UNIVERSITY of CALIFORNIA • IRVINE

3D Printing & Additive Manufacturing Overview

RapidTech
NATIONAL CENTER FOR RAPID TECHNOLOGIES

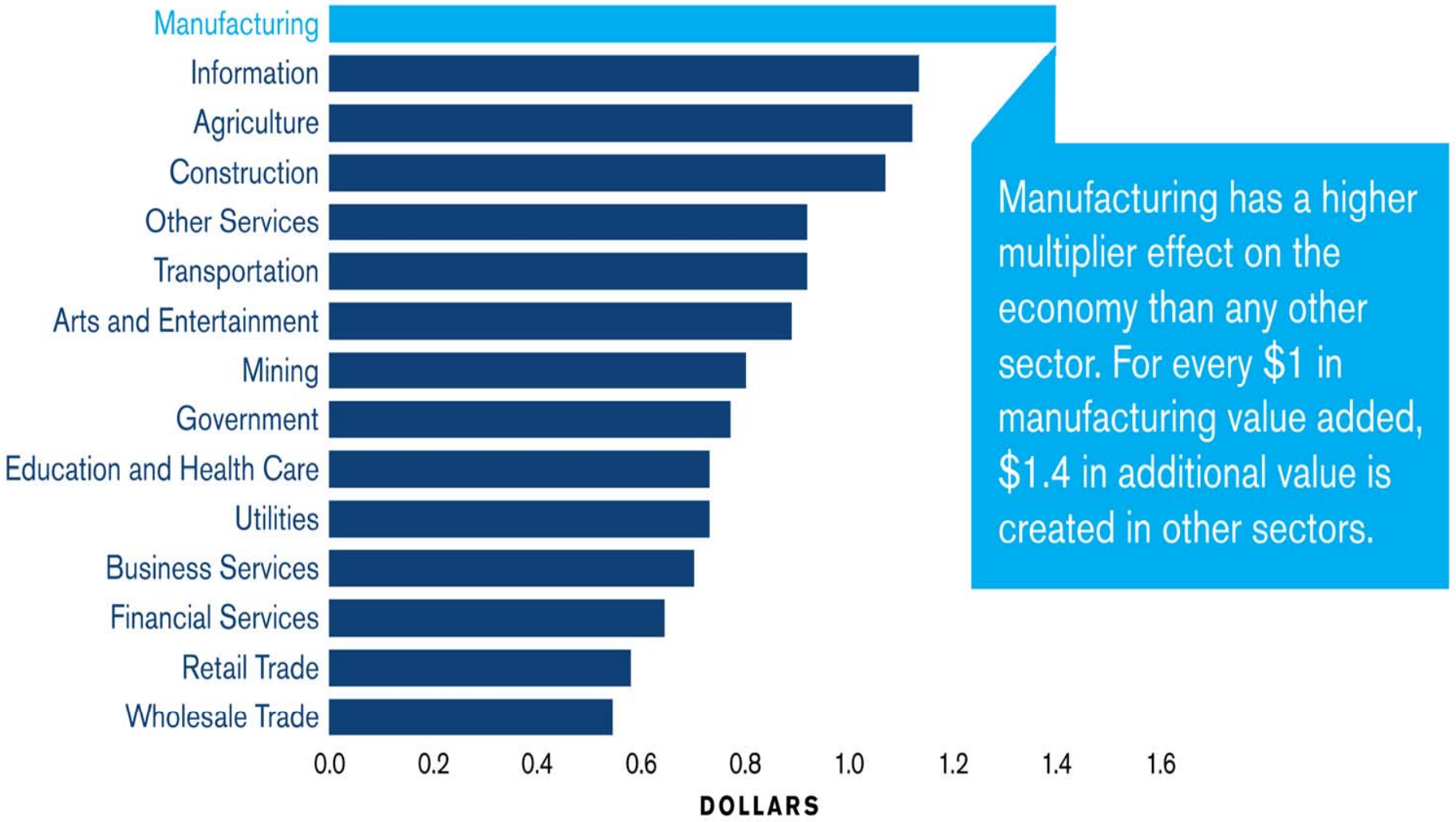
SAMUELI SCHOOL OF ENGINEERING
Unleashing innovation. Creating opportunities. Inspiring ingenuity.

Industry Perspective

"The Boeing Company recognizes the need for new manufacturing methods, materials development and training innovation. Additive manufacturing technologies have fundamentally changed how we think about design, fabrication, and support in aerospace manufacturing."

Orval M. "Jack" Nobles, Principal Investigator - Engineer 4
The Boeing Company
Boeing Research & Technology - St. Louis
Adv Mfg R&D - Fabrication Proc.
Direct Digital Manufacturing (DDM)

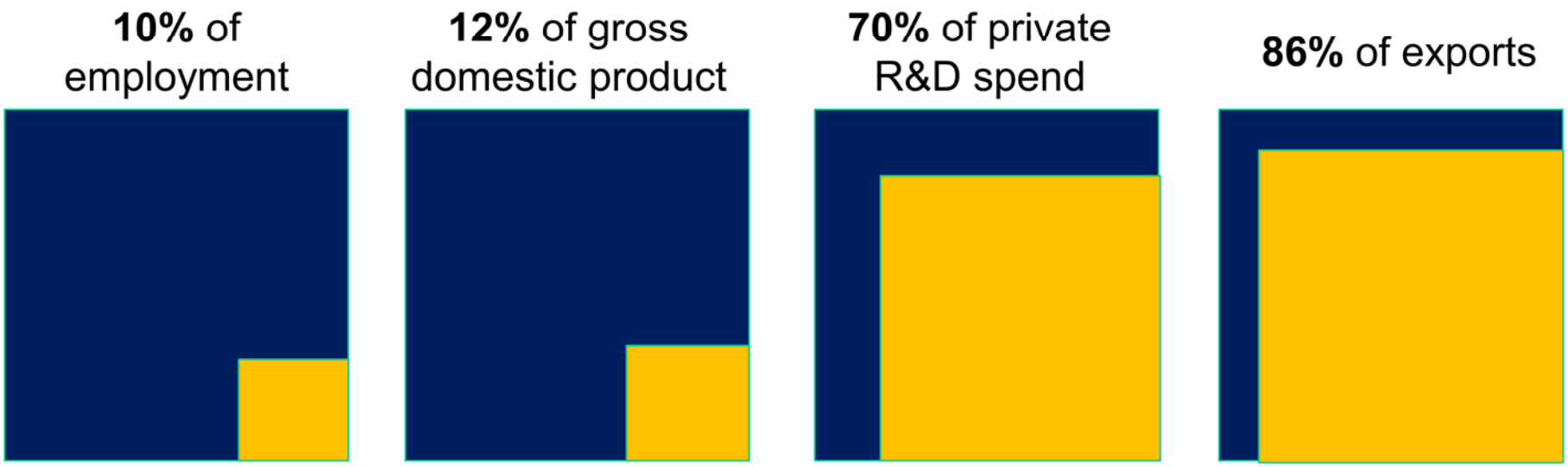
Why Manufacturing ?



Manufacturing Innovation Impact

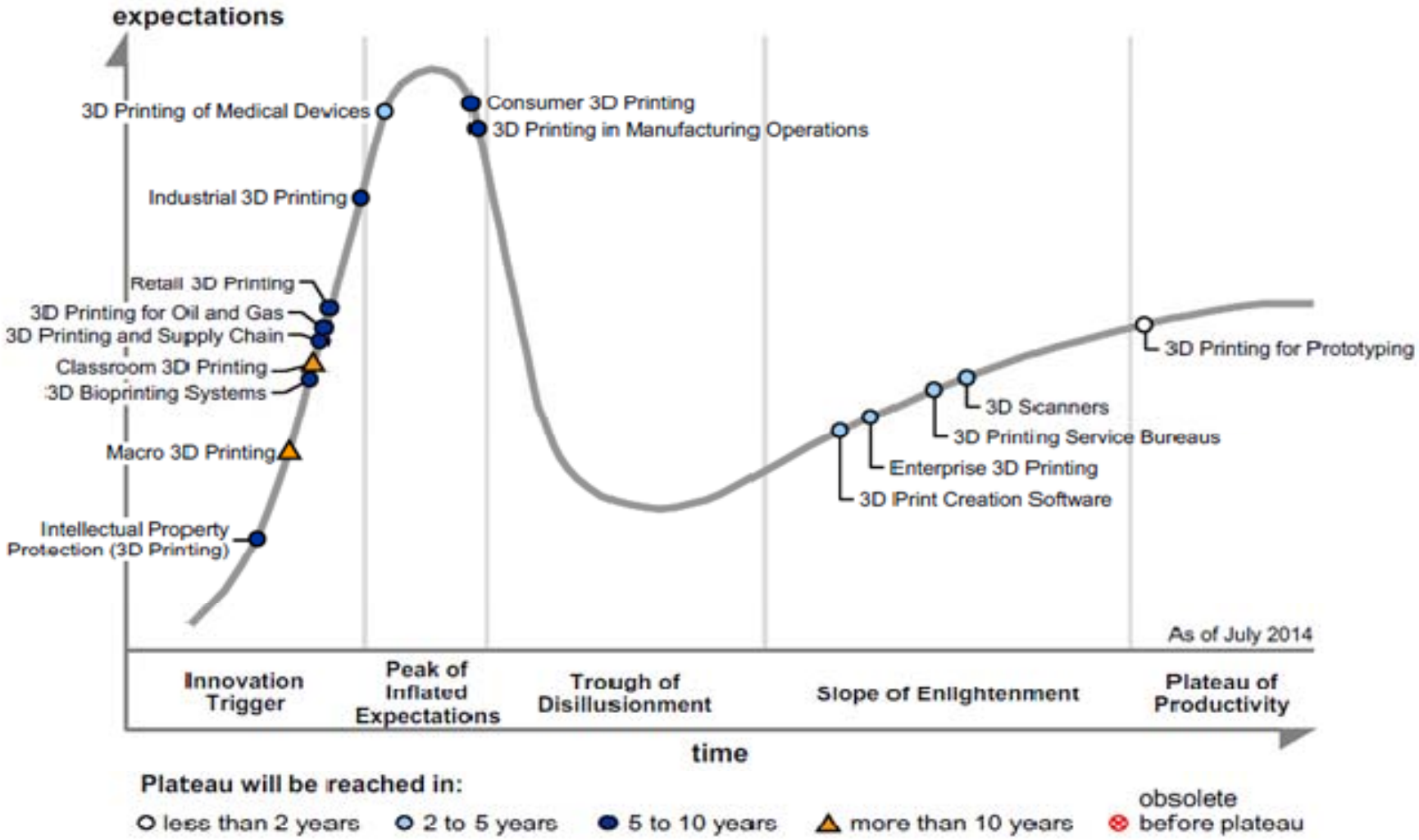
U.S. manufacturers

- Employ over half of all R&D personnel in domestic industry
- Employ over a third of all engineers
- Account for up to 90% of all U.S. patents issued annually



2014 3D Printing Hype Cycle

Figure 1. Hype Cycle for 3D Printing, 2014



Source: Gartner (July 2014)

ASTM Committee F42 on Additive Manufacturing Technologies was formed in 2009. F42 meets twice a year, usually in January and July, with about 70 members attending two days of technical meetings. The Committee, with a current membership of approximately 100, has 3 technical subcommittees; all standards developed by F42 are published in the Annual Book of ASTM Standards, Volume 10.04 . Information on the F42 subcommittee structure, portfolio of approved standards, and Work Items under development, is available from the List of Subcommittees, Standards and Work Items below. These standards will play a preeminent role in all aspects of additive manufacturing technologies

AM Technologies

- Binder jetting
- Directed energy deposition
- Material extrusion
- Material jetting
- Powder bed fusion
- Sheet lamination
- Vat photopolymerization

Binder Jet – Composite Plaster

Binder Jet – Sand Patterns

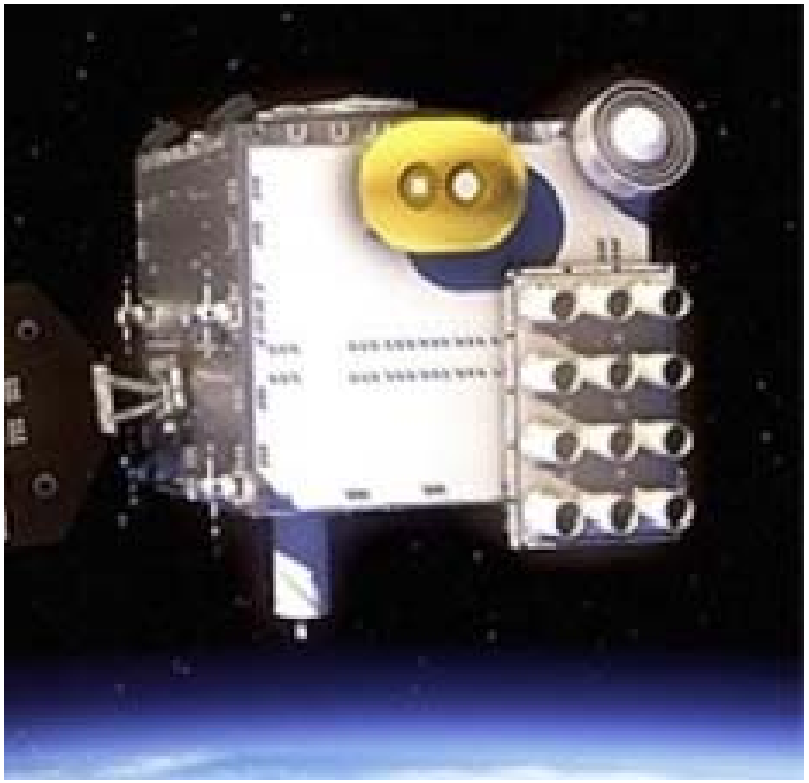
Binder Jet – Metal

Directed Energy – Electron Beam

Directed Energy - LENS

Directed Energy - LENS

Material Extrusion - Stratasys



NASA’s Jet Propulsion Laboratory (JPL) 3D printed 30 antenna array supports for the FORMOSAT-7 Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC-2) satellite mission. FDM-based Fortus 900mc 3D Production Systems from Stratasys ULTEM 9085.

Material jetting - Polyjet

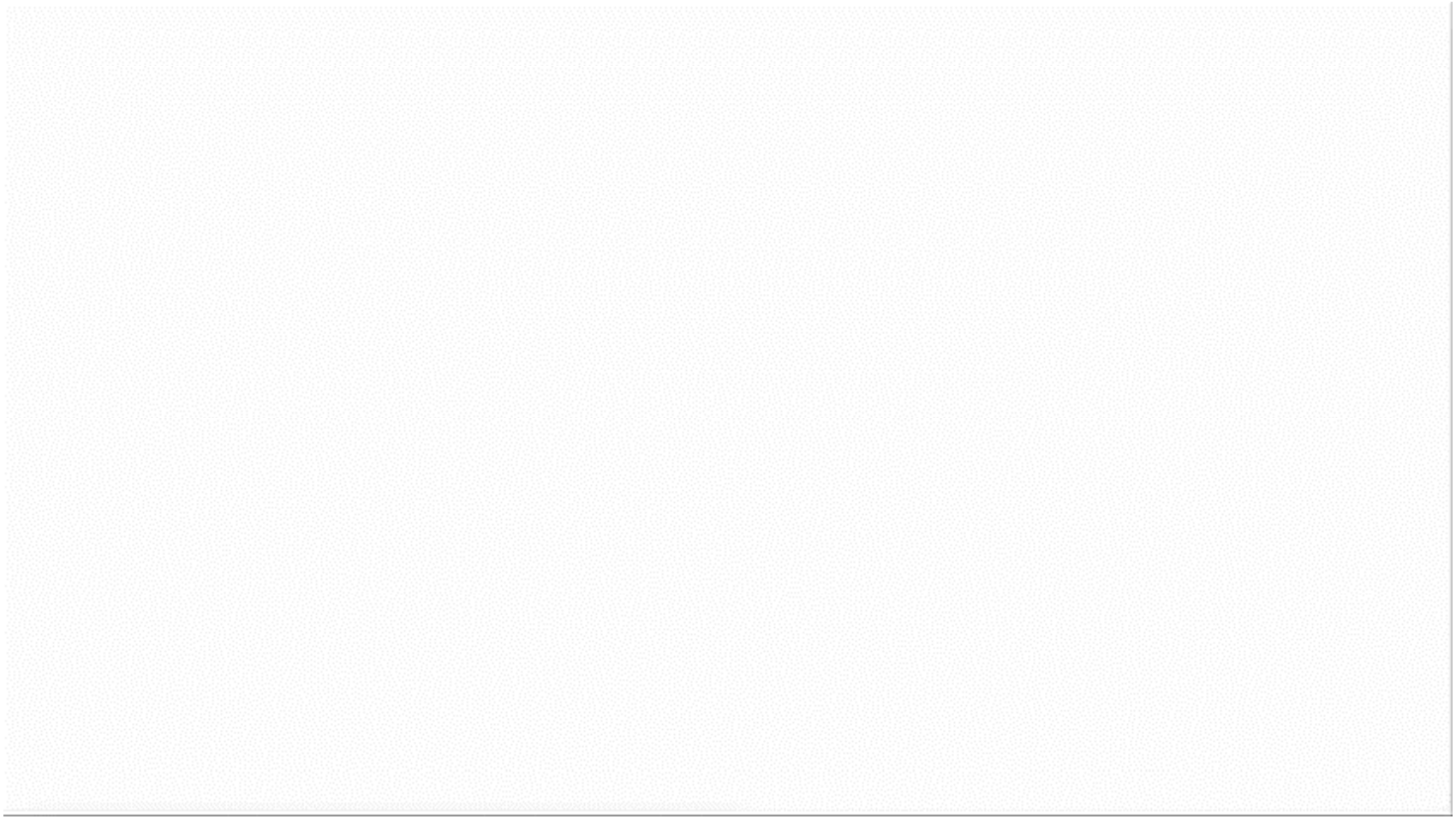
Material Jetting - Applications

Believe

Material Jetting – Injection Molds

Powder Bed Fusion

Powder Bed Fusion - DMLS



Powder Bed Fusion – Laser Cussing

Sheet Lamination – Mcor Iris

Vat Photopolymerization - SLA

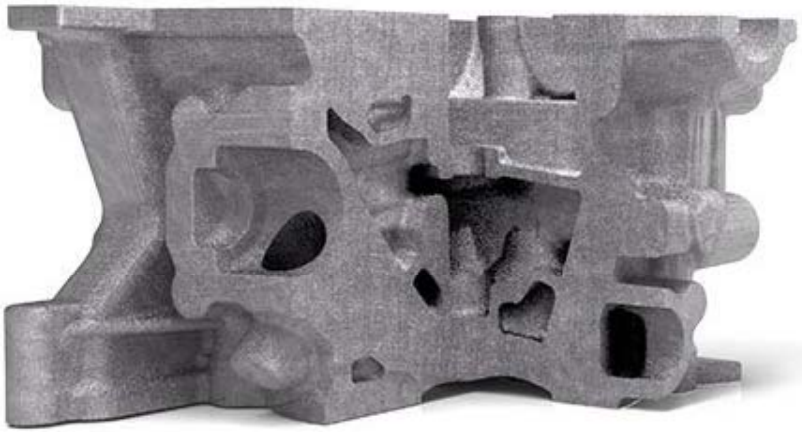
Vat Photopolymerization - DLP

Steps to Success

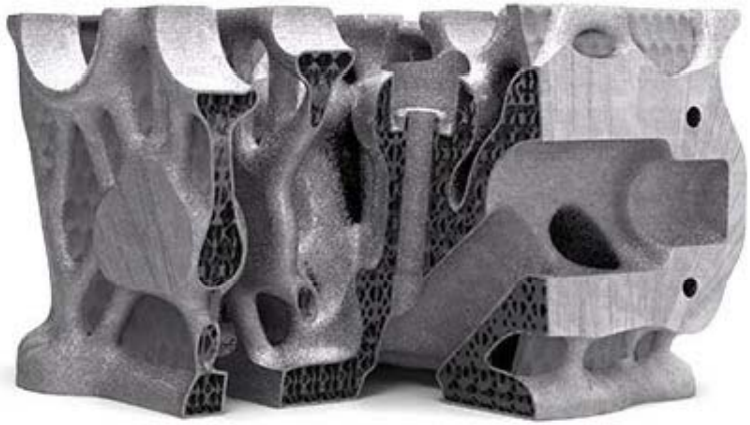
1. Computer Aided Design
2. STL convert
3. File Transfer to AM system
4. Machine Setup
5. Build
6. Remove
7. Post Process
8. Application

Complexity
is
FREE

■■■➡ *"Transforming to additive design"* ■■



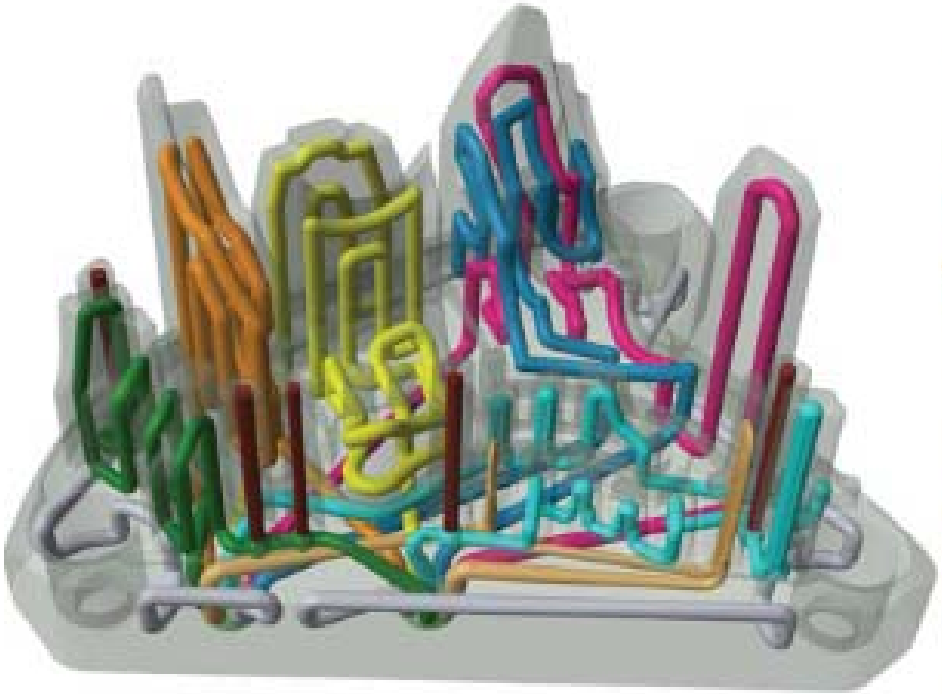
Weight: 5,1 kg
Functional Surface: 823 cm³

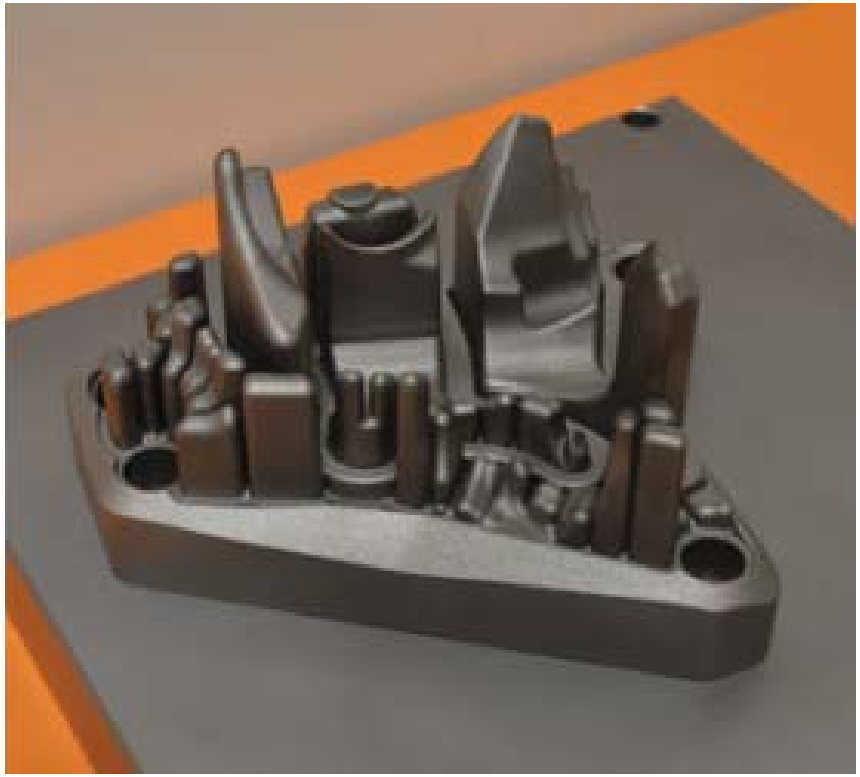


Weight: 1,9 kg
Functional Surface: 10223 cm³

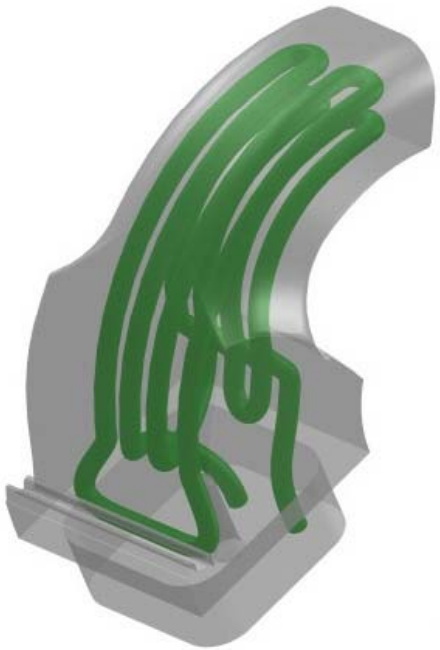
Detail of heat exchanger Al

conformal cooling Mold Side A p20

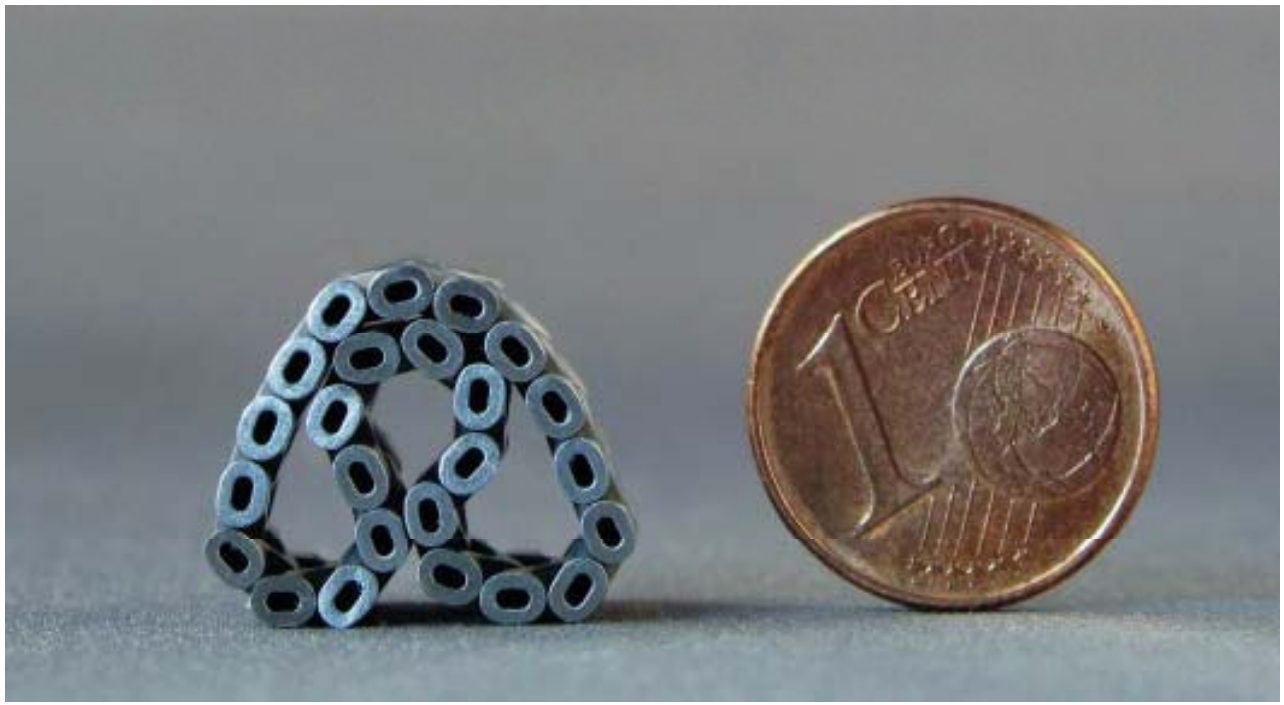




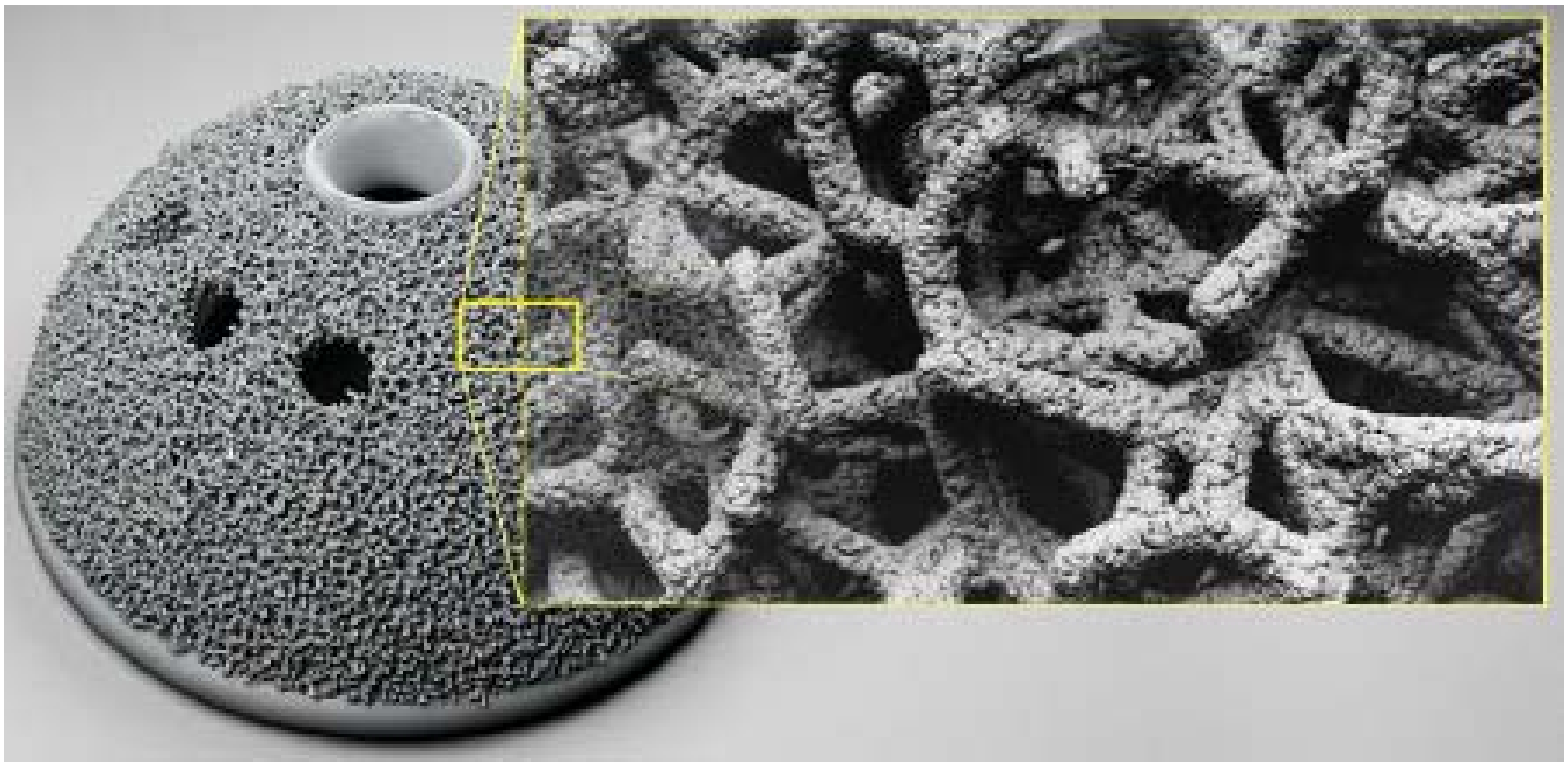
Conformal cooling



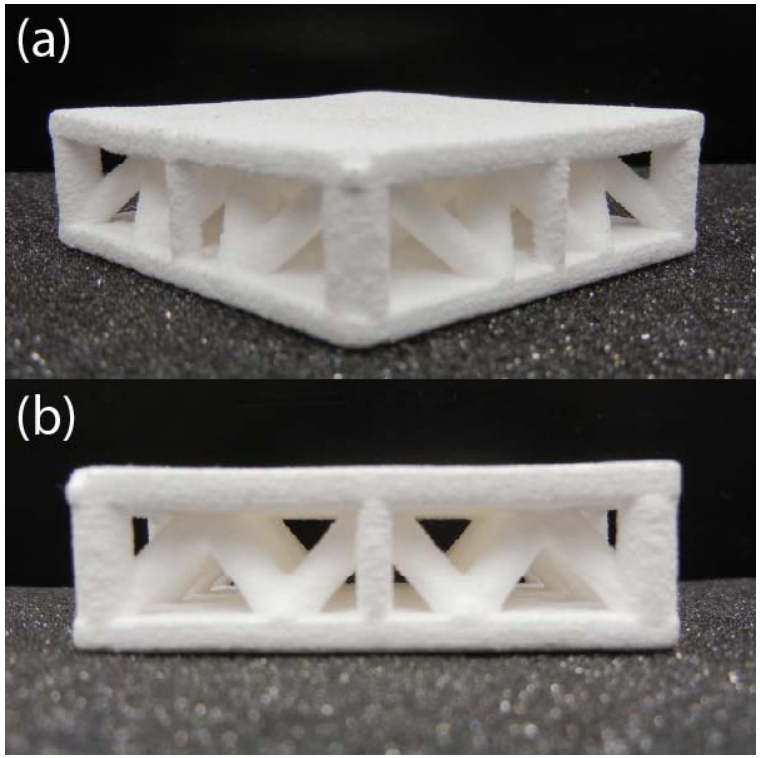
Micro Roller Chain



Acetabular Cup

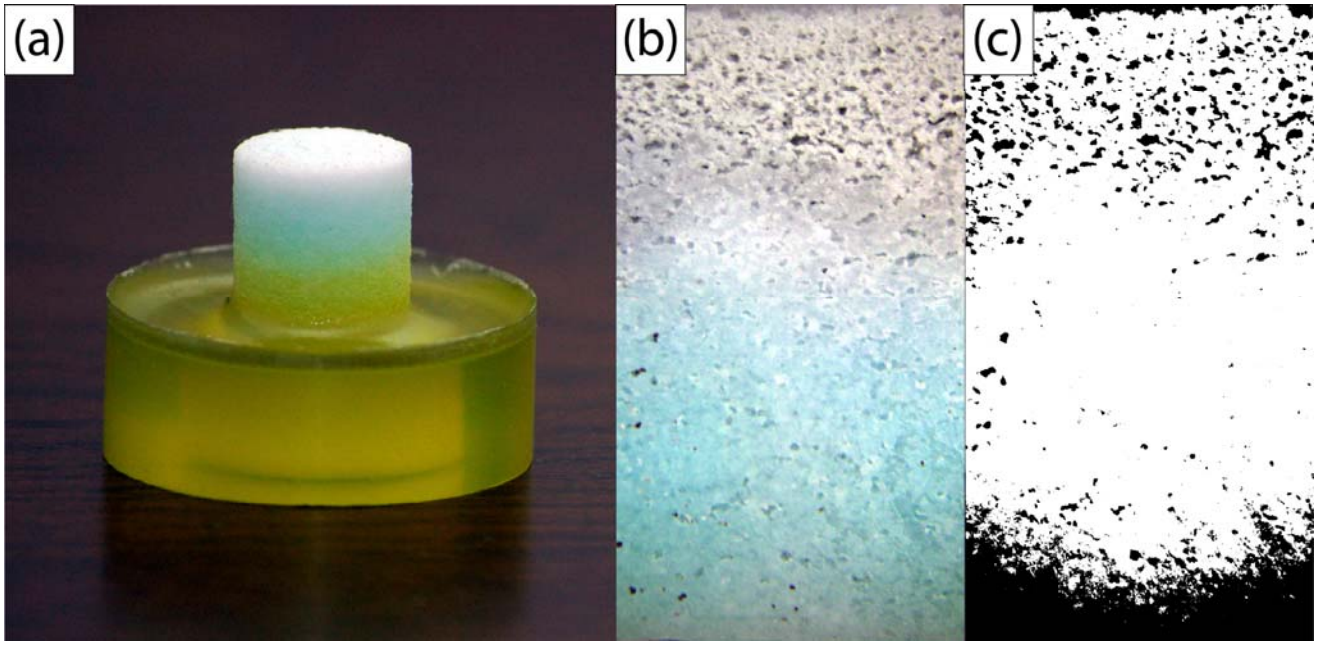


Ceramic Printing Orbital Re-entry



3D printed alumina/silica architected sandwich panel after bisque firing and sintering.
(a) Isometric view; (b) Front view. The external vertical columns were printed to support the face
sheet during sintering and preserve the shape of the part. They were removed prior to infiltration
and testing

Ceramic Printing Orbital Re-entry



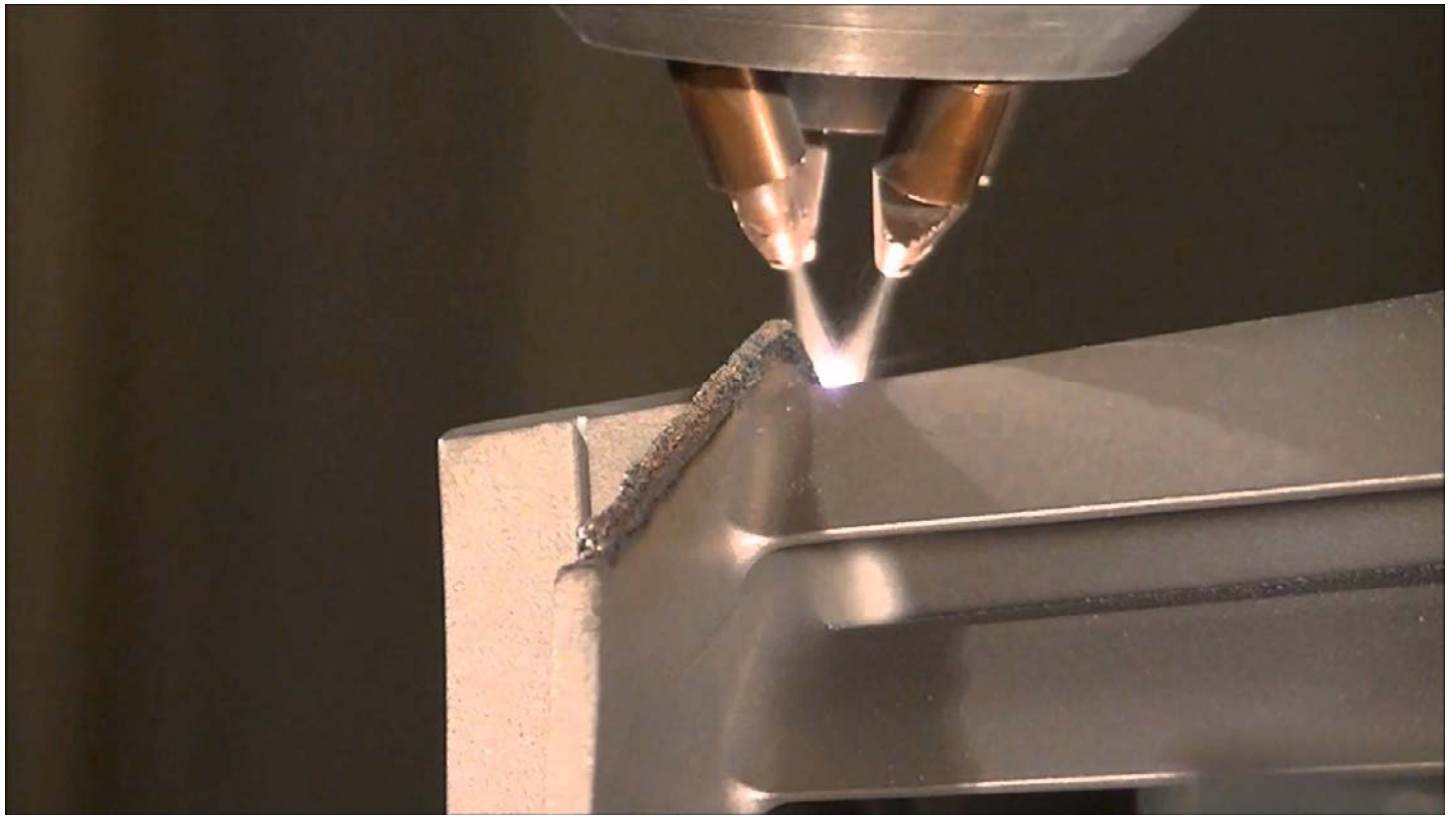
(a) Sintered ceramic cylinder embedded in epoxy resin. Notice that the resin partially wicks through the cylinder (coloring was added to emphasize the gradient in composition). (b) Optical micrograph of a cross-section of the cylinder in (a), showing a gradient in resin volume fraction; (c) Digital thresholding of the image in (b), clearly showing a gradient in porosity. Notice that the infiltrated (hybrid) regions are nearly fully dense, whereas ~50% porosity remains in the ceramic regions.

ExOne™

DIGITAL PART MATERIALIZATION

OPTOMEC®

Production Grade 3D Printers... with a Material Difference



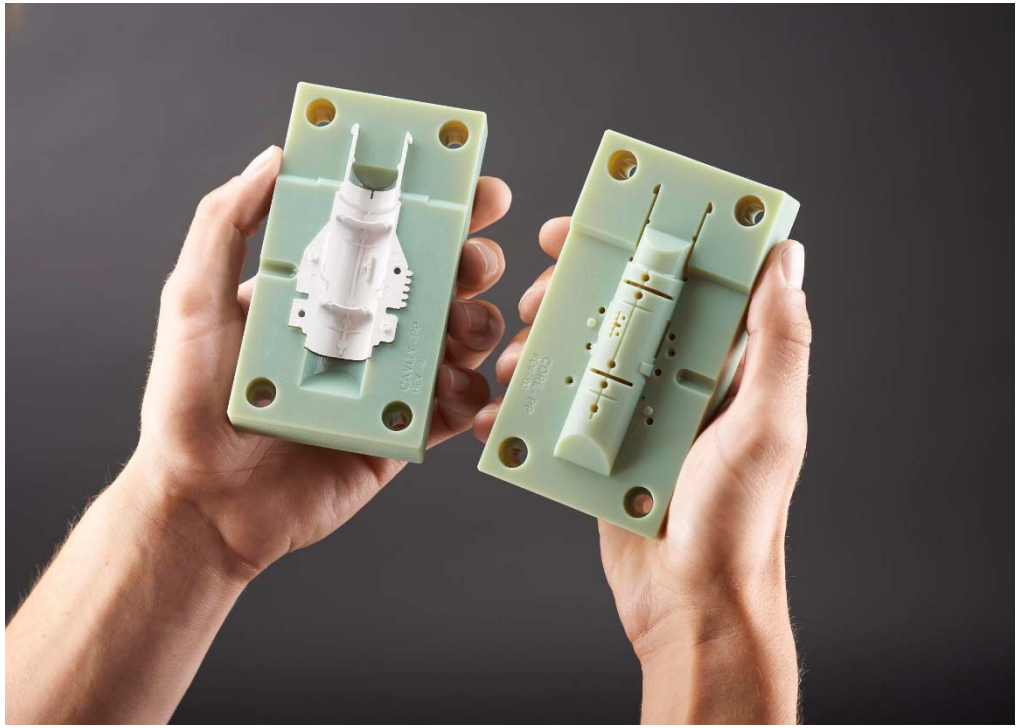
Stratasys
FOR A 3D WORLD™

FORTUS
3D PRODUCTION SYSTEMS

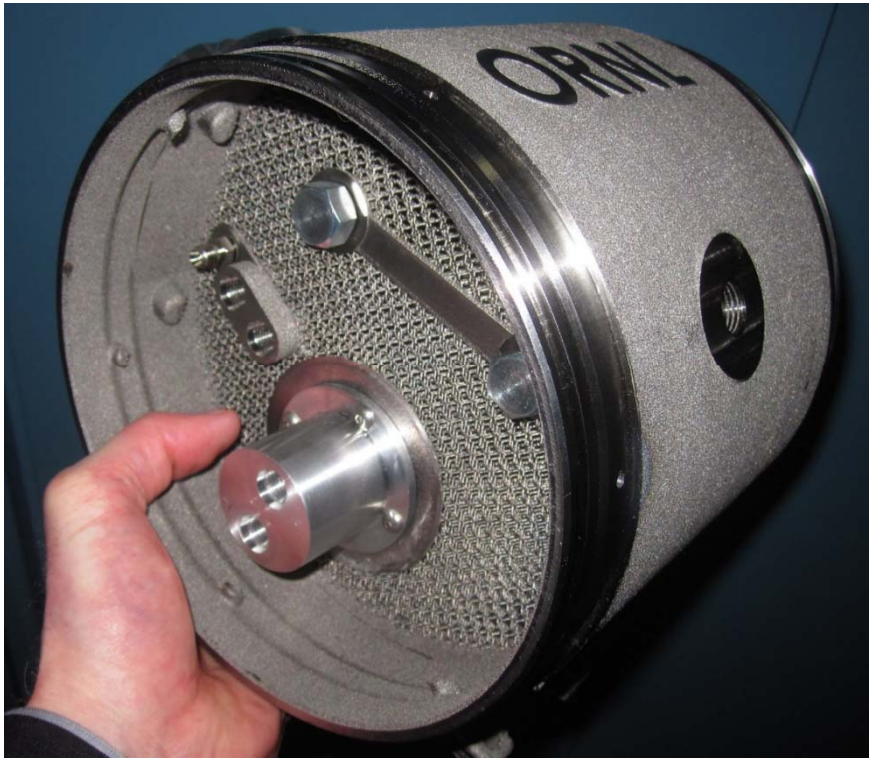
Stratasys
FOR A 3D WORLD™

OBJET

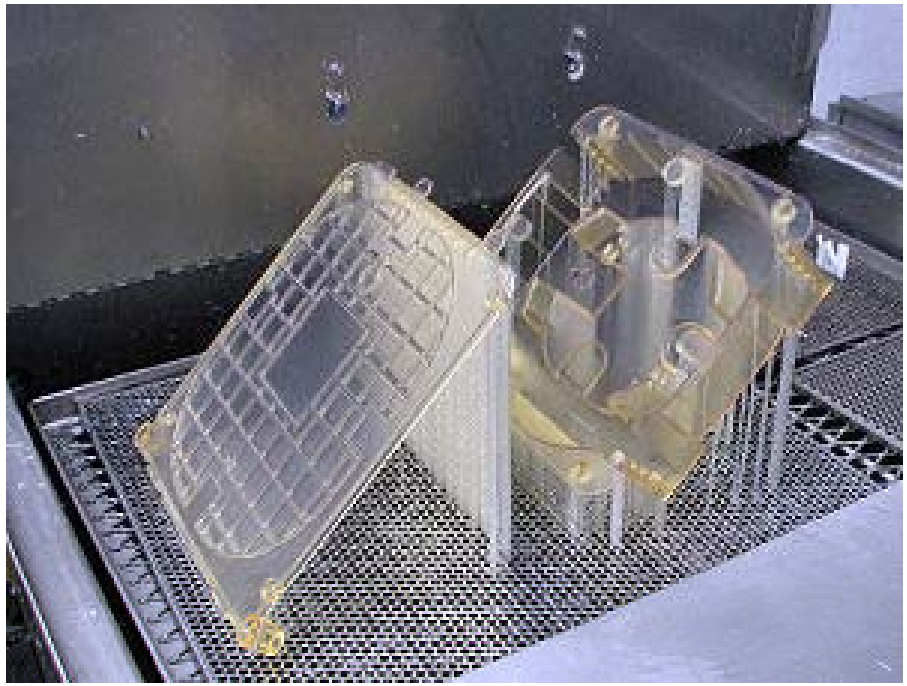
3D Printed Injection Mold

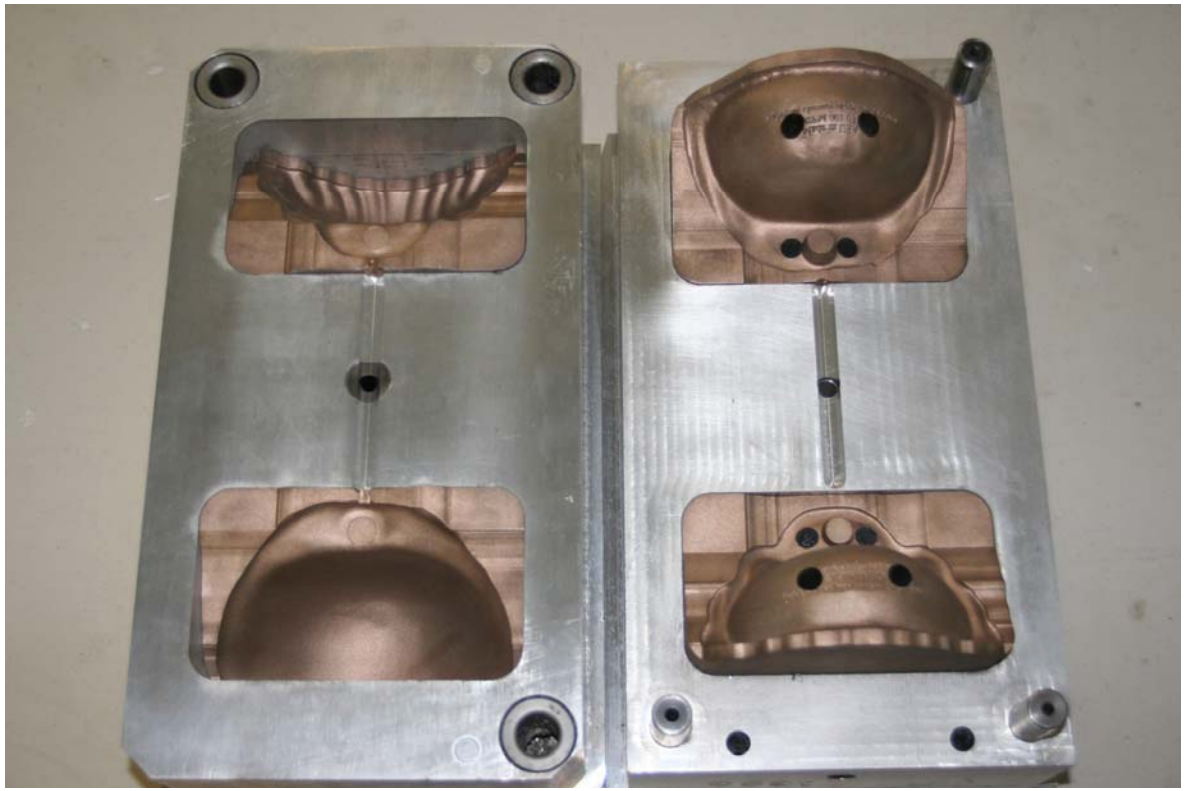


Digital Materials


ORNL

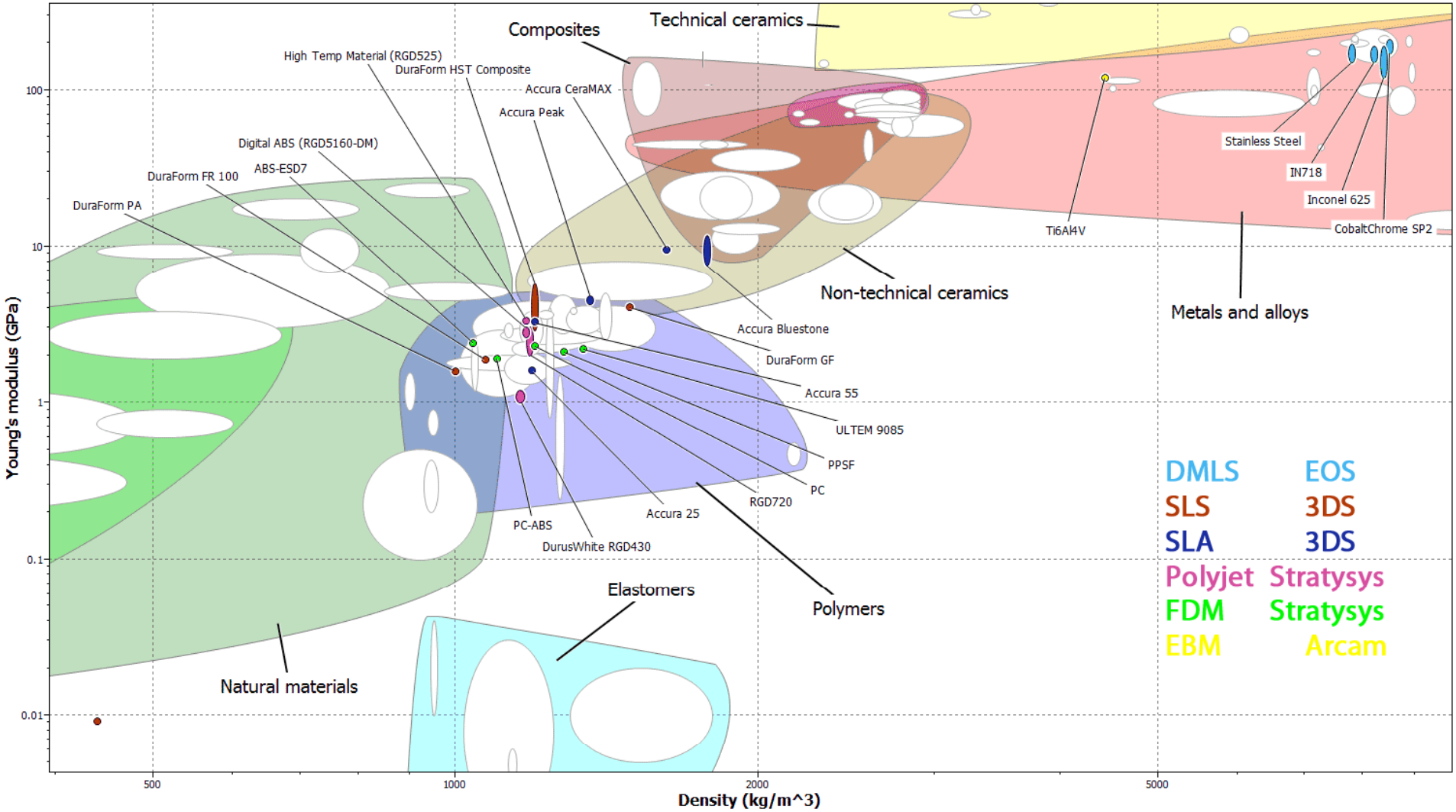
Photopolymer






$7959.00

Material Properties as they exist now



Randall Schubert, HRL Laboratories @ 2013

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Thank You !

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