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SSOE Research Symposium Dean's Awards

Title

Tantalum Coated Zirconia to Toughen Dental Implants

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Peer reviewed

MOTIVATION, CURRENT STATE OF THE ART & **PROJECT GOALS**

Currently, around 50% (~178 million) More brittle than titanium of all Americans are missing at least 1 tooth, with 12% (~40 million) Our goal is to improve the fracture of all Americans missing all of their teeth.



The two materials currently used for dental implants are zirconia and titanium.



Figure 4. Non-sintered doped samples, with a darker pink color indicating a higher dopant concentration

Zirconia is a safer alternative to titanium for dental implants.

- Inert; will not trigger allergic reactions in the body or corrode

toughness of zirconia dental implants by ≥80%. Increasing the fracture toughness means the implant will last longer.

So why Tantalum? In Y-TZP (Yttria stabilized zirconia polycrystal), yttria is added to zirconia to stabilize the tetragonal phase. Adding tantalum as an additional dopant will achieve phase stability and even greater toughness through a phase transformation toughening mechanism.

CHARACTERIZATION -

SEM (Scanning Electron Microscopy) is used to look at grain size. XRD (X-Ray Diffraction) determines the phases present in each sample. Nanoindentation allows us to measure the fracture toughness, elastic modulus, and hardness. Raman spectroscopy visualizes how phase composition changes after transformation toughening occurs.

TIMELINE

Tantalum Coated Zirconia to Toughen Dental Implants



Gabriel Reginato, Kimberly Kwandy, Haoyang Sun, Dean Osilla, Anthea Segger, Lara Victorino (All MSE Majors)



PROJECT DESIGN - Ceramic samples (Y-TZP & ATZ (alumina-toughened zirconia)) were manufactured and each one was dipped in a solution containing various concentrations of tantalum ions to investigate how the properties of the material change as the dopant is increased. The samples will also be hydrothermally aged at a high temperature to simulate the effects of 20 years of use. This allows us to investigate how tantalum helps protect zirconia from degradation over time.

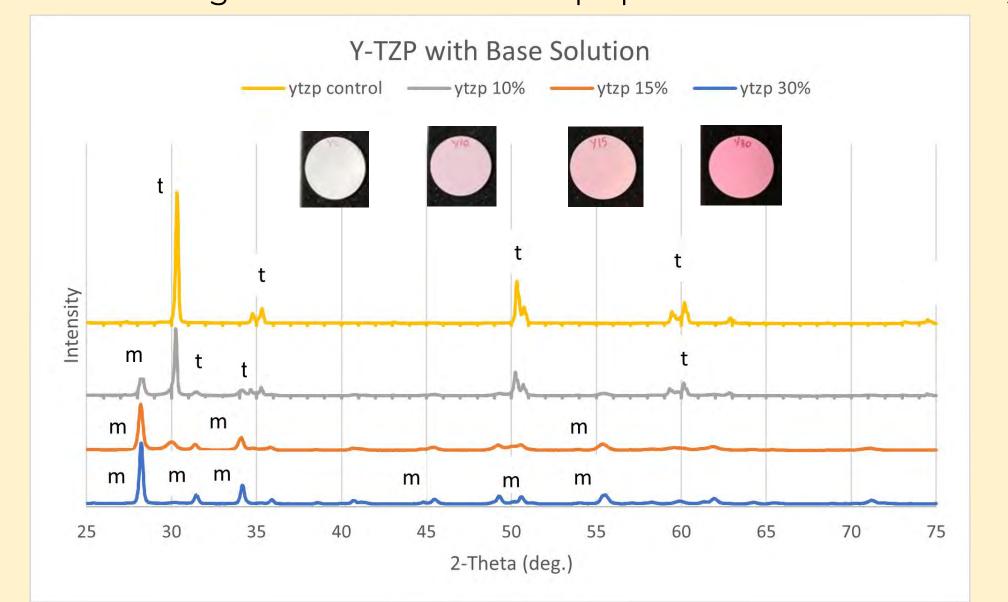


Figure 1. XRD spectra of Y-TZP samples

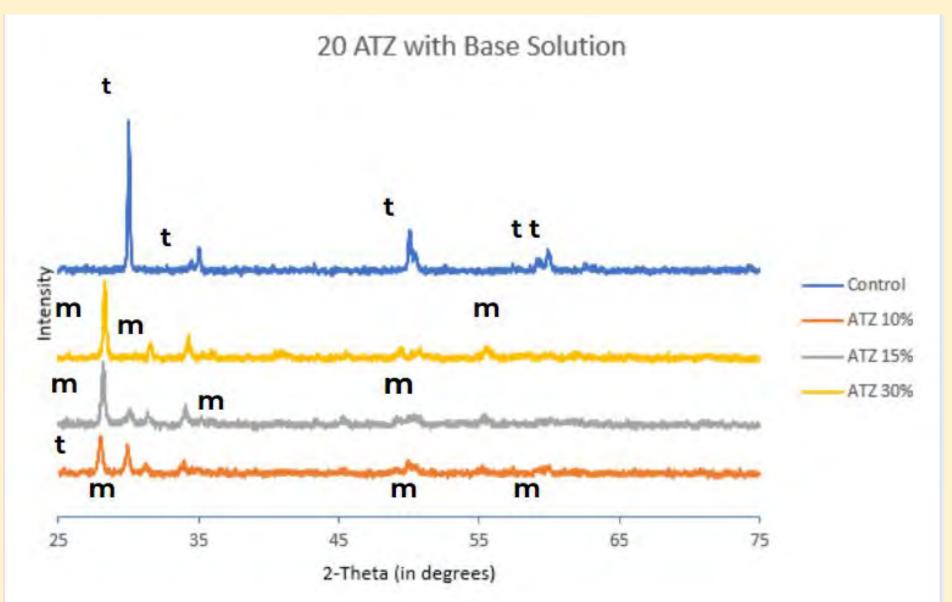


Figure 2. XRD spectra of ATZ samples

The XRD graphs in Figures 1 and 2 show how the phases (crystal structure) in the Y-TZP and ATZ change as tantalum is added. As dopant percentage increases, the crystal structure becomes more monoclinic; this is a more stable phase.

TEAM ROLES & CONTACT INFO

Name	Role & Specialization	Email
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The SEM images in Figure 3 show how the Average Grain Size (AGS) in the ceramics change as tantalum is added. As dopant percentages increases, the grain size decreases.

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Sample	3YC	3Y10	3Y15	3Y30	ATZ C	A10	A15	A30
AGS(µm)	0.7626	0.71785	0.569	0.56565	0.7935	0.69355	0.645	0.68495

Figure 3. SEM images of grain structures

Glidewell Senior Design Winter & Spring Quarters

Task Name			Feb				Mar			Apr				M	May			
	Jan 30	Feb 6	Feb 13	Feb 20	Feb 27	Mar 6	Mar 13	Mar 20	Mar 27	Apr 3	Apr 10	Apr 17	Apr 24	May 1	May 8	May 15	May 22	May 29
Nanoindentation Sample Prep						Anthe	a / Gabe											
Nanoindentation										Anthea / Gabe								
Raman Sample Prep: Sandblasting						Anthe	a / Gabe											
Raman											An	thea / Gabe						
XRD Phase 1				Kimbe	irly / Lara													
LTD of XRD samples					Kimberl	y / Lara												
XRD Phase 2 (LTD)					4		Kimber	ly / Lara										
SEM Sample Prep: Thermal Etch and Sputtering				Dean Dean	Haoyang													
SEM / EDS					1		Dean	/ Haoyang										
Rough Draft of Technical Report														All				
Technical Report Revisions and Edits																	All	
Final Report																		

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Images of teeth and samples courtesy of Glidewell.

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Sponchia, G. Orthorhombic phase stabilization and transformation phase process in zirconia tantalum-doped powders and spark plasma sintering systems.