Tantalum Coated Zirconia to Toughen Dental Implants

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Glidewell

MOTIVATION, CURRENT STATE OF THE ART & PROJECT GOALS

Currently, around 50% (~178 million) of all Americans are missing at least 1 tooth, with 12% (~40 million) 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
- More brittle than titanium

Our goal is to improve the fracture 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.

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.

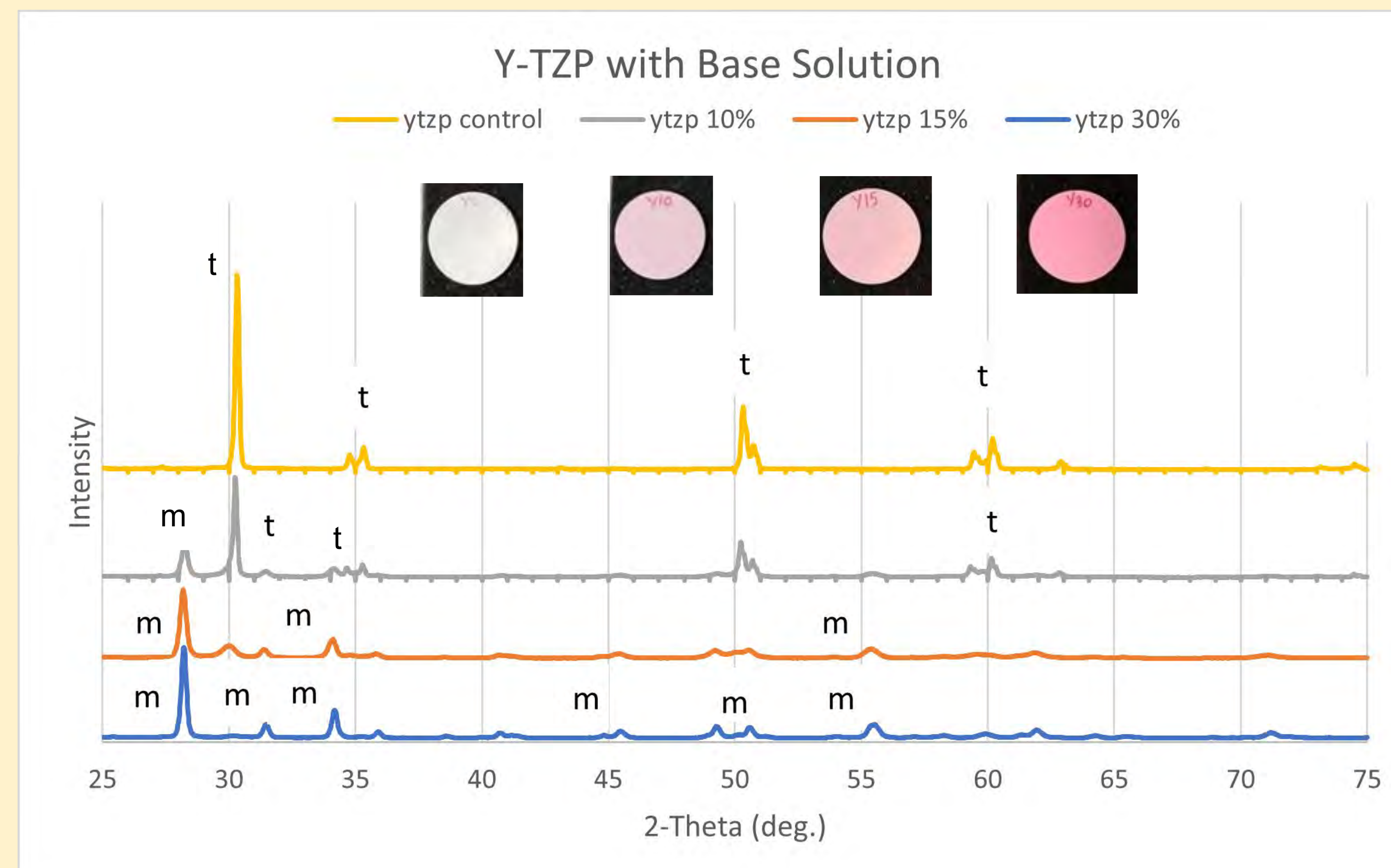


Figure 1. XRD spectra of Y-TZP samples

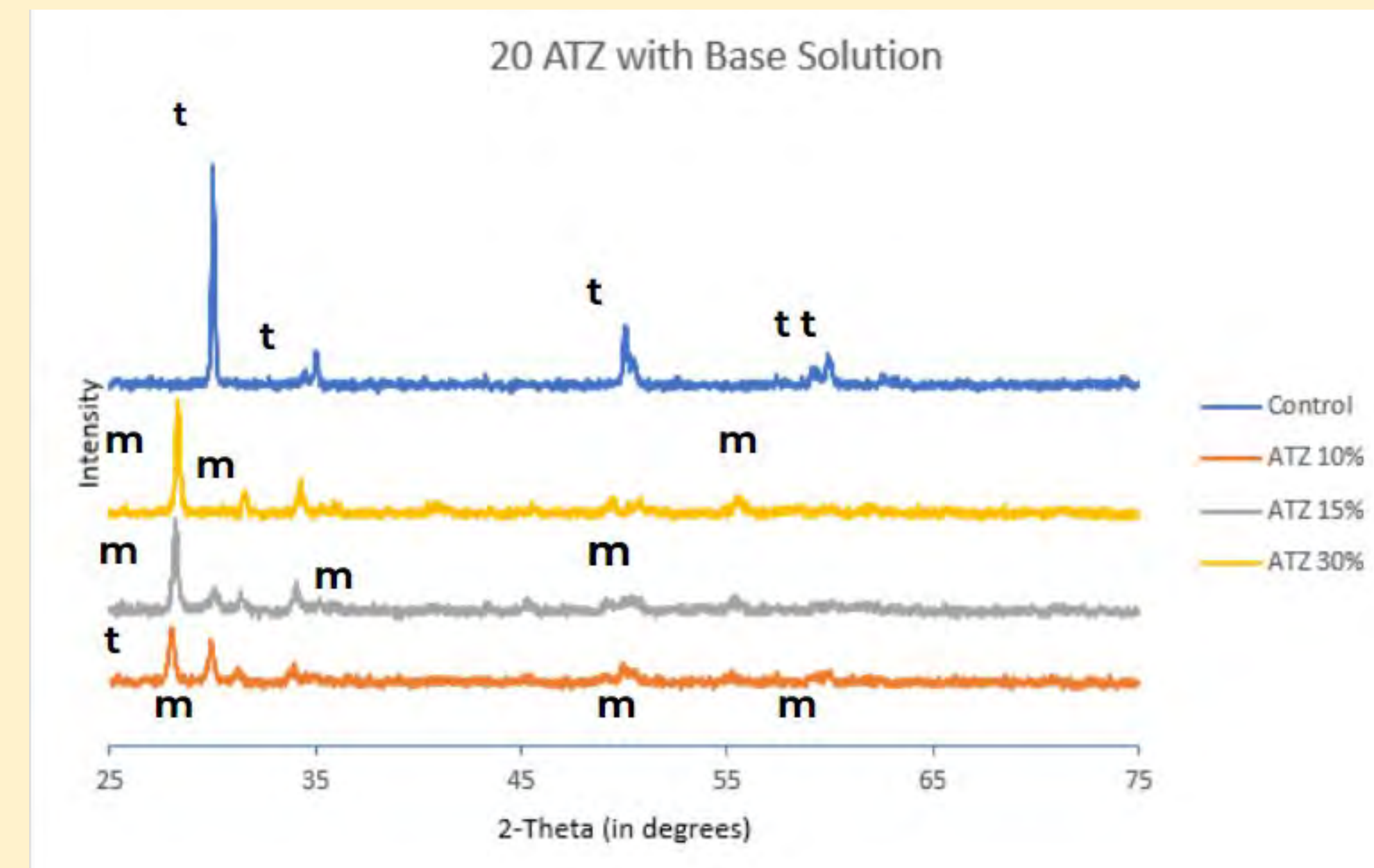
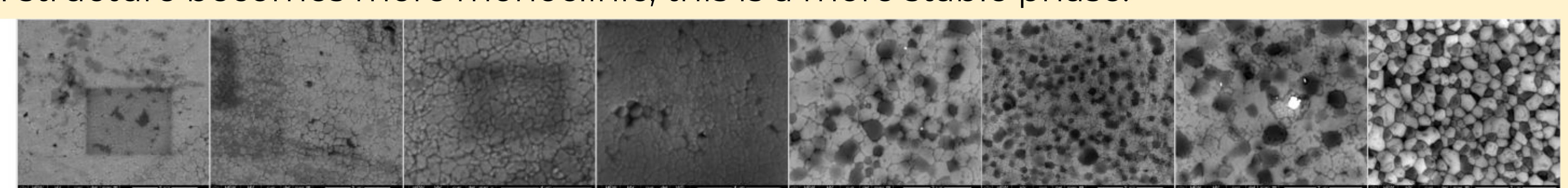


Figure 2. XRD spectra of ATZ samples

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.

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.



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

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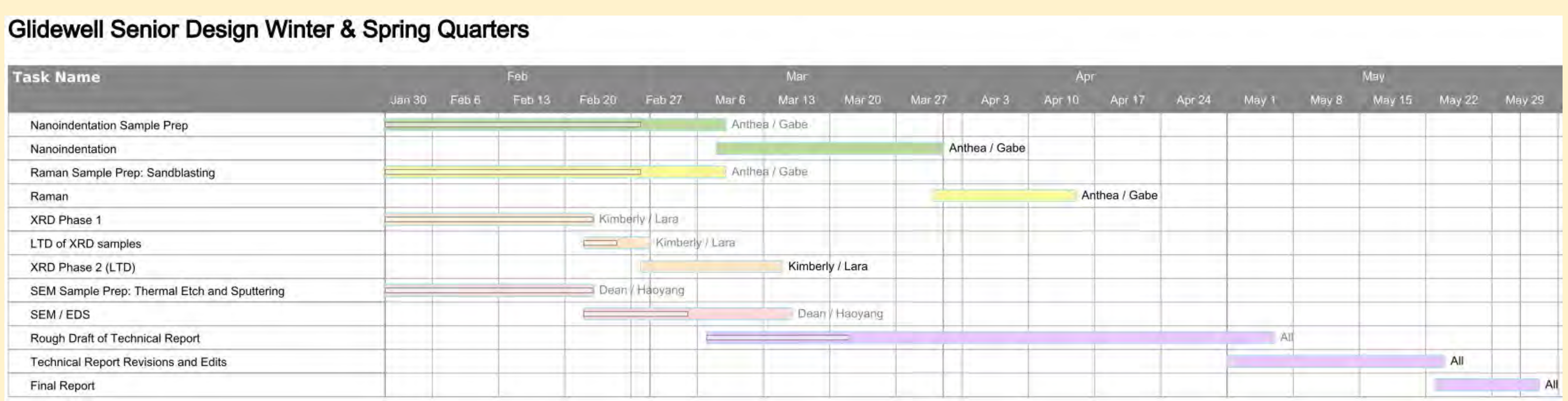
TIMELINE



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Images of teeth and samples courtesy of Glidewell.

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