Evaluating TiNbZr Alloy for Biomedical Applications

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BACKGROUND

OBJECTIVE & MOTIVATION :

The aim of this work is to evaluate a favorable composition of a Titanium, Zirconium, Niobium alloy. Samples were created and the degradation and biocompatibility properties were assessed.

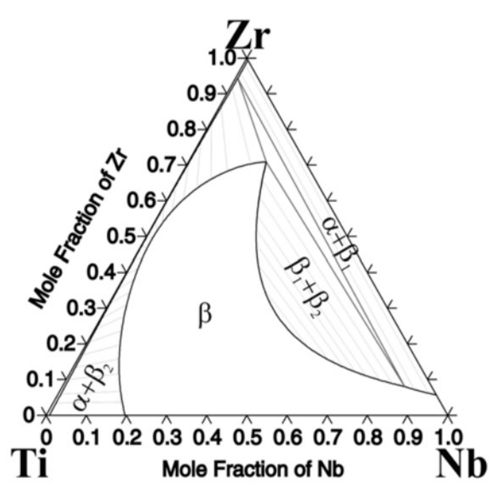


Fig. 1 Calculated cross-section at 843 K[1]

The favorable crystalline phase for this work is BCC. These BCC alloys have properties such as thermal memory (shape memory) and super elasticity. This makes them an ideal candidate for biomedical applications such as bioagent defeat, stents, orthopedics and orthodontics, amongst other things. With this in mind aa Ti-25Nb-8Zr alloy was created.

MATERIALS & METHODS :

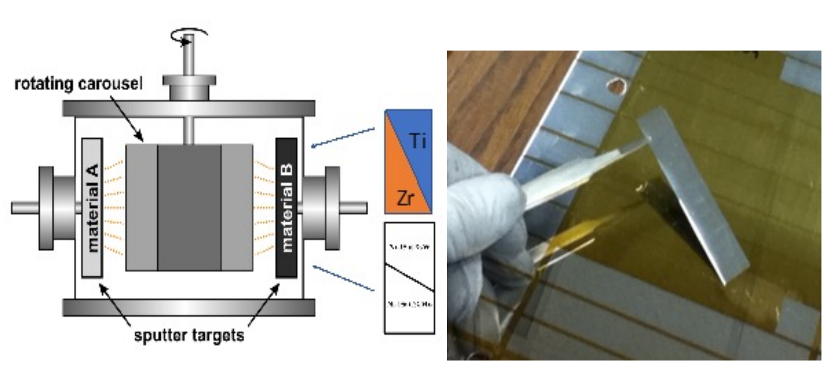


Fig. 2 Sputtering set-up and thin film sample[3]

The initial plan was for the samples to be created using Sputtering. Sputtering is a form of physical vapor deposition (PVD) and occurs when an energetic particle impacts a first surface, which is also known as a target. This would have produced thin films as samples.

Weigh Out Powders — Measure the correct amount of powders for the Ti-25Nb-8Zr composition

Create Metal Pellets — Combine the powders and compress them to 5 tons in a die press to create pellets

Sinter Pellets — Place pellets in the furnace for 5 hours at 1100 °F

Biocompatibility Testing — Plasma coat and sterilize pellets, do cell culture on/around them

Corrosion Testing — Create modified SBF solution and keep pellets in it for 0-7 Days

This is the plan that was executed

RESULTS

BIOCOMPATIBILITY TESTS :

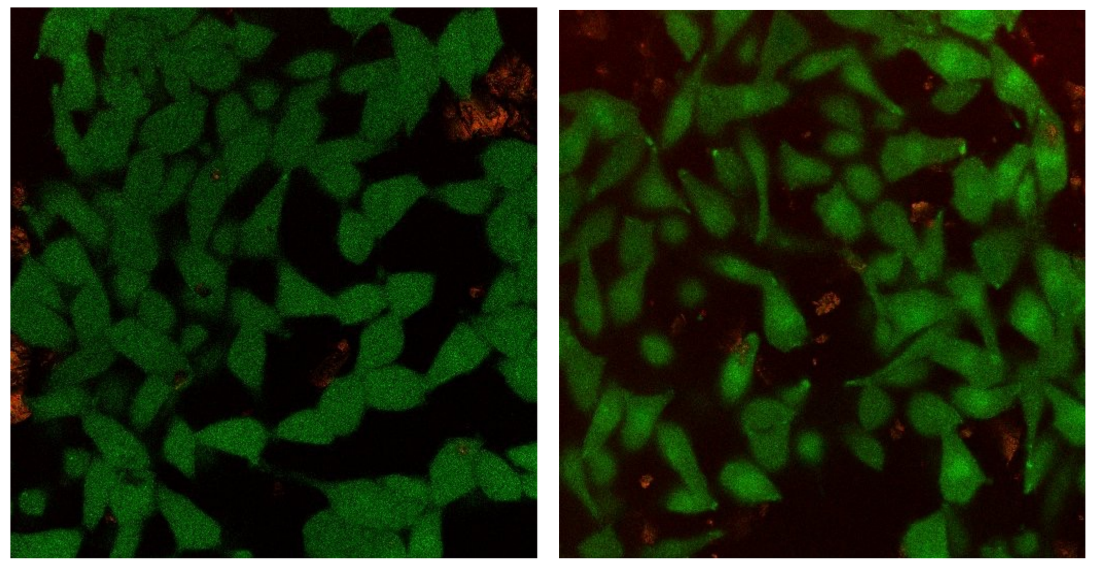


Fig. 3 Cells Cultured on Dish containing **TiNbZr** Pellet, Cell Viability: 90.52 ± 3.14%

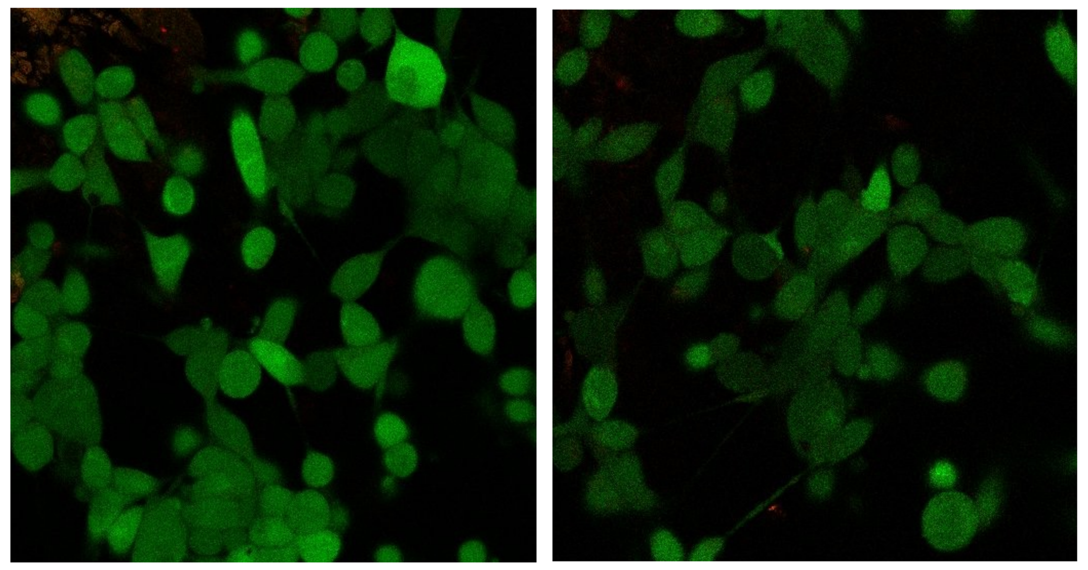


Fig. 4 Cells Cultured on Directly on **TiNbZr** Pellet, Cell Viability: 87.73 ± 8.18%

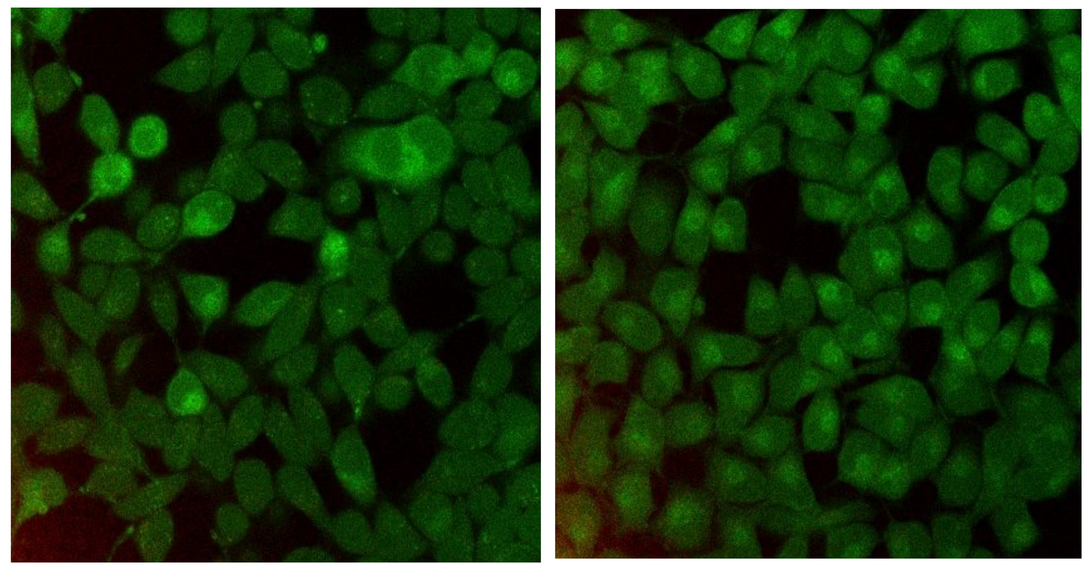


Fig. 5 *Control:* Cells Cultured on Empty Dish Cell Viability: 99 ± 0.58%

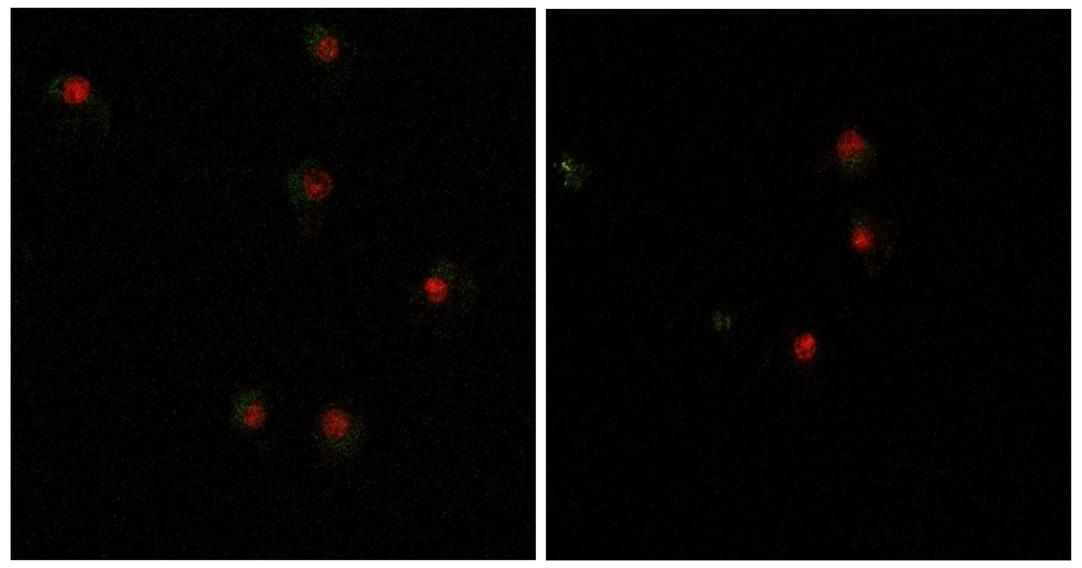
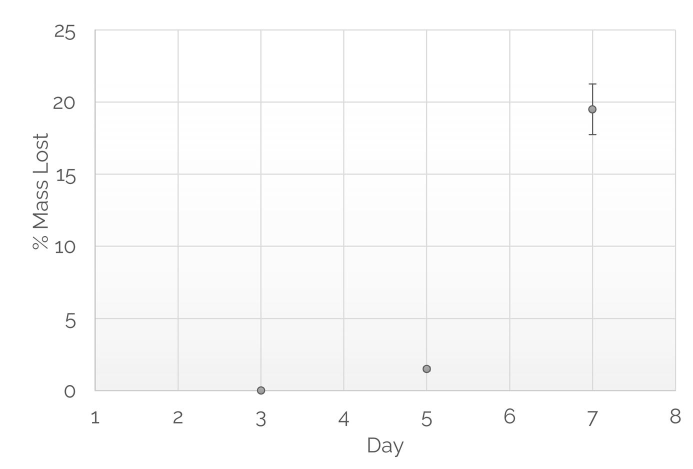


Fig. 6 *Negative Control:* Cells Cultured on Nickel Pellet, Cell Viability: 0%

CORROSION TESTS :



Corrosion Rate:
0.1921 ± 0.0133 g/day

Fig. 7 Graph of TiNbZr Corrosion Rate, Samples Measured at 0, 3, 5 and 7 Days in modified simulated body fluid (SBF) + Calculated Corrosion Rate

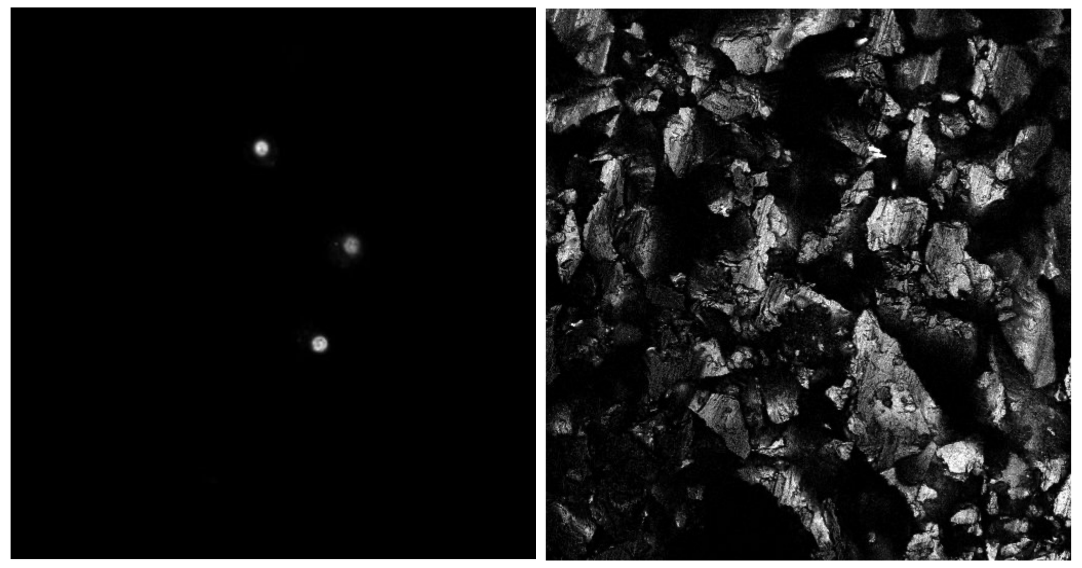


Fig. 8 Microscope image of uncorroded Nickel pellet surface (left) and surface bacterial corrosion of TiNbZr pellet (right)

CONCLUSIONS

- Ti-25Nb-8Zr displays good biocompatibility which is promising for biomedical applications
- This alloy can sustain longer time periods within the body that are often required of things such as stents or implants
- This alloy could be enhanced by different coatings to further improve its corrosion and biocompatibility properties

FUTURE DIRECTIONS

- Create thin film samples using PVD to evaluate shape memory and super elasticity properties of this alloy composition
- Investigate other TiNbZr alloy compositions
- Evaluate different surface coatings to decrease bacterial surface corrosion

REFERENCES

[1] Gasik, Michael & Yu, H.. (2009). Phase equilibria and thermal behaviour of biomedical Ti-Nb-Zr alloy. [2] Weihs, Timothy (2021, September). *A Three-Tiered Combinatorial Approach with ML/UQ-guided Characterization for Rapid Screening of Structural Alloys with Bulk Microstructures.* [3] Collado, Marcelo & Nava Rodriguez, Nestor & Cabás, R & San Juan, Jose & Lautier, J-M. (2011). CHARACTERIZATION RESULTS OF A NOVEL SHAPE MEMORY ALLOY AND PIN PULLER MECHANISMS BASED ON THIS TECHNOLOGY. 10.13140/2.1.4353.0246.