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MUSCULOSKELETAL INNOVATIONS

Development of Hard Antibacterial (TiN/Ag) Coatings on
Orthopedic Instruments Fabricated from Ti-alloys

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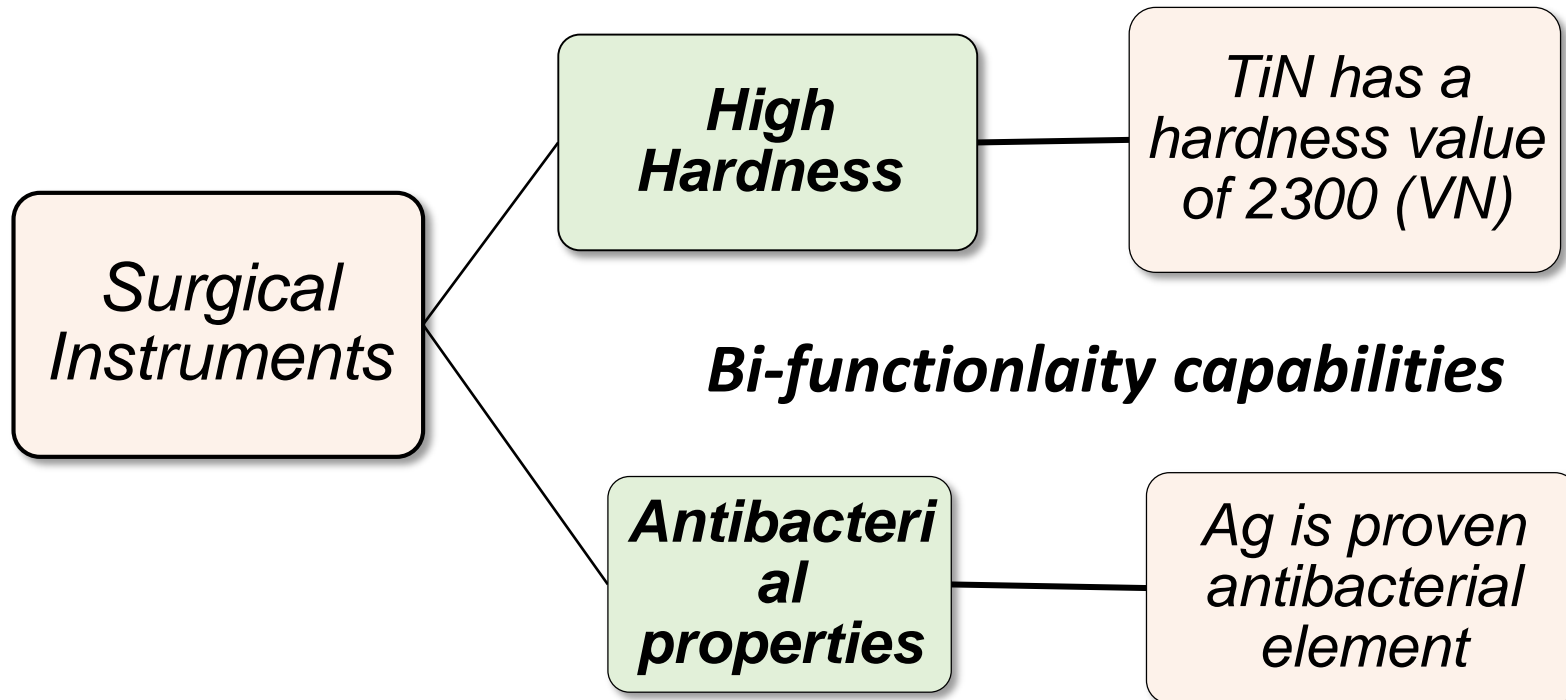
University of Toledo

Outline

- Introduction
- Project Aims
- Methods
- Project Progress & Next Step
- Milestones & Timeline
- Q & A

Introduction

Why TiN-Ag coatings ?



Processing Techniques

- ☐ Sputtering
- ☐ Ion-beam deposition
- ☐ Physical Vapor deposition

References:

1. Moseke C, Gbureck U, Elter P, Drechsler P, Zoll A, Thull R, Ewald A. Hard implant coatings with antimicrobial properties. *Journal of Materials Science: Materials in Medicine*. 2011; 22:2711-20.
2. Arcos T, Oelhafen P, Aebi U, Hefti A, Uggelin MD, Mathys D, Guggenhe R. Preparation and characterization of TiN–Ag nanocomposite films. *Vacuum*. 2002;67:463-70.
3. Zhao J, Cai XM, Tang HQ, Liu T, Gu HQ, Cui RZ. Bactericidal and biocompatible properties of TiN/Ag multilayered films by ion beam assisted deposition. *Journal of Materials Science: Materials in Medicine*. 2009;20:101.
4. Schmitz T, Warmuth F, Werner E, Hertl C, Groll J, Gbureck U, Moseke C. Physical and chemical characterization of Ag-doped Ti coatings produced by magnetron sputtering of modular targets. *Materials Science and Engineering: C*. 2014;44:126-31.

Project Aims

Specific aim 1: To determine and optimize the parameters for magnetron sputtering process to produce TiN/Ag coatings on Ti6Al4V substrates, by evaluating the coating integrity by XRD, SEM, micro- and nano-hardness and comparing the data to commercially available TiN coated orthopedic instruments.

Specific aim 2: Examine the antibacterial properties by correlating Ag⁺ release kinetics with the zone of inhibition and two-color fluorescence assay with common bacteria such E. Coli.

Specific aim 3: Determine the impact of repeated autoclave cycles of the coated substrates/instruments on the antibacterial properties.

Methods-Fabrication

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Magnetron Sputtering (PVD)

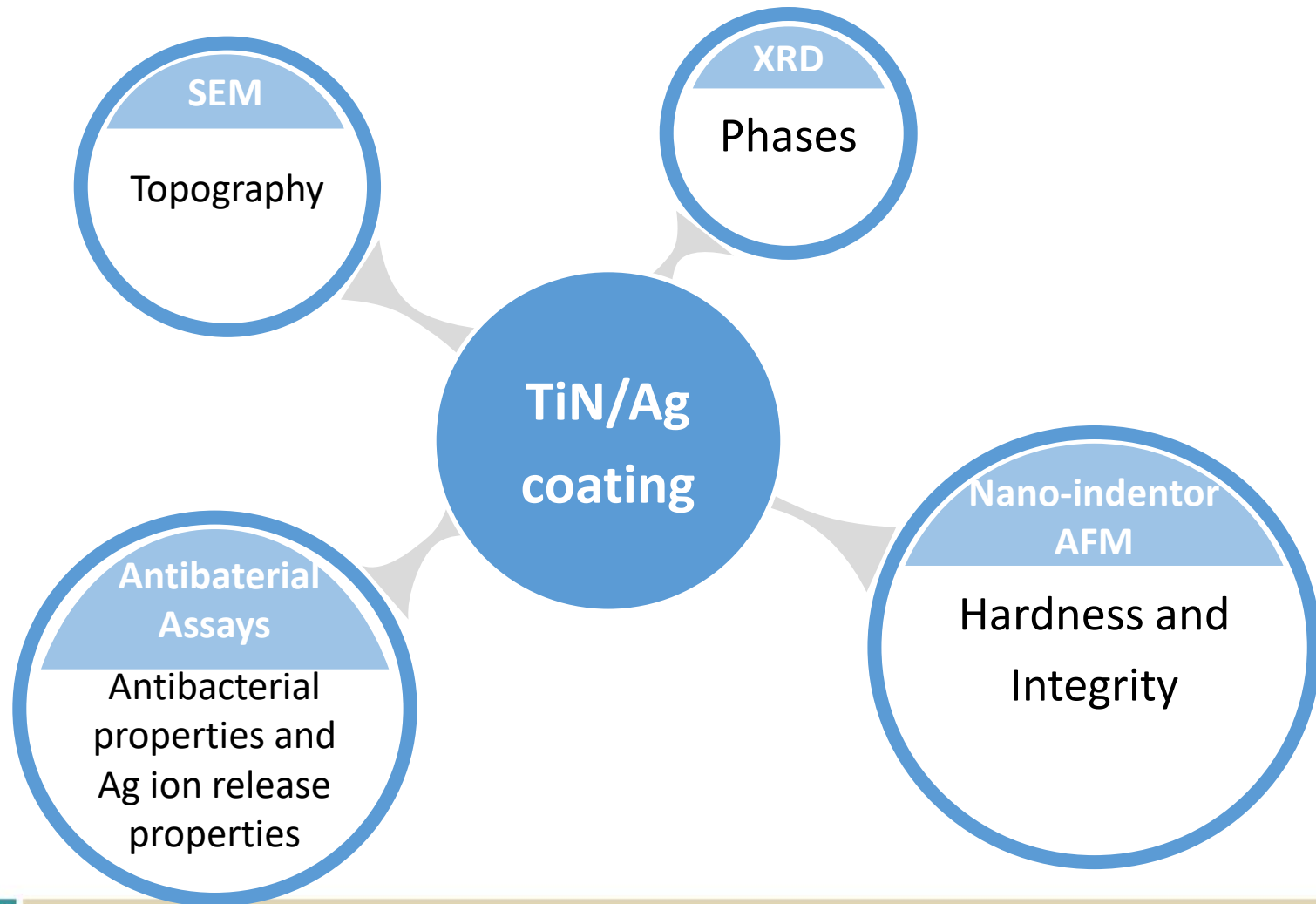
- ❑ Different materials can be coated on substrates simultaneously and uniformly.
- ❑ Makes the coatings compact and bond tightly onto the substrates.
- ❑ Different silver Ag contents coatings can be formed by the changing process parameters.

The Set-Up



Methods-Characterization

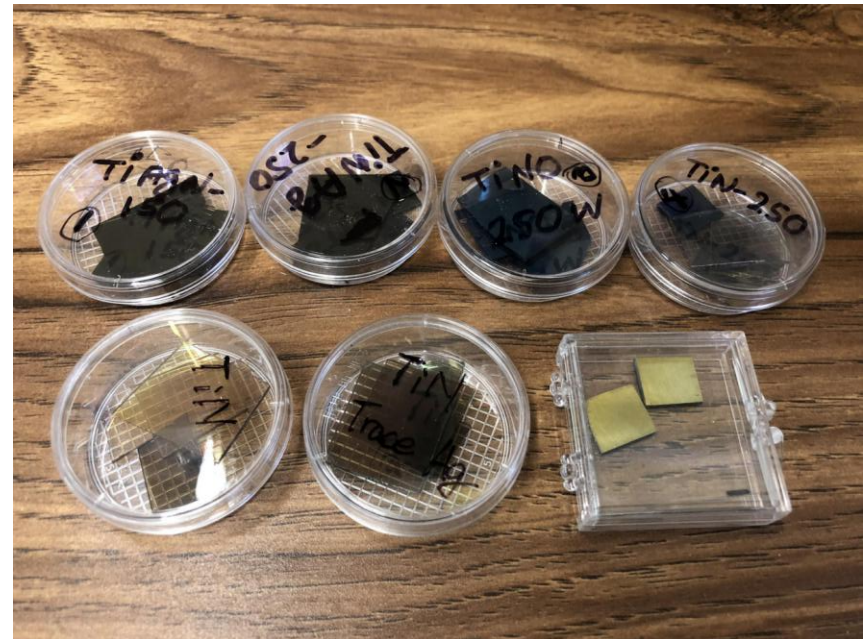
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Project Progress

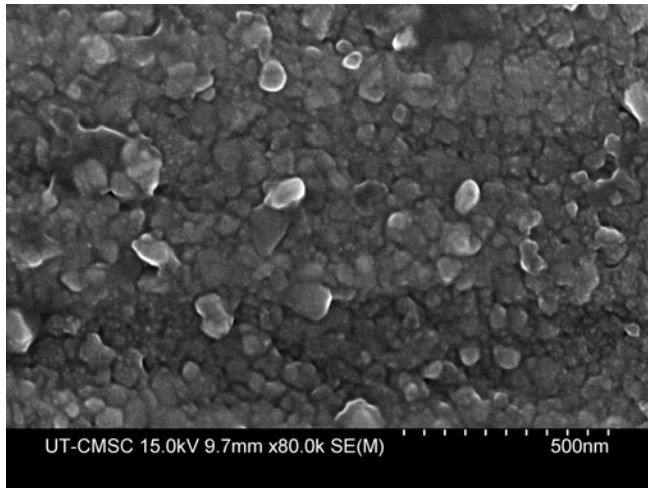
Samples with different parameters

Samples are prepared on both Ti and glass substrates in order to remove background effects.

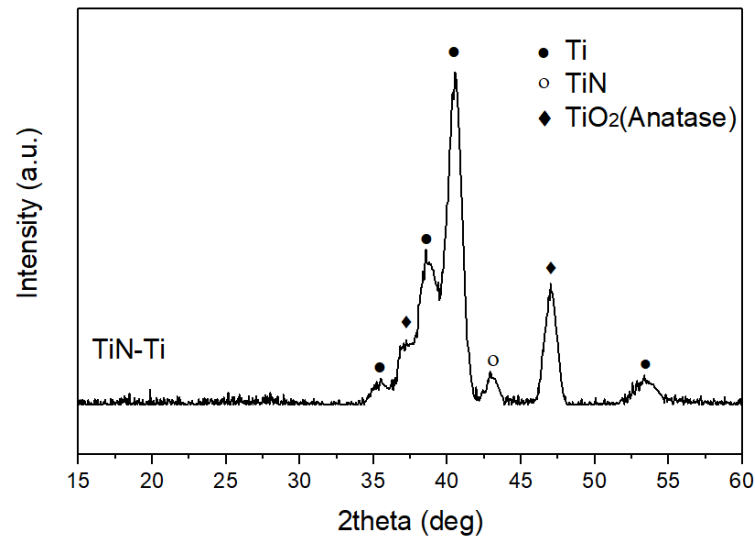


Project Progress

TiN coating on Ti substrate



SEM image shows compact coating grains.



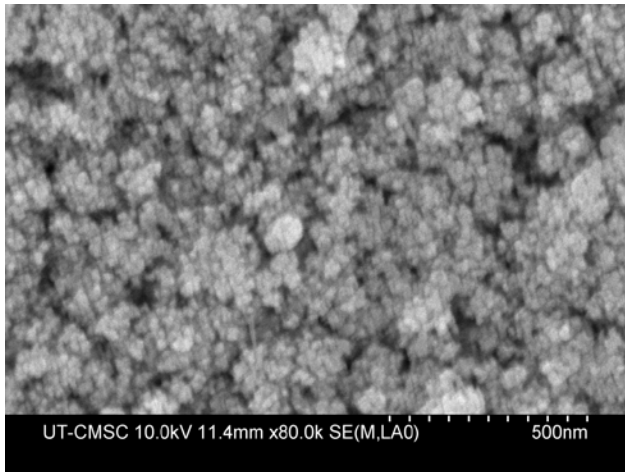
XRD pattern

Rf Power	Ar/N ₂	O ₂ /N ₂	Silver added	Substrate heated
150W	1/1	0.01	No	Unheated

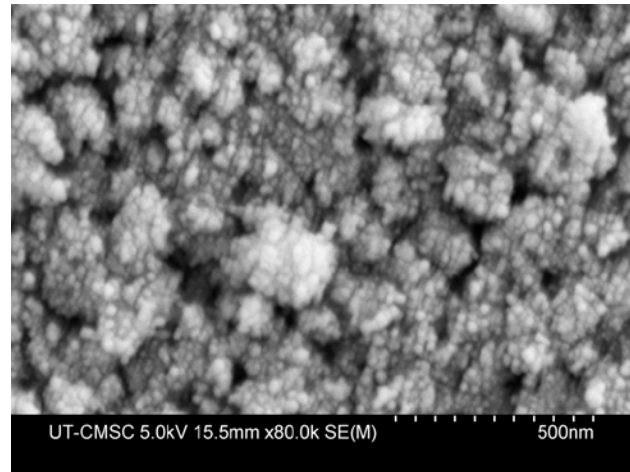


Project Progress

Coatings on glass substrates



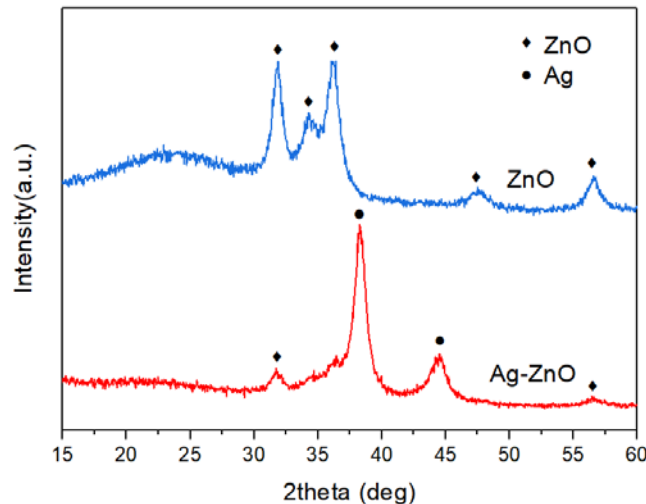
SEM image of ZnO coating
(Due to system contamination)



SEM image of ZnO-Ag coating
(Due to system contamination)

Project Progress

Coatings on glass substrate



Zn was not added purposefully. It can be a trace of contamination from unknown source.

XRD patterns of two set of samples

	Rf Power	Ar/N ₂	Area ratio Ag/Ti	Substrate heated
ZnO	150W	1/1	0	Unheated
Ag-ZnO	250W	1/1	0.1	Unheated

Project Progress

Antibacterial Properties

- Zone of inhibition method can show the antibacterial property and Ag⁺ release kinetics of coatings.

No antibacterial property was shown from ZOI method.

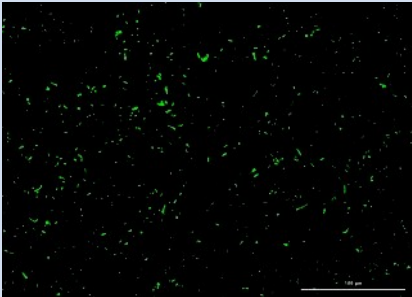
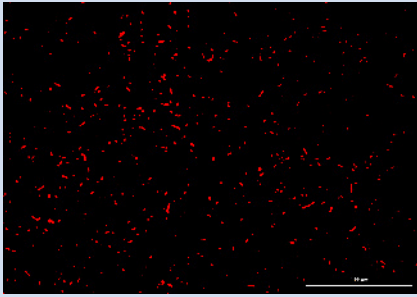
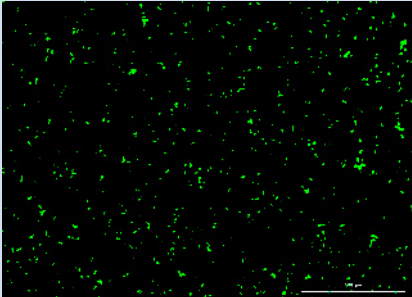
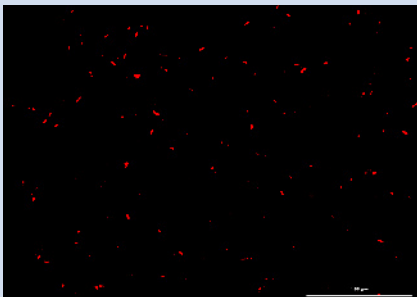
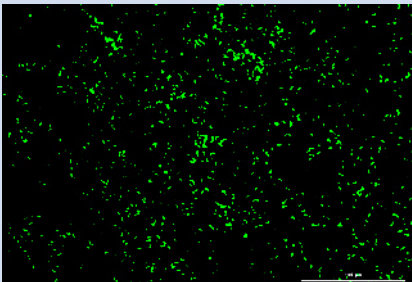
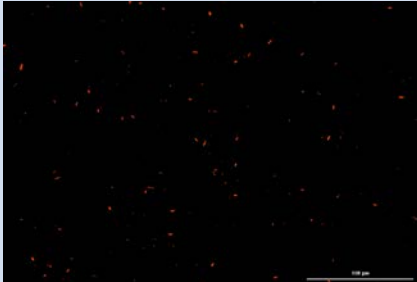
- Two-color fluorescence assay was used to characterize the contact killing property of coatings.

LIVE/DEAD BacLight Bacterial Viability Kit L7012 (Syto9/PI) was employed as dyes and the stained samples was analyzed by Cytation 5.

The results showed that Ag doped coatings process contact killing antibacterial property.

Project Progress

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Samples	Green	Red
Ag-ZnO coating(glass)		
ZnO coating(glass)		
Pure glass		

Next Step

- Remove system contamination
- Combination of TiN and Ag
- Measure the nanohardness of synthesized coating

Milestones & Timeline

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Q & A

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Thank You