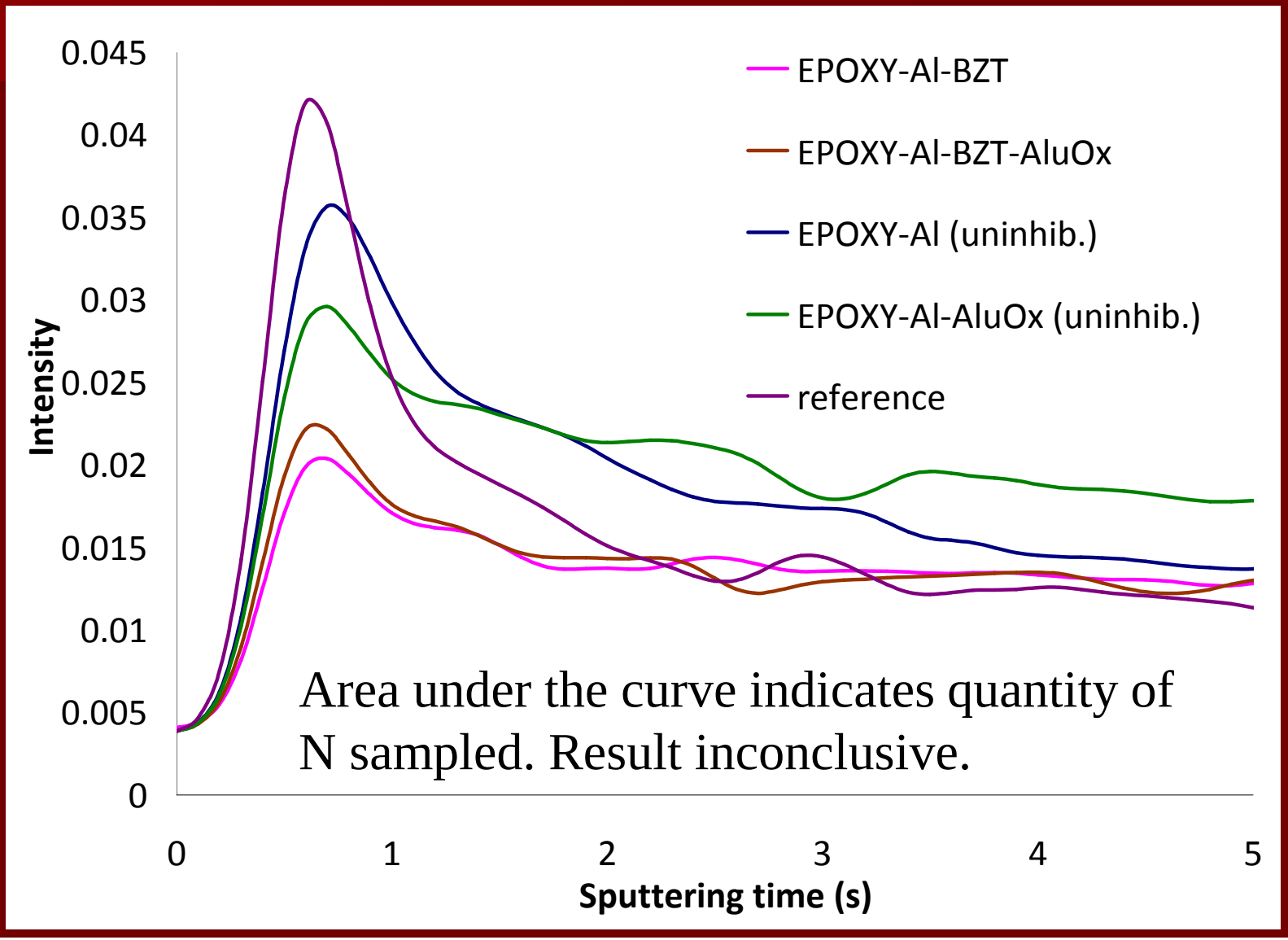
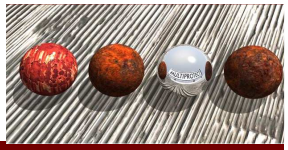


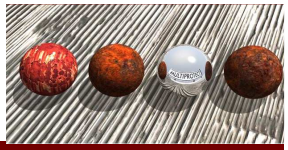
# Nitrogen profiles of bare alloy





# Summary and conclusions

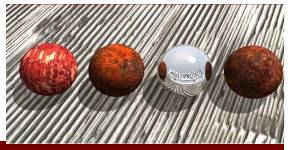
- Comparison of the intensity of corrosion of the bare alloy can be made by inspection of Al depth profiles.
- Comparison of thickness of corroded layers can be made by inspection of the O depth profiles.
- Assessment of extent of de-alloying and re-distribution of Cu can be made by inspection of depth profiles.
- An inhibitory effect of the empty AluOx nanocontainers, due to chloride absorption, was inferred rom the Cl depth profiles.
- Presence of BZT inhibitor could not be confirmed by inspection of N depth profiles.



# Additional Work

A third paper has been published detailing a study of depth profiles obtained by sputtering the bare alloy after corrosion in the presence of the inhibitor-doped specimens from EADS:

*Surf. Interface Anal.* **2016**, 48, 341 – 352



# Thank you...

...any questions?