MSE-1: Post-Process Annealing of 3D Printed PEEK Spinal Fusion Cages

Karen Wells, Richard Reynolds, James FitzPatrick

Problem Statement:

How can the mechanical performance of 3D printed PEEK spinal fusion cages be improved through a post- processing heat treatment such that printed cages have properties similar to traditionally manufactured cages?

Approach:

Investigated the effect of various heat treatments on cage porosity, crystallinity, morphology, and ultimately mechanical properties of 3D printed cages:

- Designed heat treatment process based on previous PEEK studies.
- Characterized all samples via microCT, XRD, and SEM.
- Studied failure mode differences between machined and printed cages.

Results:

Table 1: Porosity values pre- and post-anneal (n=18)

	Avg Pre-Anneal Porosity	Avg Post-Anneal Porosty	Avg Change in Porosity
Top Scans			
1500_200C	96.64%	97.10%	0.45%
1500_300C	96.85%	96.81%	-0.04%
2000_200C	96.11%	95.96%	-0.15%
2000_300C	97.07%	96.89%	-0.18%
Bottom Scans			
1500_200C	97.47%	97.20%	-0.27%
1500_300C	96.80%	97.15%	0.35%
2000_200C	95.46%	95.53%	0.07%
2000_300C	96.80%	96.69%	-0.11%

Table 2 Crystallinity values pre- and post-anneal (n=6)

Print Speed	Pre-Anneal Crystallinity	Post 300°C Anneal Crystallinity	Overall Change
1500 mm/min	24±3%	30±2%	+6% (p=.03)
2000 mm/min	26±2%	34±5%	+8% (p=.02)

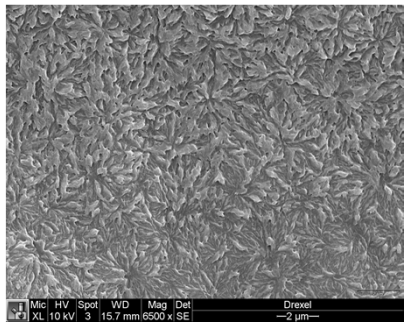

Figure 1: Enhanced surface morphology on annealed 3D printed cages

- MicroCT – no significant change in porosity.
- XRD – Crystallinity improved by 6-8%.
- SEM – showed enhanced surface morphology in 300°C annealed cages.

Discussion & Conclusions:

- Differences in failure mode between printed cages and machined cages still being studied.
- Pores seen to act as crack initiation/propagation sites.
- Thin aligned fibers (~300 nm) observed in porous regions of mechanically tested samples.
- Annealing demonstrated ability to increase crystallinity, but not decrease porosity:
  - Effect on mechanical properties to be determined.

Contact: Dr. Michele Marcolongo

Department Head and Professor,
Materials Science & Engineering
E-mail: marcolms@drexel.edu
Phone: 215-895-2329

DREXEL UNIVERSITY
Materials Science and Engineering
College of Engineering