Investigation on the physical-chemical and biological properties of Ti surfaces treated by AC Plasma Electrolytic Oxidation (PEO)

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S. Martinelli[1,2], M. Pavarini[1], A. Steeves[2], E. I. Alarcon[3], R. Chiesa[1], F. Variola[2]

[1] Department of Chemistry, Materials and Chemical Engineering "G. Natta", Politecnico di Milano, Milano, Italy [2] Department of Mechanical Engineering, University of Ottawa, Ottawa, Canada

[3] Department of Biochemistry, Microbiology and Immunology, University of Ottawa Heart Institute, Ottawa, Canada

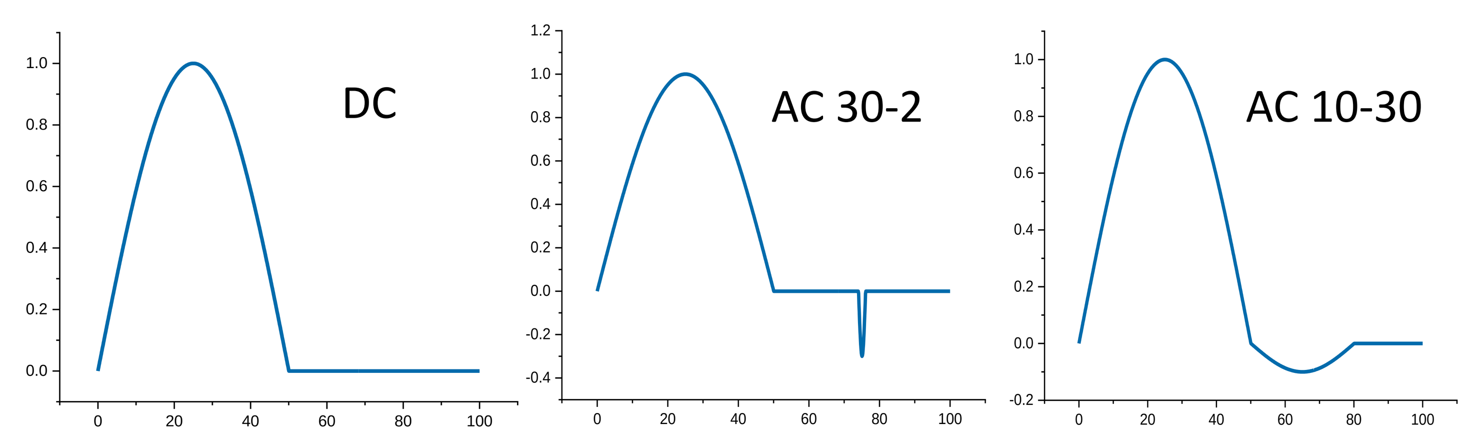
INTRODUCTION

- **Plasma Electrolytic Oxidation (PEO)** ➞ simple and cost effective electrochemical surface modification technique to produce thick and microporous coatings on Ti and its alloys[1].
- Localized surface melting ➞ easily **embed** doping **particles or ions** in the coatings[2] to provide **antibacterial** and **pro-osteogenic** properties.
- Doping agents:
  - **Copper** can provide contact killing antimicrobial properties[3,4].
  - **Zinc** can promote bone mineralization and osteoblast differentiation[5].

AIM OF THE WORK

- Exploit the **PEO** technique to provide **antibacterial** and **pro-osteogenic** properties to Ti surfaces for implantable devices.
- Investigation of the **effect of alternate current** on the surface in PEO, to evaluate its potential advantages over unipolar conditions.

ELECTROLYTE AND PROCESS CONDITIONS

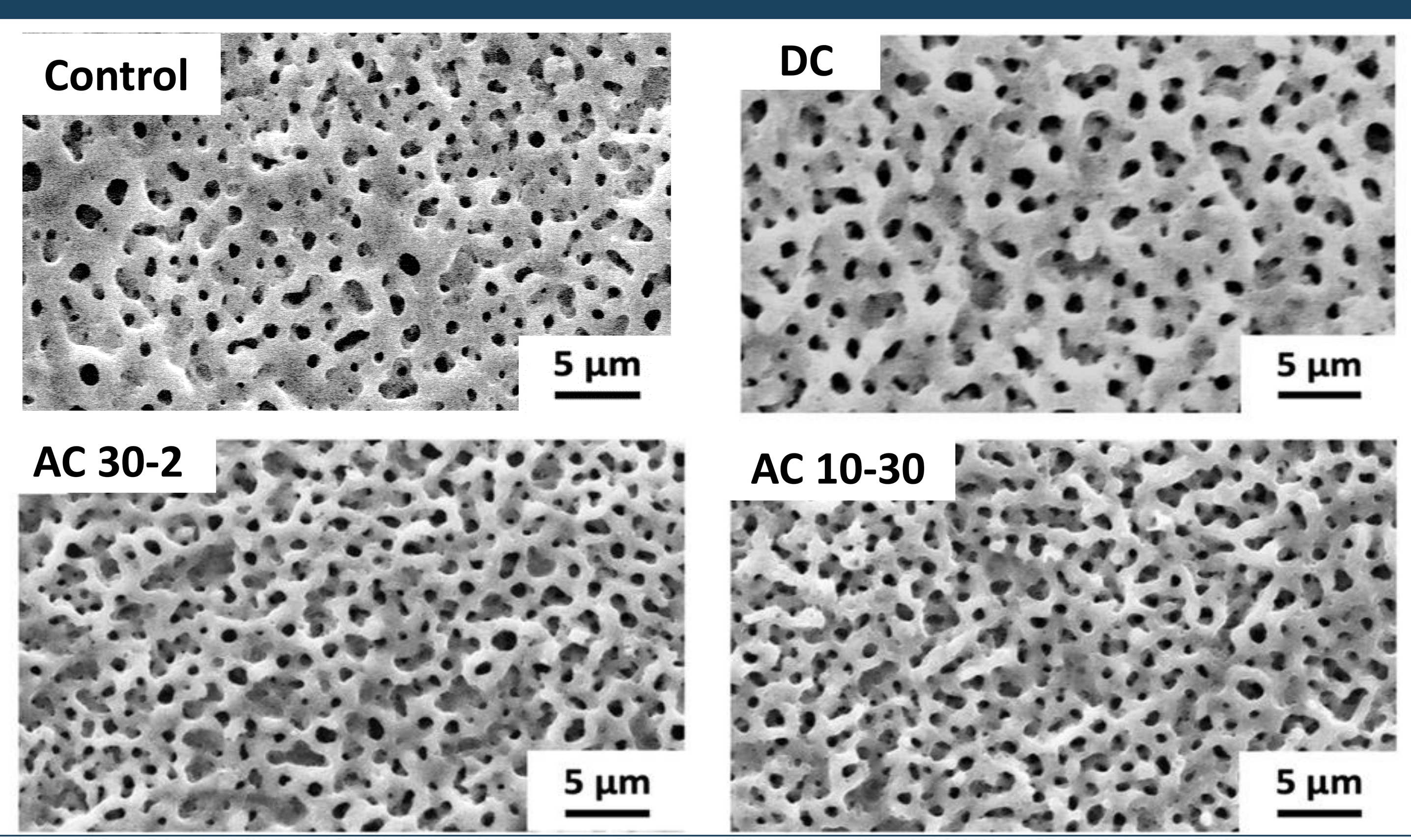


Electrolyte	PEO[6]	PEOCuZn[6]
$Na_2B_4O_7$	0.1 M	0.1 M
NaOH	0.1 M	0.1 M
Na_2SiO_3	0.02 M	0.02 M
$Cu(CH_3COO)_2$	-	2 mM
$Zn(CH_3COO)_2$	-	0.01 M

- Grade 2 cp-Ti discs (Ø 12mm, th. 0.67mm).
- Undoped and co-doped electrolytic baths.

	Control	DC	AC 30-2	AC 10-30
Termination voltage	300 V	300 V	300 V	300 V
Treatment duration	7 min	7 min	7 min	7 min
Anodic duty cycle	50%	50%	50%	50%
Cathodic duty cycle	-	-	2%	30%
Cathodic-Anodic ratio	-	-	30%	10%
Frequency	100 Hz	100 Hz	100 Hz	100 Hz
Solution	PEO	PEOCuZn	PEOCuZn	PEOCuZn

MORPHOLOGICAL CHARACTERISATION (SEM)

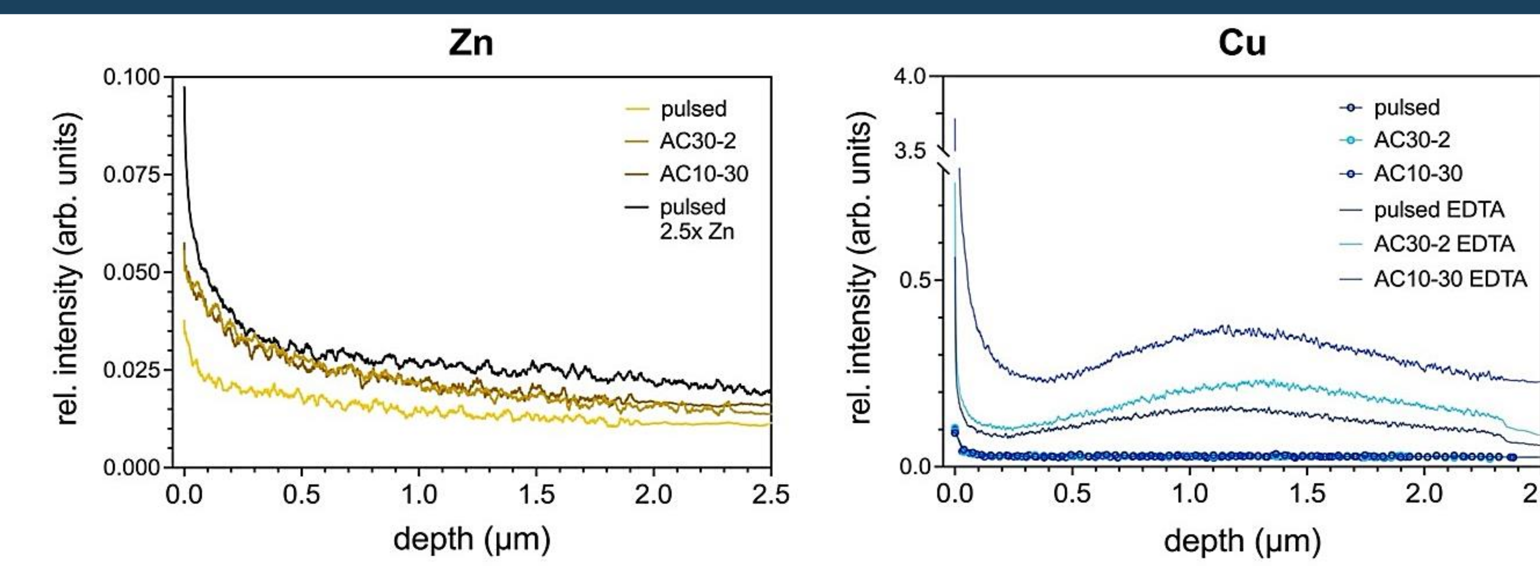


Homogeneous **microporous morphology.**

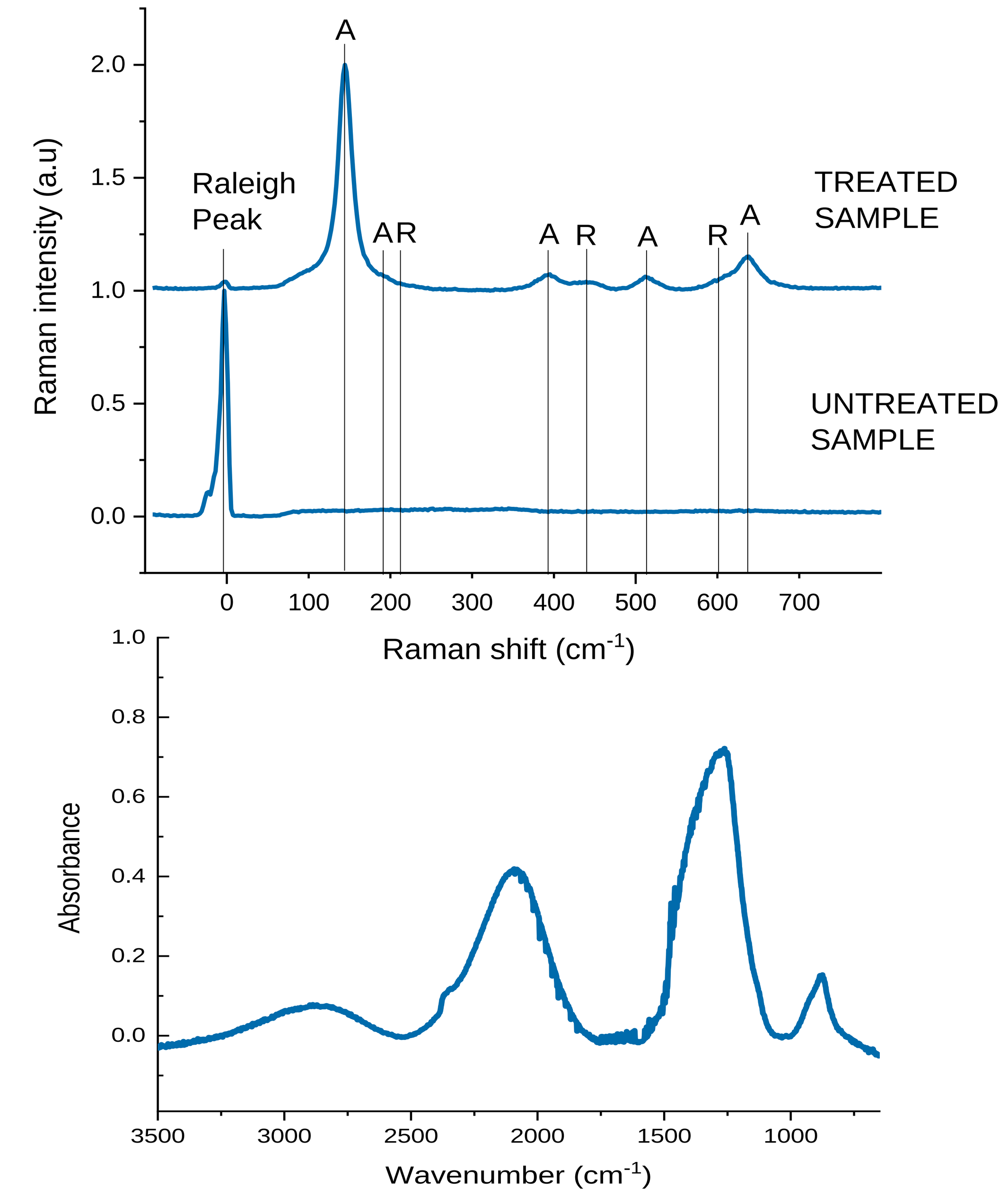
	PORE DIMENSION	POROSITY
Control	845 ± 257 nm	8%
DC	948 ± 204 nm	9%
AC 30-2	946 ± 177 nm	11%
AC 10-30	982 ± 199 nm	12%

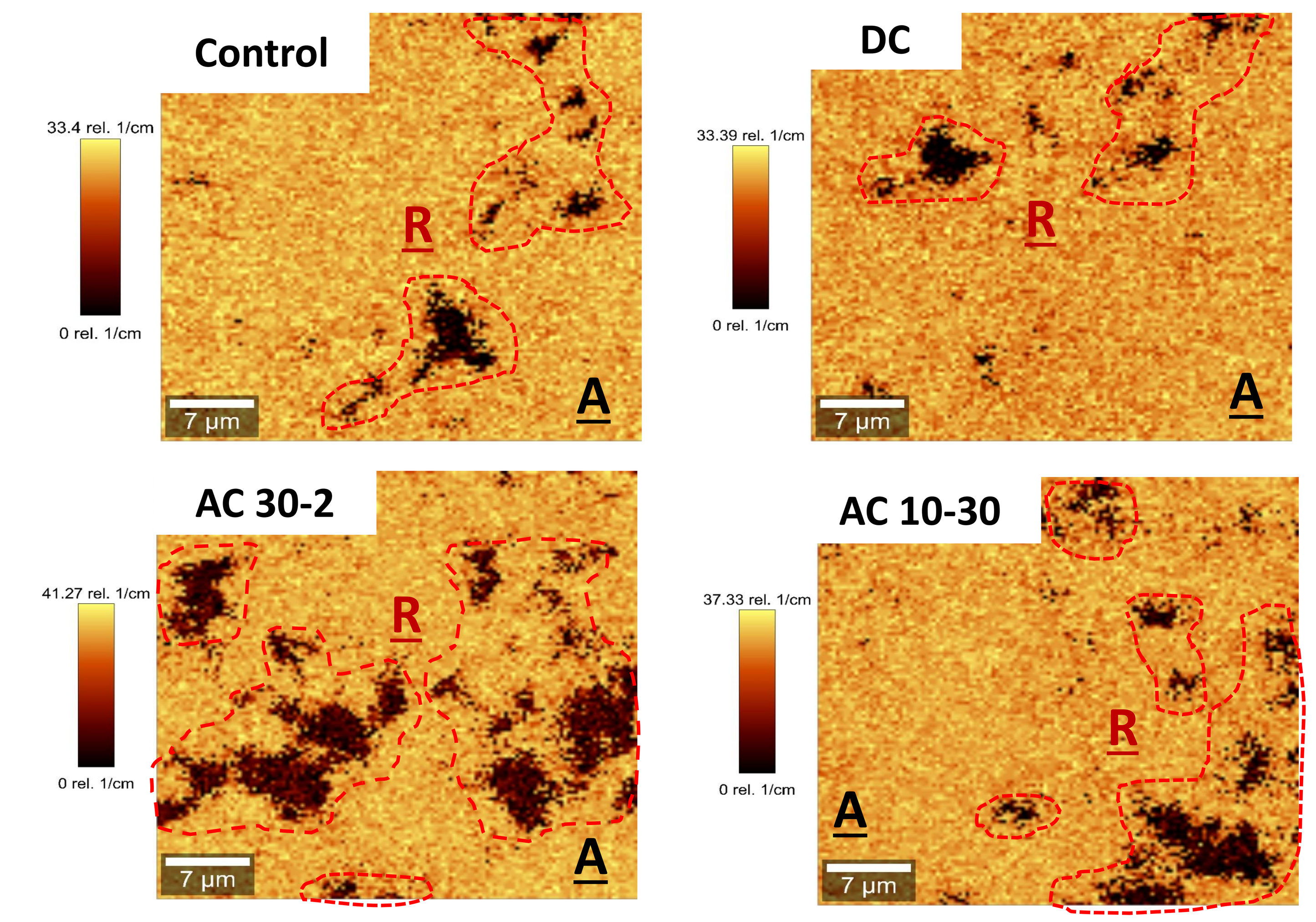
CHELATING AGENTS (GDOES)

- Addition of 2 mM **EDTA-Na_2** at solution PEOCuZn[6] as chelating agent for copper.
- Main **problem** ➞ EDTA instability
  - ↳ Dopants exponential depletion in the electrolytic bath with use.



PHYSICOCHEMICAL CHARACTERISATION (Raman + FT-IR)





- The treated surface has **both Anatase and Rutile** domains.
- The **Rutile domain's dimension changes** in between the same sample or different conditions.

CONCLUSIONS

Embedding of dopants with **AC** in PEO process **>** Embedding of dopants with **DC** in PEO process

- **Dopants** are mainly concentrated **on the surface** ➞ **antibacterial** effect.
- Embedding efficiency based on the **amplitude and position of the cathodic** duty cycle.
- The effect of the **cathodic phase is synergistic** with the introduction of **chelating agents**.

ONGOING & FUTURE WORK

- **Bioactive properties** ➞ HMSCs adhesion, proliferation, spreading and osteogenic differentiation by confocal microscopy and gene profiling assays.
- **Bacterial colonization and biofilm formation** on the doped PEO surfaces with *Pseudomonas*.
- **Stabilisation of EDTA** in PEO process changing the pH of the solution.

REFERENCES

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sara.martinelli@polimi.it