Milestone 4 (Individual) – Cover Page

Team Number: 26

Please list full name and MacID.

Full Name:	MacID:
Hassan Bokhari	Bokharh

MILESTONE 4 (STAGE 1) – PRELIMINARY MATERIALS SELECTION

Team Number: 42

Complete worksheets on the following pages, considering **2 candidate materials** you will consider for your selected implant component. Each worksheet includes a table for 1 of the 3 materials selection criteria (structure, properties, processing).

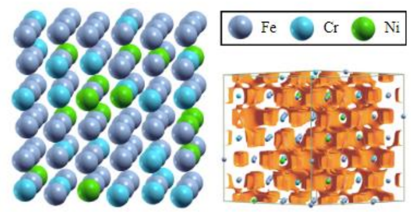
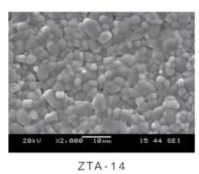
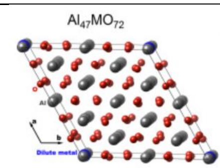
- → You only need to consider **ONE** implant component
  - All team members should consider the same component for their independent materials selection
- → Remember, you only need to research 2 of the 3 criteria (i.e., only complete **TWO** of the 3 worksheets)
  - Consider the same candidate materials when completing each worksheet
  - **Complete your worksheets before coming to Design Studio 10**

Implant Component:	Femoral Head

MILESTONE 4 (STAGE 1) – PRELIMINARY MATERIALS SELECTION
STRUCTURE

Team Number: 42

Complete this worksheet if you are researching **STRUCTURE** as one of your two required materials selection criteria.

Material	Class	Atomic Arrangement	Interatomic Bonding	Molecular formula
316L AISI Alloyed Stainless Steel	Metal alloy/ Ferritic [1]	 Figure 1: The 108 atoms supercell of 316L stainless steel generated with the SQS method (left). [2] Ferritic – cube, shape, crystal, structure [2]	- Metallic Bonding - Method towards creating alloy and metallic bonds involves Thermoplastic Bonding (TPB) creating atomic diffusion at high temperatures [3]	$Fe_{73}Cr_{21}Ni_{14}$ [2]
BIOLOX Delta (patented name) Professionally known as Zirconia-toughened alumina – 14 (ZTA – 14) [4]	Composite Ceramics [5]	 [6]  [7] Monoclinic crystalline structure transformed from compressed tetragonal crystal structure [6]	- Zr-O bonds quantify many strength properties of material. [7] - Strong interatomic bonding in comparison with other RE's (reactive elements) [7] -Ionic bonding [6]	$Zr-Al_2O_3$ [6]

MILESTONE 4 (STAGE 1) – PRELIMINARY MATERIALS SELECTION
PROPERTIES

Team Number: 42

Complete this worksheet if you are researching **PROPERTIES** as one of your two required materials selection criteria.

Material	Elastic Modulus	Ultimate Strength	Toughness, Fracture	Wear	Corrosion Resistance	Biological properties
316L AISI Alloyed Stainless Steel	200 GPa [8]	586 MPa [8]	112-278 MPa $m^{1/2}$ [9]	High wear resistance that can be increased with surface coating [10]	Superior corrosion resistant compared to other metals [8] -Performs well against corrosion in fresh water and saltwater systems [8] -Studies do show slight susceptibility to corrosion in biological environment long term. [10]	- Studies show biocompatibility of metal inside human body applications of implants etc. [10] - Adequate osteointegration [10] - Demonstrates superior biocompatibility [10]
BIOLOX Delta (patented name) Professionally known as Zirconia-toughened alumina – 14 (ZTA – 14) [4]	338 GPa [6]	689 MPa [11]	5-7 MPa.m1/2 [11]	Very hard and wear resistant [11]	-Very high corrosion strength even when put under pressure in different temperature environments [11]	-Relatively low volume to weight ratio advantageous to medical applications [11] -Suitable for orthopedic load-bearing components [12] -No adverse tissue reactions after implantation [12] -Great biocompatibility [12] -Chemical inertness [12] -Doesn't account for osteointegration [12]

Works Cited

316L AISI Alloyed Stainless Steel

[1] "Stainless steel | Definition, Composition, Types, & Facts | Britannica." https://www.britannica.com/technology/stainless-steel (accessed Nov. 28, 2022).

[2] E. Bévillon, J. P. Colombier, B. Dutta, and R. Stoian, "Ab initio nonequilibrium thermodynamic and transport properties of ultrafast laser irradiated 316l stainless steel," *Journal of Physical Chemistry C*, vol. 119, no. 21, pp. 11438–11446, May 2015, doi: 10.1021/ACS.JPCC.5B02085.

[3] K. W. Dong, J. Kong, Y. Peng, Q. Zhou, and K. H. Wang, "Thermoplastic bonding of TC4 and 316L stainless steel with a Ti-based bulk metallic glass as the filler metal," *Journal of Materials Research and Technology*, vol. 11, pp. 487–497, Mar. 2021, doi: 10.1016/J.JMRT.2021.01.042.

[8] "Specification Sheet: Alloy 316/316L," Jun. 2014. https://www.sandmeyersteel.com/images/316-316l-317l-spec-sheet.pdf (accessed Nov. 28, 2022).

[9] H. Alsalla, L. Hao, and C. Smith, "Fracture toughness and tensile strength of 316L stainless steel cellular lattice structures manufactured using the selective laser melting technique," *Materials Science and Engineering: A*, vol. 669, pp. 1–6, Jul. 2016, doi: 10.1016/J.MSEA.2016.05.075.

[10] N. S. Al-Mamun, K. Mairaj Deen, W. Haider, E. Asselin, and I. Shabib, "Corrosion behavior and biocompatibility of additively manufactured 316L stainless steel in a physiological environment: the effect of citrate ions," *Addit Manuf*, vol. 34, p. 101237, Aug. 2020, doi: 10.1016/J.ADDMA.2020.101237.

Zirconia-Toughened Alumina - 14

[4] T. Tateiwa *et al.*, "Burst Strength of BIOLOX®delta Femoral Heads and Its Dependence on Low-Temperature Environmental Degradation," *Materials 2020, Vol. 13, Page 350*, vol. 13, no. 2, p. 350, Jan. 2020, doi: 10.3390/MA13020350.

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[6] "Z I R C O N I A-T O U G H E N E D A L U M I N A : W H Y," 2021, Accessed: Nov. 28, 2022. [Online]. Available: https://www.ceramics.net/sites/default/files/stc-white-paper-zta-zirconia-toughened-alumina-01062021.pdf

[7] S. L. Shang, Y. Wang, B. Gleeson, and Z. K. Liu, "Understanding slow-growing alumina scale mediated by reactive elements: Perspective via local metal-oxygen bonding strength," *Scr Mater*, vol. 150, pp. 139–142, Jun. 2018, doi: 10.1016/J.SCRIPTAMAT.2018.03.002.

[11] C. Piconi, "Oxide Ceramics for Biomedical Applications," *Encyclopedia of Materials: Science and Technology*, pp. 6595–6601, 2001, doi: 10.1016/B0-08-043152-6/01165-7.

[12] "Zirconia Toughened Alumina (ZTA) - INSACO Inc." https://www.insaco.com/material/zirconia-toughened-alumina-zta/ (accessed Nov. 28, 2022).