

Developments in Metals and Bioresorbables Showcase the Future of Orthopedic Materials

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 **Millstone**

 **MTEC**



Sandvik's Metal Powders and Machining Solutions for the Medical Industry



Agenda

1. Sandvik Osprey® Powders
2. Machining Solutions
3. Sustainability in AM
4. Summary



Sandvik Osprey[®] Powders

World-leading manufacturer of gas-atomized metal powder

More than

2000
grades

First year of
powder sales

1979

Osprey®

Metal powders

**Our program of Osprey®
metal powder includes:**

- Low-alloy steels
- Tool steels
- Maraging steels
- **Stainless steels** and duplex steels
- Nickel-based alloys
- **Cobalt alloys**
- **Titanium alloys**
- Copper alloys
- Expansion alloys
- Soft magnetic alloys
- Superalloys
- Binary alloys
- Master alloys
- **Zirconium alloys**
- Tungsten powder

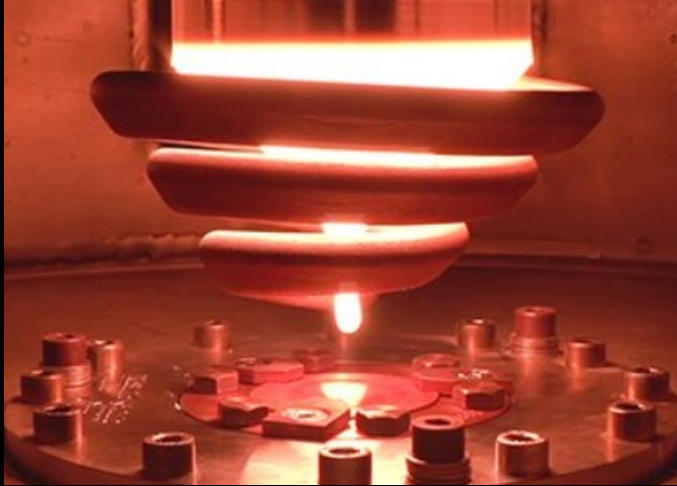


Production sites



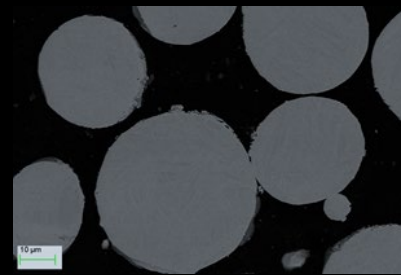
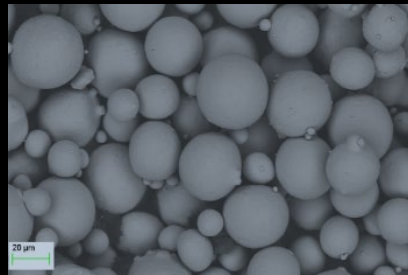
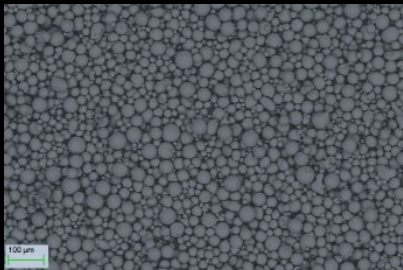


Sandviken, Sweden



- State-of-the-art atomizing plant with electrode melting
 - Electrode Inert Gas Atomization technology (EIGA)
 - Atomizing titanium powder with low oxygen & nitrogen levels
 - Titanium dedicated downstream sizing, large scale blending & packing facility AS9100 certified
- High quality titanium powders
 - Hot Isostatic Pressing (HIP); <250 μm
 - Additive Manufacturing (AM); 150 to 53 μm , 106 to 45 μm & 53 to 15 μm
 - Metal Injection Molding (MIM); <45 μm & <25 μm

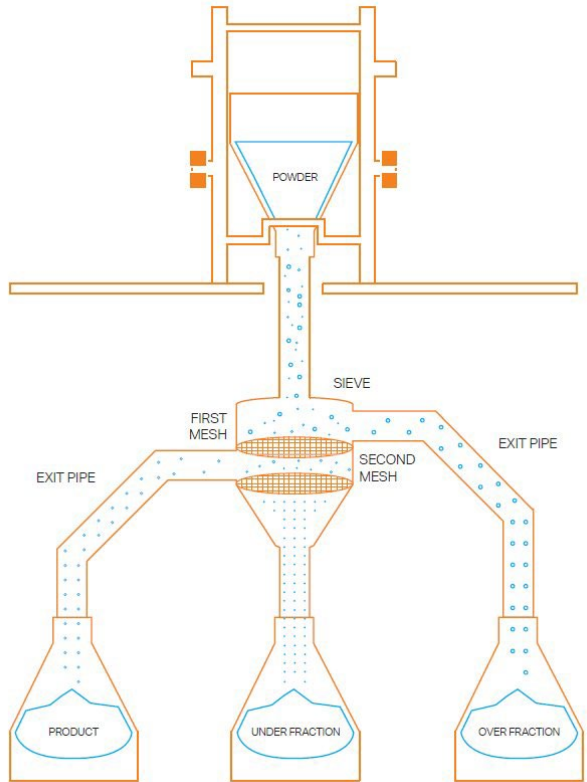
POWDER MORPHOLOGY



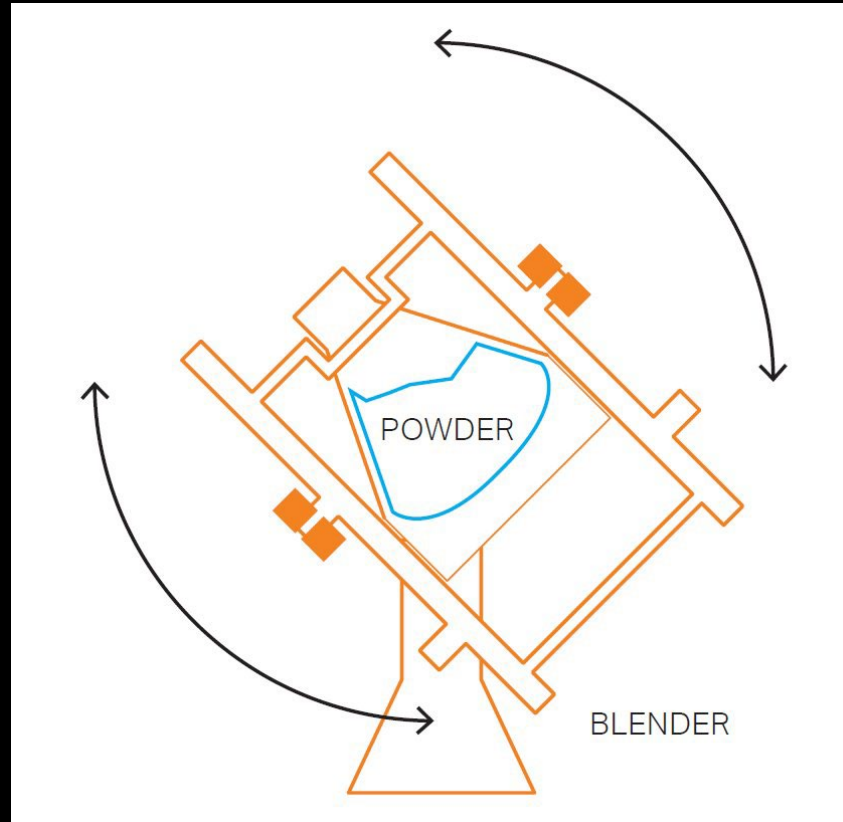
Osprey® Ti-6Al-4V Grade 5 & Grade 23

Osprey® CP-Ti Grade 1 & 2

Sieving, blending, and packing



Sieving under
inert atmosphere



Blending for homogenization before
packing



Packing



Machining Solutions



Shaping a brighter future together

Competence across the metal manufacturing value chain

- We aim to know our customers needs even before they do
- We want to come into the chain as early as possible and stay as late as possible
- We adapt to meet the customer challenges



Medical full component solutions

We listen to our customers and understand the MedTech industry to ensure we solve pre-machining challenges, creating and delivering innovative, productive and sustainable machining strategies and concepts for all complex component challenges.

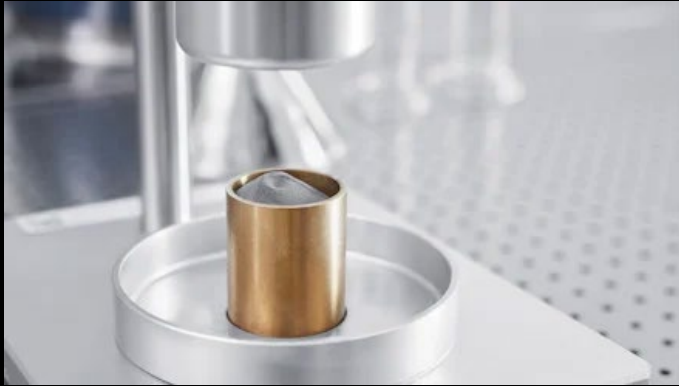


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Sustainability in AM

Experimental Set-up



- Sandvik Osprey Ti64

Particles size ranges

- 15-45 μm (Standard PSD)
- 45-90 μm (Large PSD)



- Renishaw 500Q Flex

Three different layer thicknesses
at two different PSDs

- 30 μm (Standard PSD)
- 60 μm (Standard PSD)
- 90 μm (Standard PSD)
- 90 μm (Large PSD)

Testing

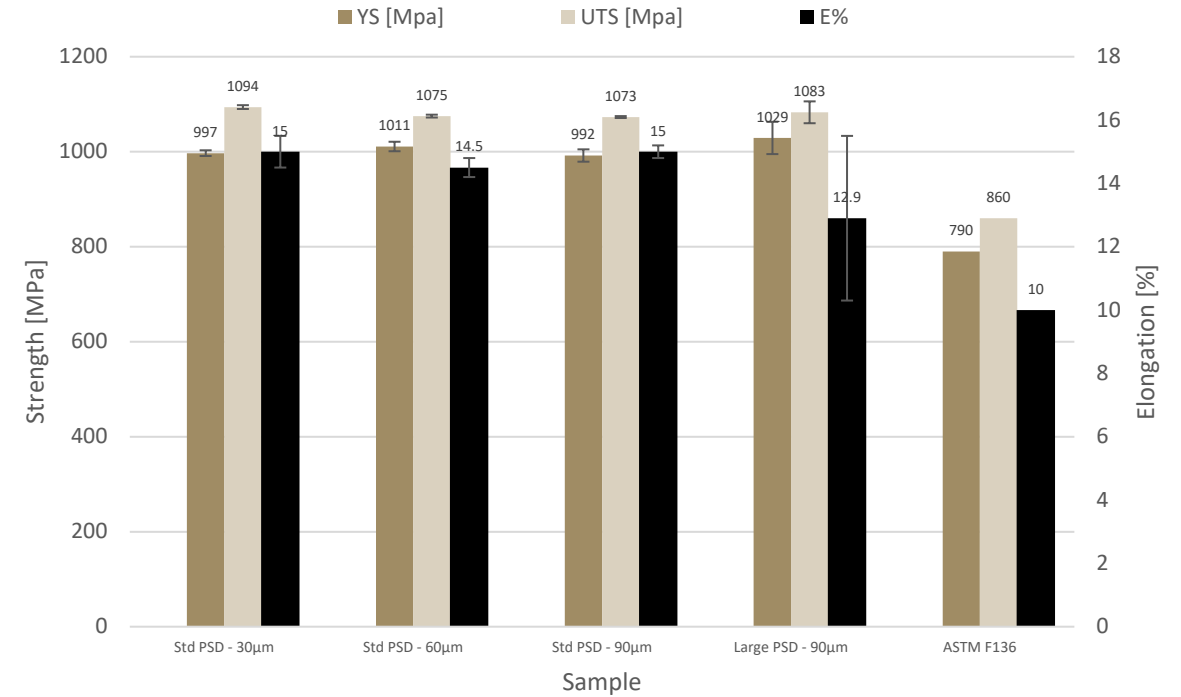


- Rel. density
- Microstructure
- Tensile properties
- Hardness
- CVN impact energy

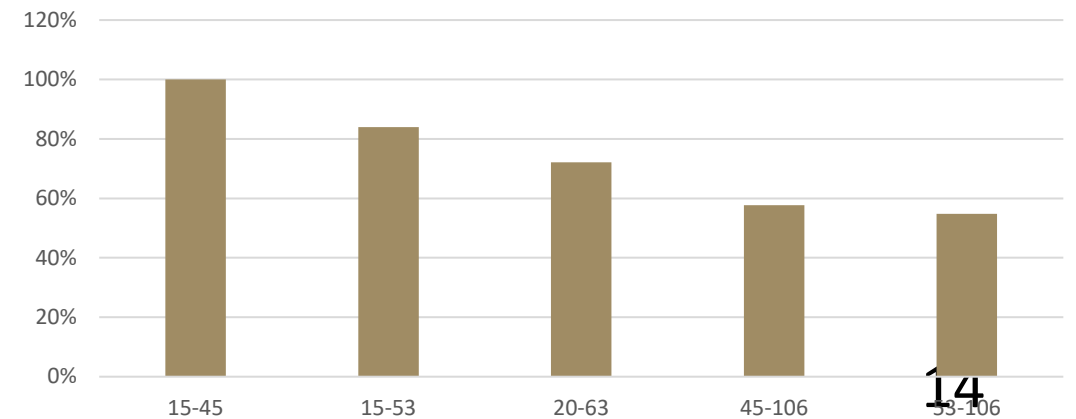


Wider PSD

- Reduced powder cost
- Possibility to use higher layers
- Increased productivity
- Mechanical properties on par with standard processes
- Density >99,9%
- Microstructure like standard processes



Price as a function of PSD



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Summary

- Sandvik Additive Manufacturing offers a wide range of metal powder alloys for Medical applications, suitable for AM and MIM.
- High level of automation in our Ti-powder manufacturing paves the way for consistent and high-quality products.
- Sustainability targets with a clear ambition to reduce waste, increase productivity and lower the manufacturing costs for our customers.
- Sandvik's total offer of manufacturing and machining expertise together with digital solutions is unique and supports our customers to reach their full potential.



Thank you

Biomaterial Opportunities

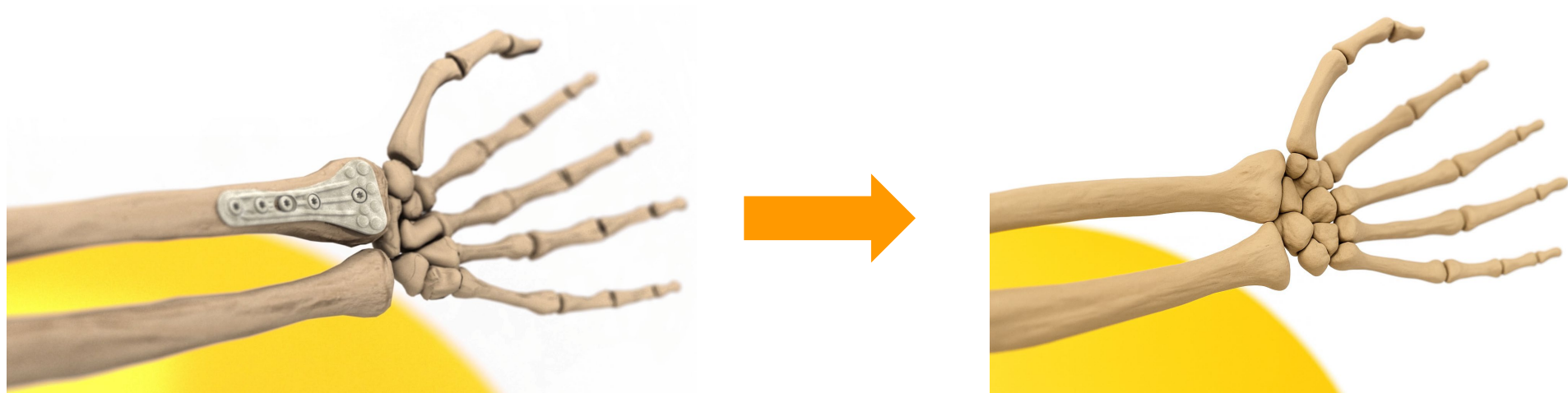
Dr. Tech. Ville Ellä
R&D Director, New Technologies
Arctic Biomaterials

ABMCOMPOSITE
Arctic Biomaterials

OMTEC[®]



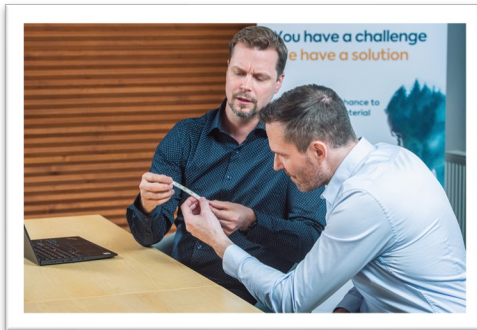
Strength to Your resorbable implants



Arctic Biomaterials

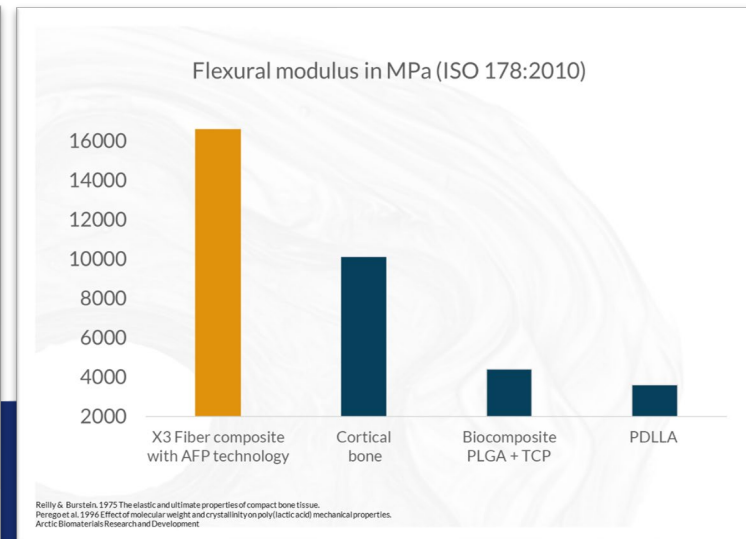
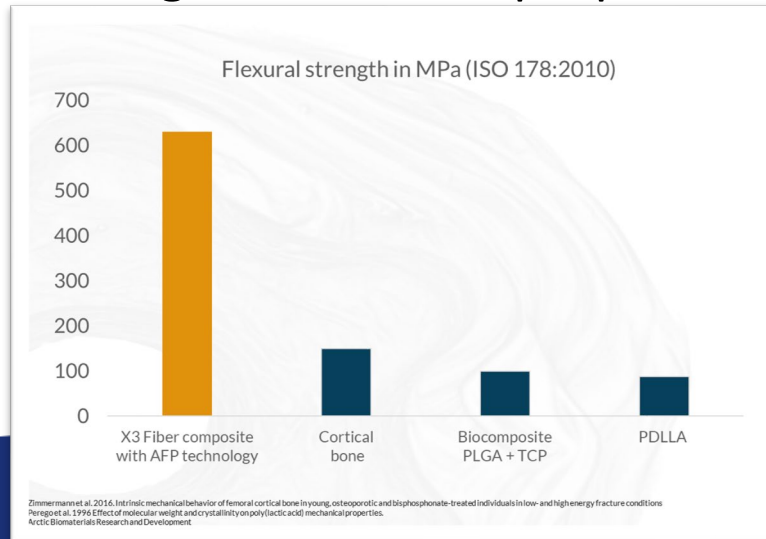
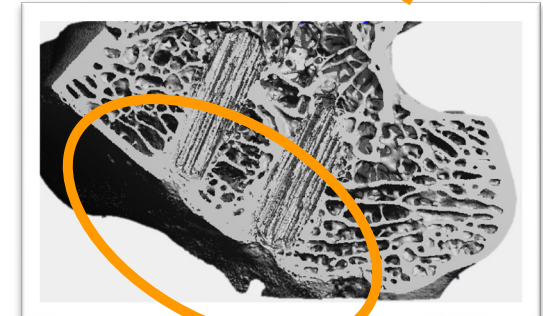
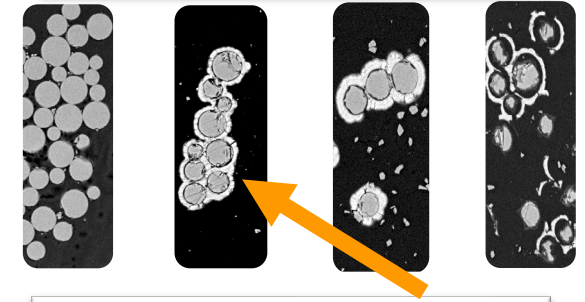
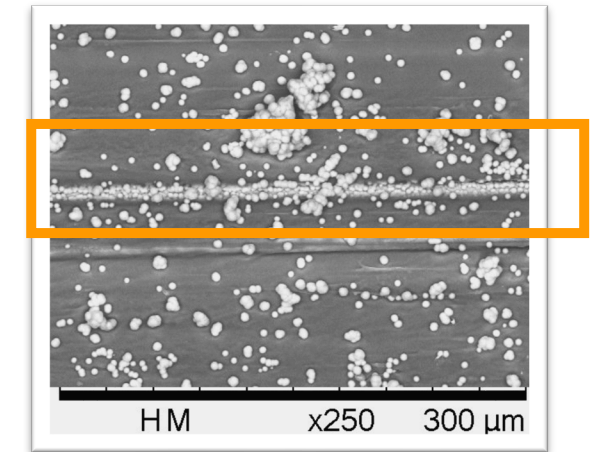
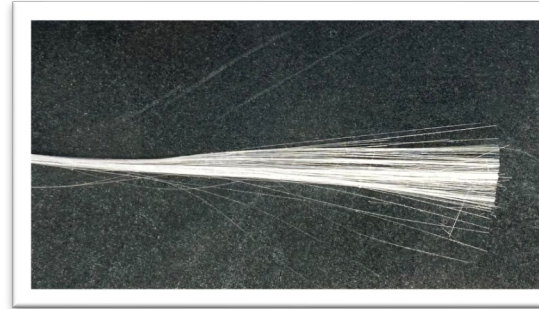


- Biopolymer and biocomposite processing
- Raw materials and semi-finished implants
- Biomaterial & bioresorbable implant R&D
-  Class 7 & 8 clean room manufacturing



X3 fiber composite

- X3 fiber + polymer
- Bioactive & fully bioresorbable
- Promoting bone healing
- Similar benefits that of ceramic composite materials e.g. TCP or HA
- High mechanical properties





ABMCOMPOSITE
Arctic Biomaterials

**Bioresorbable and bio-integrative
X3 fiber composite staple
inserted to porcine bone**

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A collage of 12 images showcasing various 3D printed medical devices. The devices include: a bundle of white sutures in a black container; a long, thin, white plate with four circular holes; two white, threaded screws; a white, U-shaped bracket; two white, rectangular blocks; a white, Y-shaped implant with three circular holes; a white, curved, thin rod; a white, cylindrical, multi-ribbed implant; a white, square, mesh-like structure; a white, thin, curved rod; and a white, thin, curved rod. The devices are displayed against various backgrounds, including black, white, and grey. Some images include copyright notices: "©2022 Arctic Biomaterials" and "©2020 Arctic Biomaterials Oy. All rights reserved."

- Extremities
 - Foot & ankle
 - Upper extremities
- Trauma
- Sports medicine
- Neurosurgery
- Craniomaxillofacial
- Chest

X3 fiber composite options

X3 fiber pellet

- Injection molding
- When the short X3 fiber is a best option
- Cost-efficient
 - < 1.5% of implant price



X3 fiber tape

- Winding, Tape laying, compression molding
- When higher strength required
- Cost-efficient
 - Material yield > 95%



X3 fiber filament

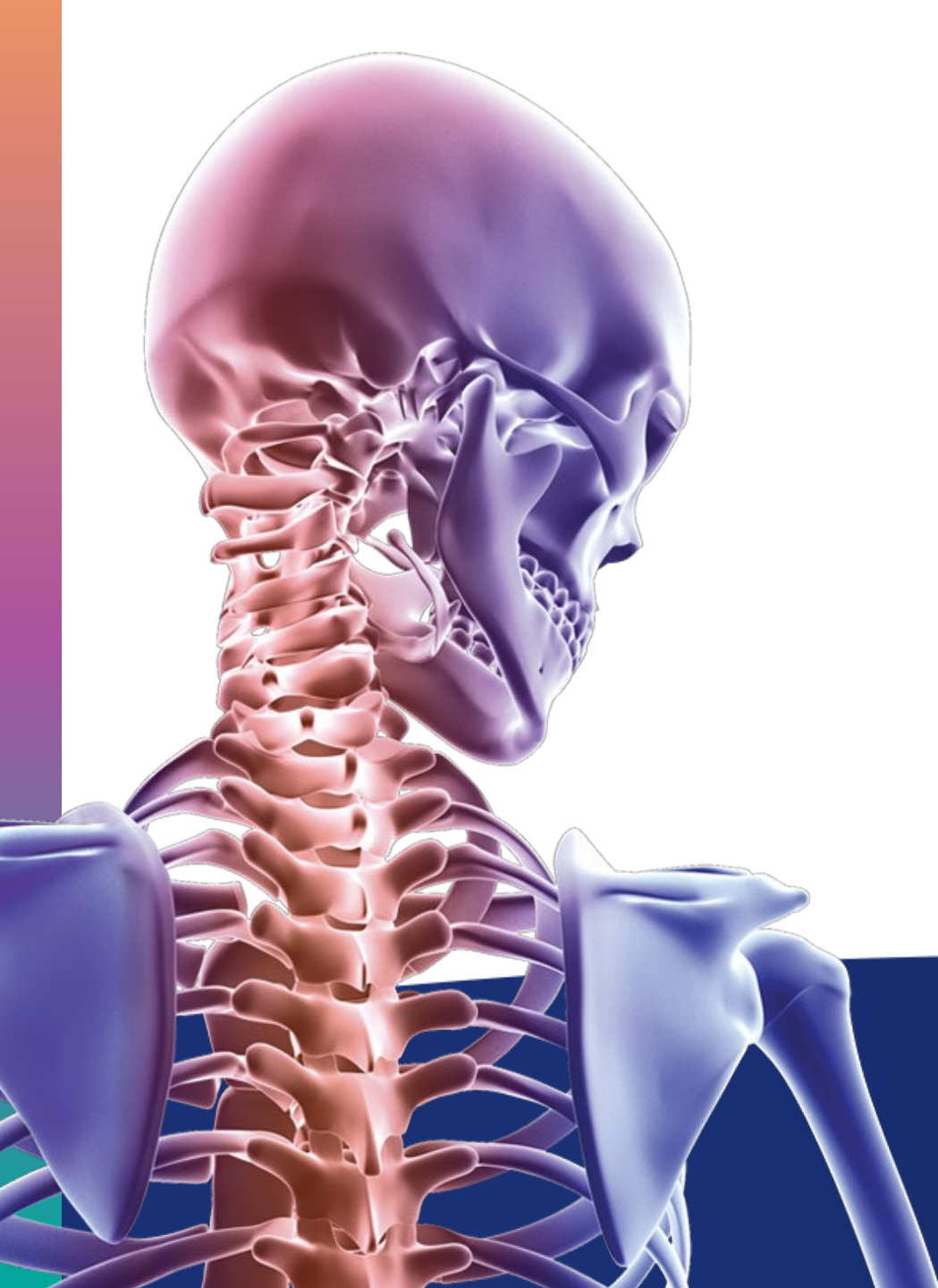
- Filament winding, compression molding, *3D Printing, AFP
- When higher strength required
- Cost-efficient
 - Material yield > 97%



Custom X3 fiber articles

- Rods, preforms, laminates
- Customer desired shapes and designs
- Tailored to **your** needs





Thank You

Dr. Tech. Ville Ellä
ville.ella@abmcomposite.com
Arctic Biomaterials

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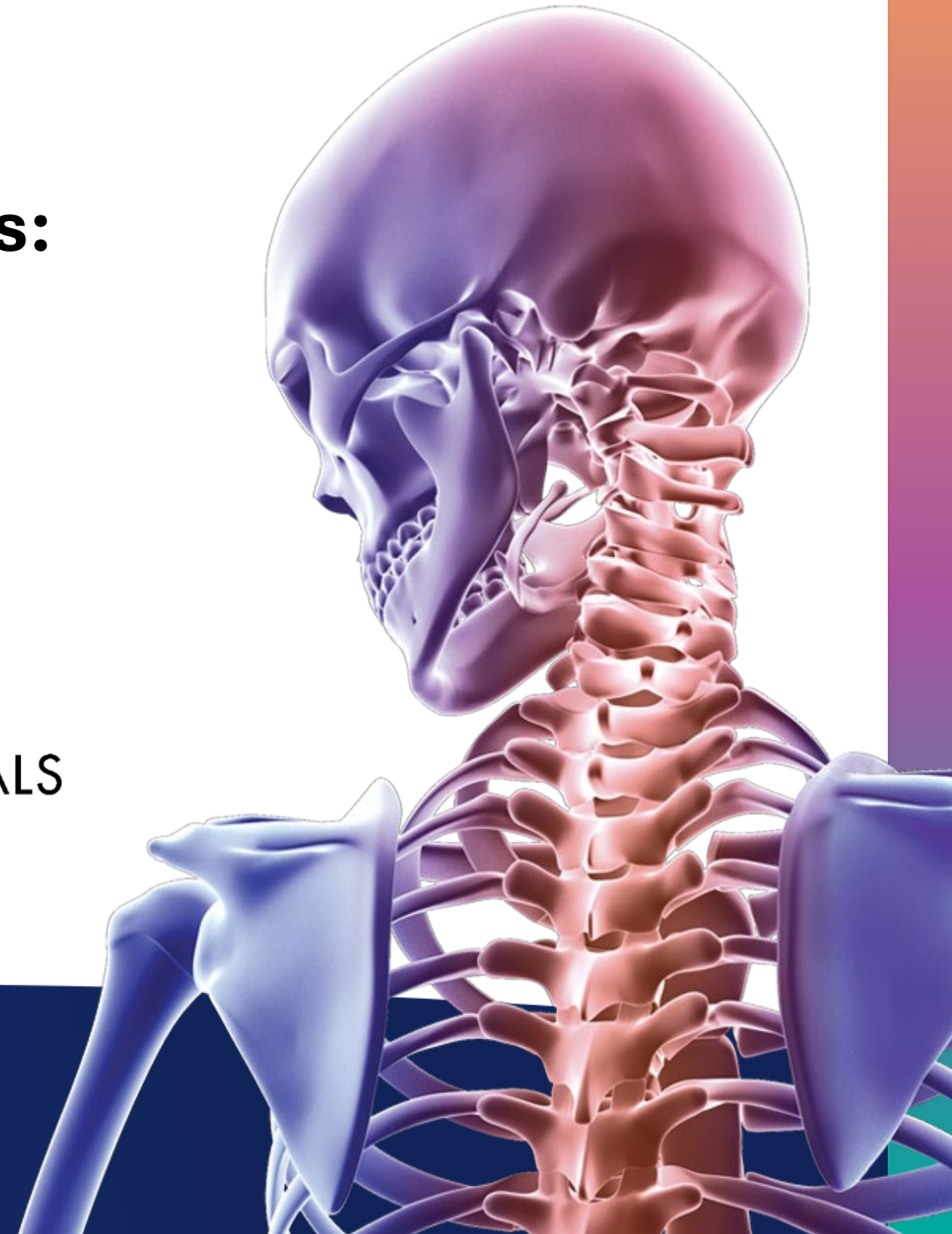
Advancing Metals for Orthopedics:

R&D Highlights from Fort Wayne Metals

Adam Griebel
Sr. R&D Engineer
Fort Wayne Metals



FORT WAYNE METALS





FORT WAYNE METALS

Agenda

- Fort Wayne Metals Intro
- Absorbable Magnesium Alloys
- Nickel-free Superelastic
- High Strength / High Stiffness



FORT WAYNE METALS

Fort Wayne Metals

- Booth 612
- High-performance, high-precision wire, bar, strands, and cables
- Broad Material Portfolio
 - Nitinol
 - Stainless steel (*300s, 400s*)
 - Cobalt-based (*MP35N[®], 35N LT[®], L605, FWM[®] 1537, FWM[®] 1058*)
 - Titanium (*CP Grades 1-4, Ti 6/4 ELI, Ti 6/7, Ti 3/2.5, Betas, etc.*)
- Sustained commitment to R&D
 - Fort Wayne Metals **Research Products**, LLC





Absorbable Magnesium Alloys

- Mg: Attractive mechanical performance *for absorbables*
 - Strength:
 - Mg: 200-400 MPa
 - Ti: 400-1000 MPa
 - PLLA: ~50 MPa
 - Stiffness:
 - Mg: 45 GPa
 - Ti: ~100-120 GPa
 - PLLA: ~5 GPa



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Absorbable Magnesium Alloys

- Alloy Composition
 - WE43 (Mg-Y-Nd-Zr)
 - **ZXM100 (Mg-Zn-Ca-Mn)**

Uncoated
12 weeks

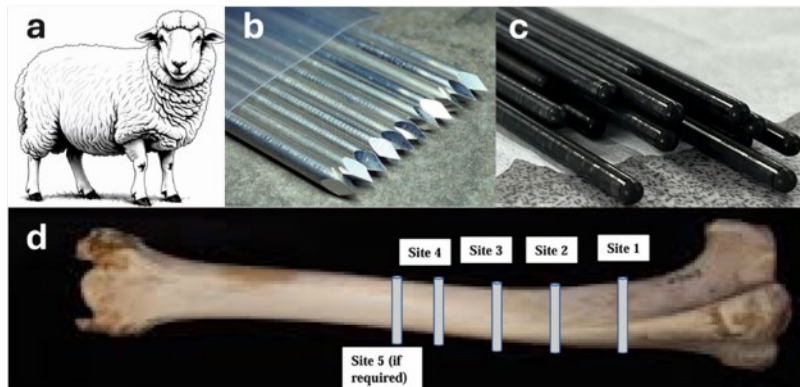
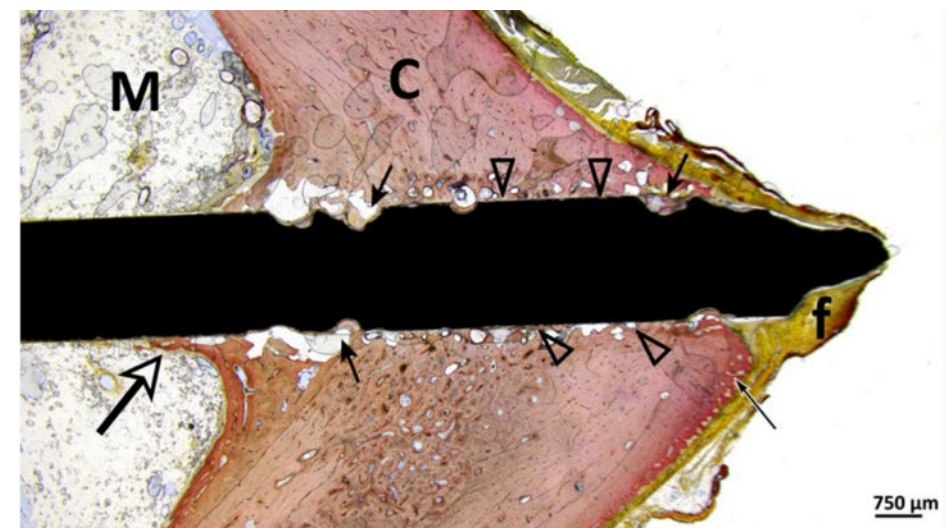


Figure 1. A sheep model (A) was used to assess implantation of bare (b) and MgF₂-coated (c) k-wires bicortically through the tibia. K-wires had distal trocar tips (b) and proximal blunt ends (c).





FORT WAYNE METALS

Absorbable Magnesium Alloys

- Alloy Composition
 - WE43 (Mg-Y-Nd-Zr)
 - **ZXM100 (Mg-Zn-Ca-Mn)**
 - Centerless ground bar (2-15 mm)
 - Wire (0.05-2 mm)
 - Strip/Sheet





Absorbable Magnesium Alloys

- Standardization

ISO 20721

Guidance for the assessment of absorbable metallic implants

ASTM F3160

Metallurgical
Characterization

ASTM F3268

in vitro
degradation testing

WK83979

Corrosion Fatigue
(under development
through ASTM)

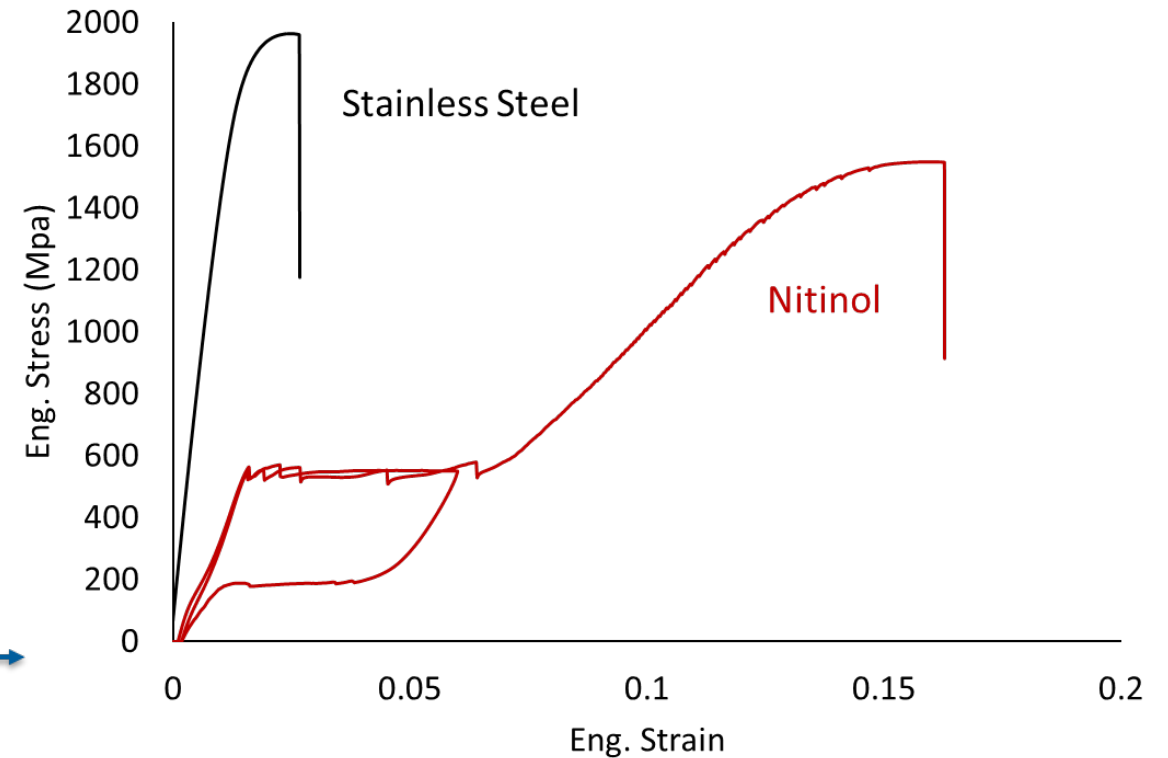
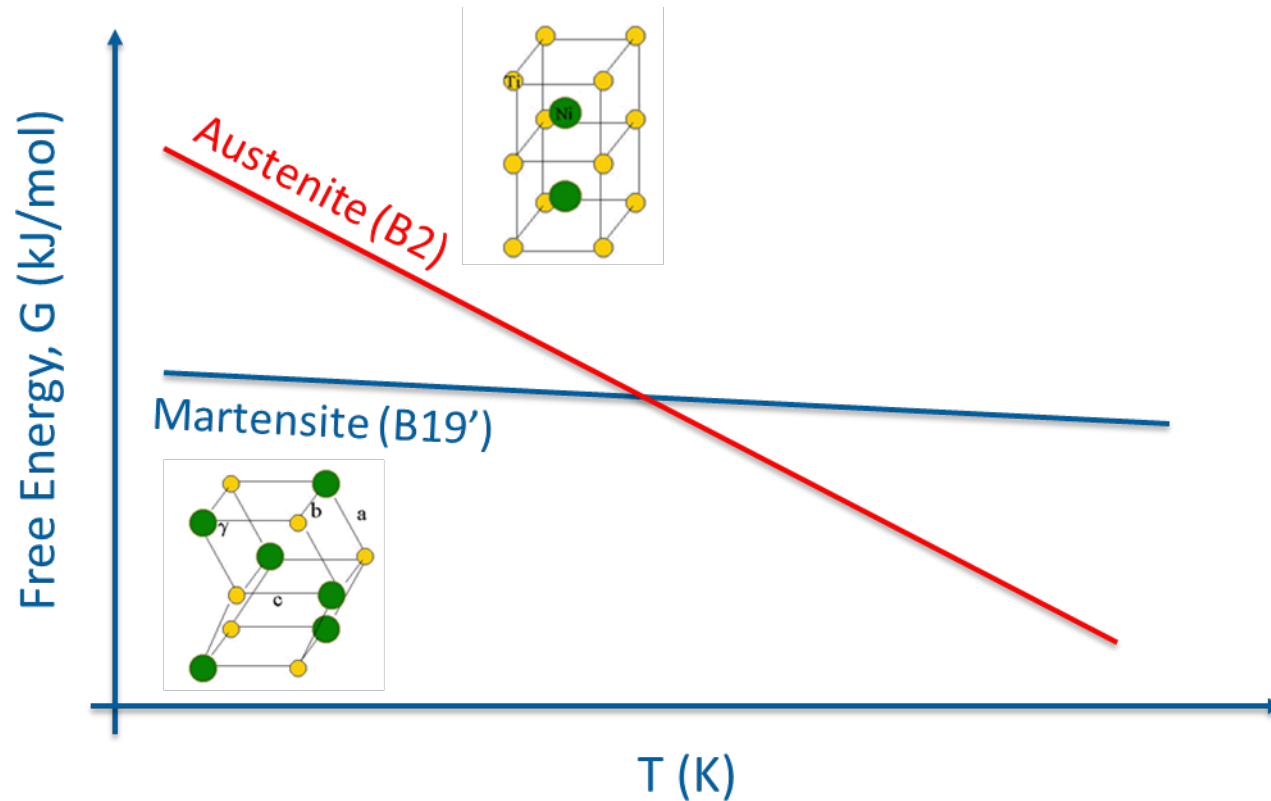
ISO 37137-1

Biological
Evaluation



Nickel-free superelastic

- Nitinol: Nickel + Titanium

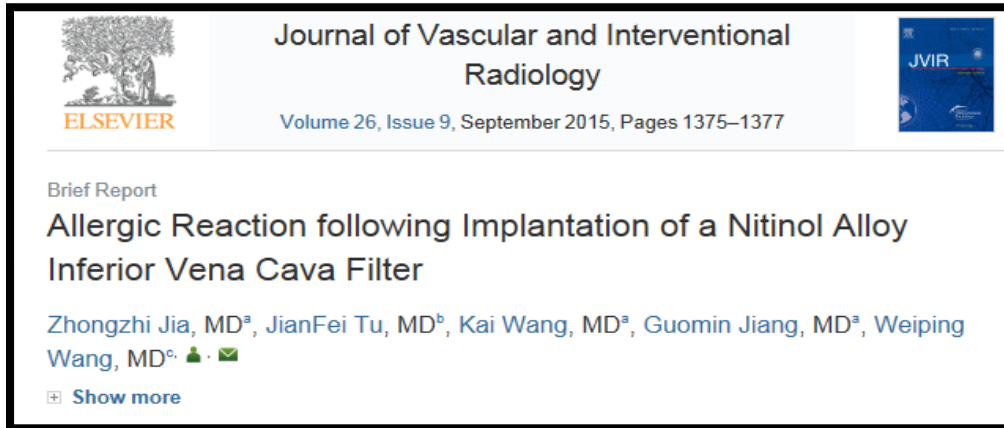




FORT WAYNE METALS

Nickel-free superelastic

- Nitinol: **Nickel** + Titanium



Occlusion of metallic biliary stent related to nickel allergy

Salman Fasih Khan, MBBS, Mary Ann Sherbondy, MD, Adrian Ormsby, MD, Vic Velanovich, MD
Detroit, Michigan, USA

Nickel hypersensitivity in the orthodontic patient

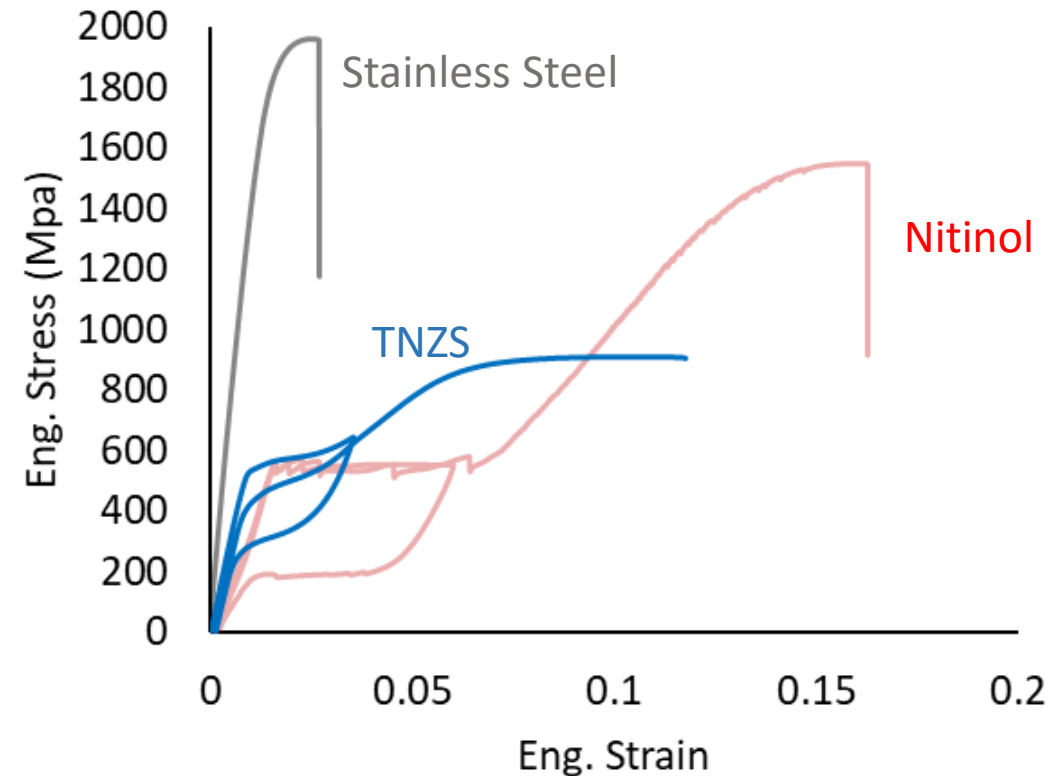
Justin K. Bass, DMD,^a Howard Fine, DMD, MMSc,^b and George J. Cisneros, DMD, MMSc^c
Bronx, N.Y.

Nickel is one of the most common causes of allergic contact dermatitis and produces more alle



Nickel-free superelastic

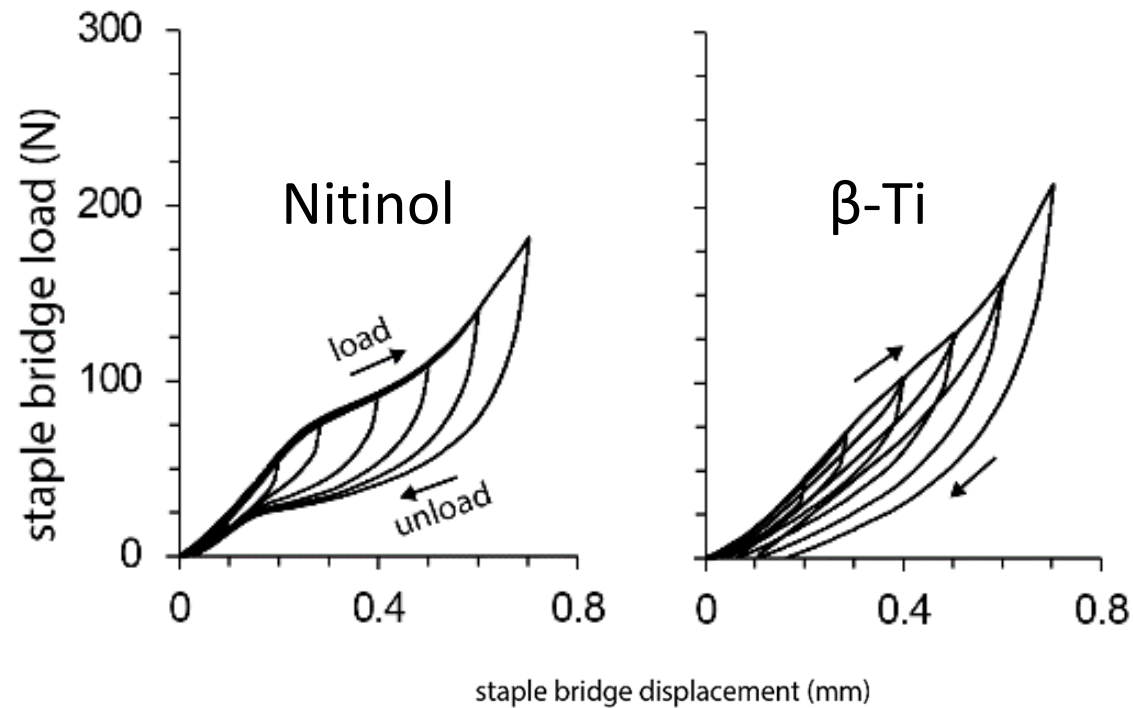
- β -Titanium: nickel free, superelastic?
- Success! TNZS
 - Ti-Nb-Zr-Hf-Sn
 - US11111571B2





Nickel-free superelastic

- Bone Staple Study





FORT WAYNE METALS

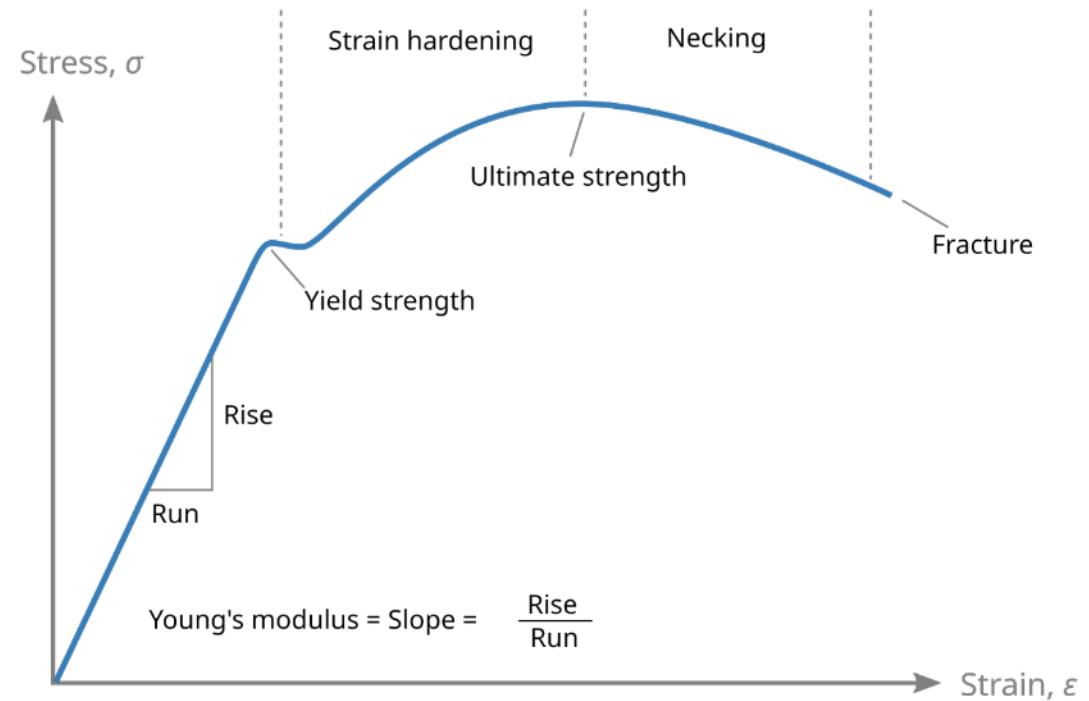
Nickel-free superelastic

- Material Availability
 - R&D quantities
 - Bar, Wire, Sheet, Billet



Smaller, Stiffer, Stronger

- Engineering review
 - Strength vs Stiffness

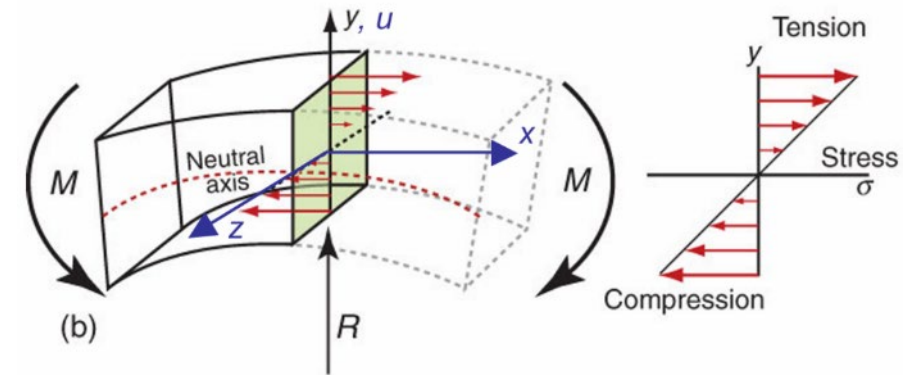




Smaller, Stiffer, Stronger

- Engineering review
 - Strength vs Stiffness
 - Beam bending

$$\text{Bending Stiffness} = E * I = E * \frac{\pi}{64} d^4$$





FORT WAYNE METALS

Higher strength, higher stiffness

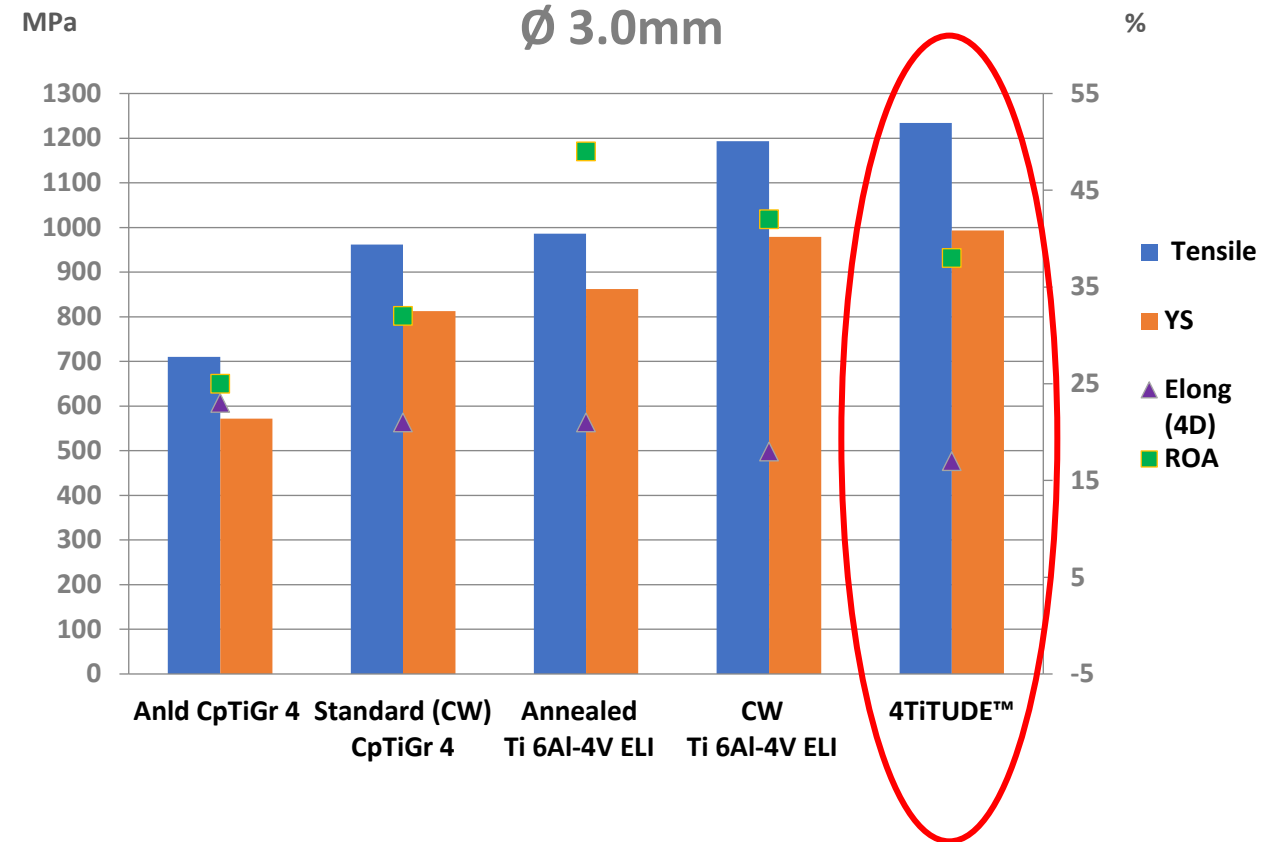
- Higher Strength
 - By Processing



FORT WAYNE METALS

Higher strength, higher stiffness

- Higher Strength
 - By Processing
 - 4TiTude®





Higher strength, higher stiffness

- Higher Strength
 - By Processing
 - 4TiTude®
 - cECAP

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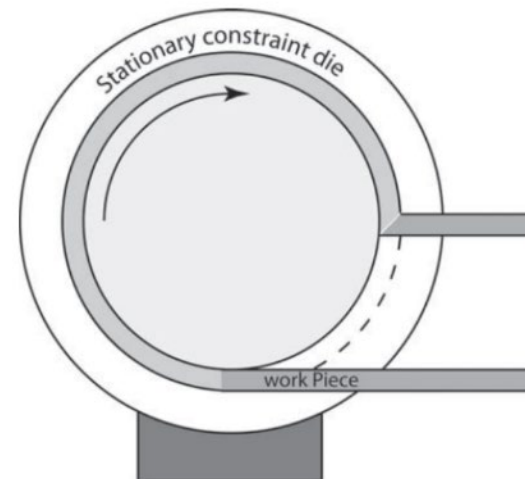
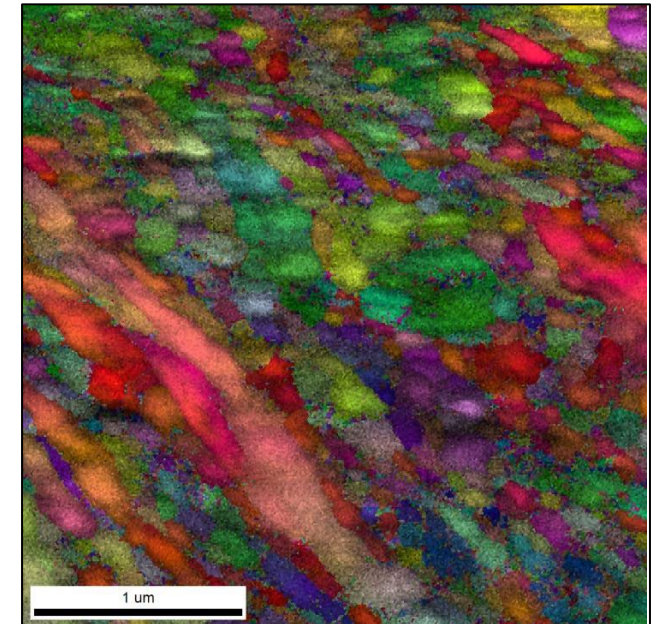


Fig.11. A schematic illustration of the ECAP-Conform process [53].





Higher strength, higher stiffness

- Higher Strength
 - By Processing
 - By Alloying
 - NiTi+Nb+Y

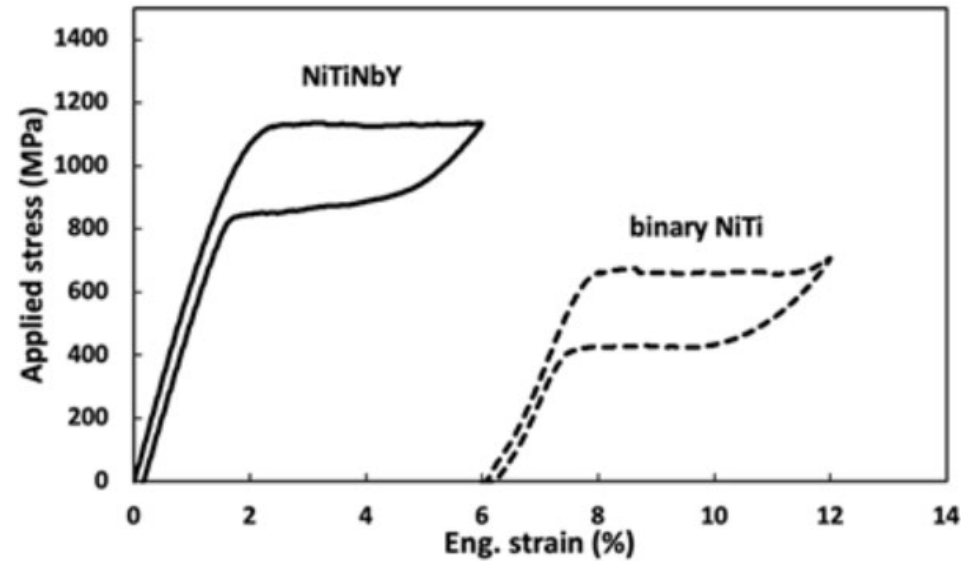


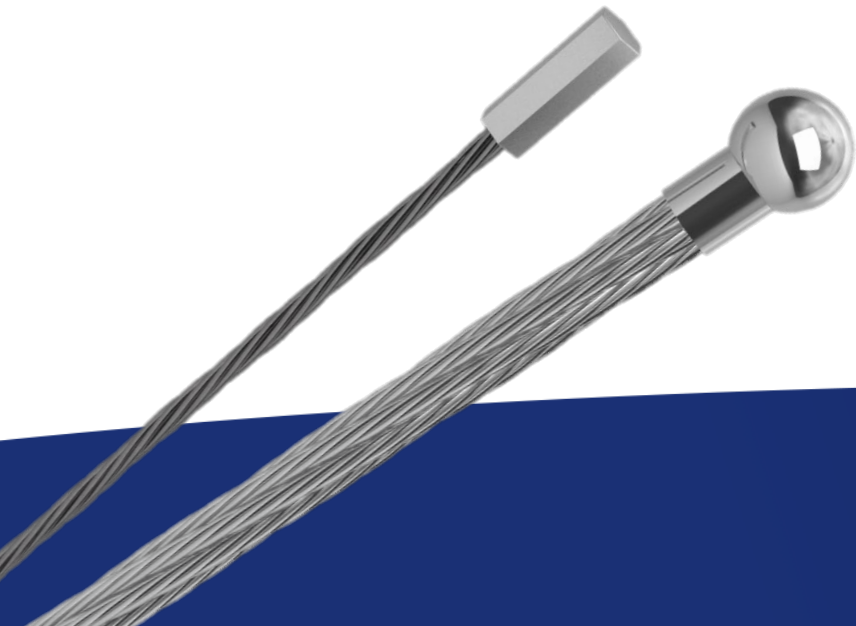
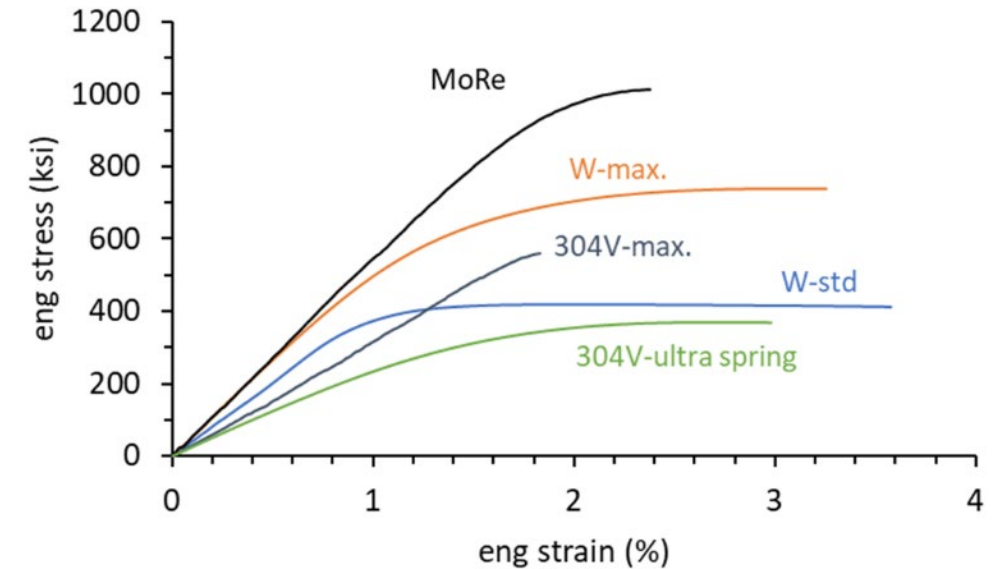
Figure 1 Comparison of the room temperature loading and unloading stress-strain curves of wires made from NiTiNbY and binary NiTi alloys.



FORT WAYNE METALS

Higher strength, higher stiffness

- Higher Strength
 - By Processing
 - By Alloying
 - By Material Class
 - Tungsten (W)
 - Molybdenum-Rhenium (MoRe)

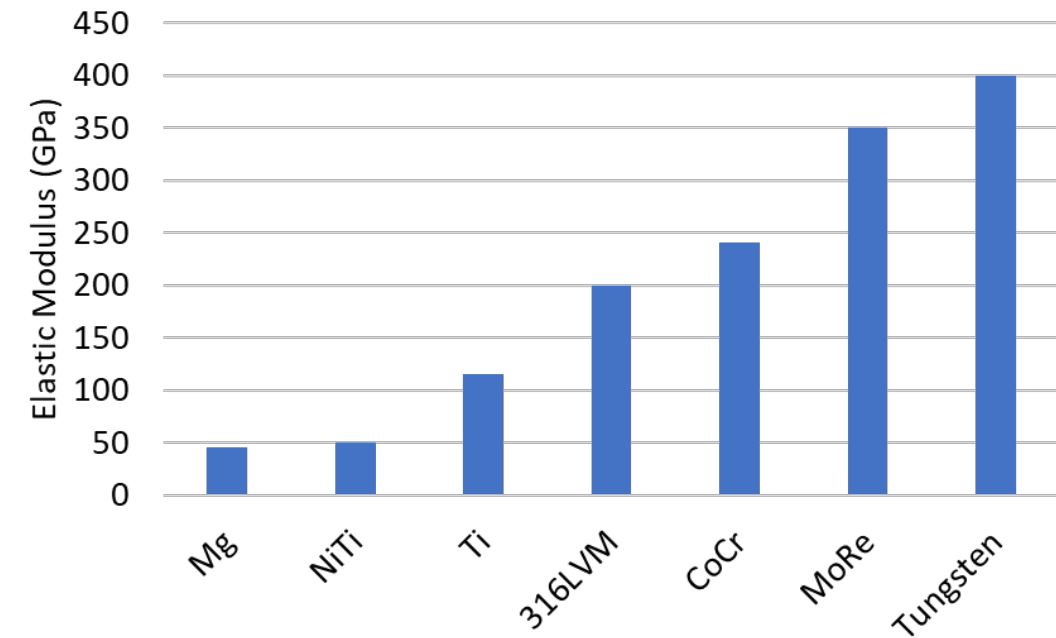




FORT WAYNE METALS

Higher strength, higher stiffness

- Higher Strength
- Higher Stiffness
 - Geometry dominates
 - Modulus of metals
 - $\varnothing 9 \text{ mm Ti} \approx \varnothing 6 \text{ mm CoCr} \approx \varnothing 5 \text{ mm MoRe}$



Summary

- Fort Wayne Metals
 - Booth 612
- Absorbable Magnesium Alloys
 - Alloy ZXM100
- Nickel-free superelastic
 - Alloy TNZS
- High Strength / High Stiffness
 - Many tools in the toolbox



FORT WAYNE METALS



Thank You

Adam Griebel
adam_griebel@fwmetals.com



FORT WAYNE METALS



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 MTEC®