The promise of Multi materials - 3D printing

Dr. Eynat Matzner
Director of Materials Research and Development
Stratasys

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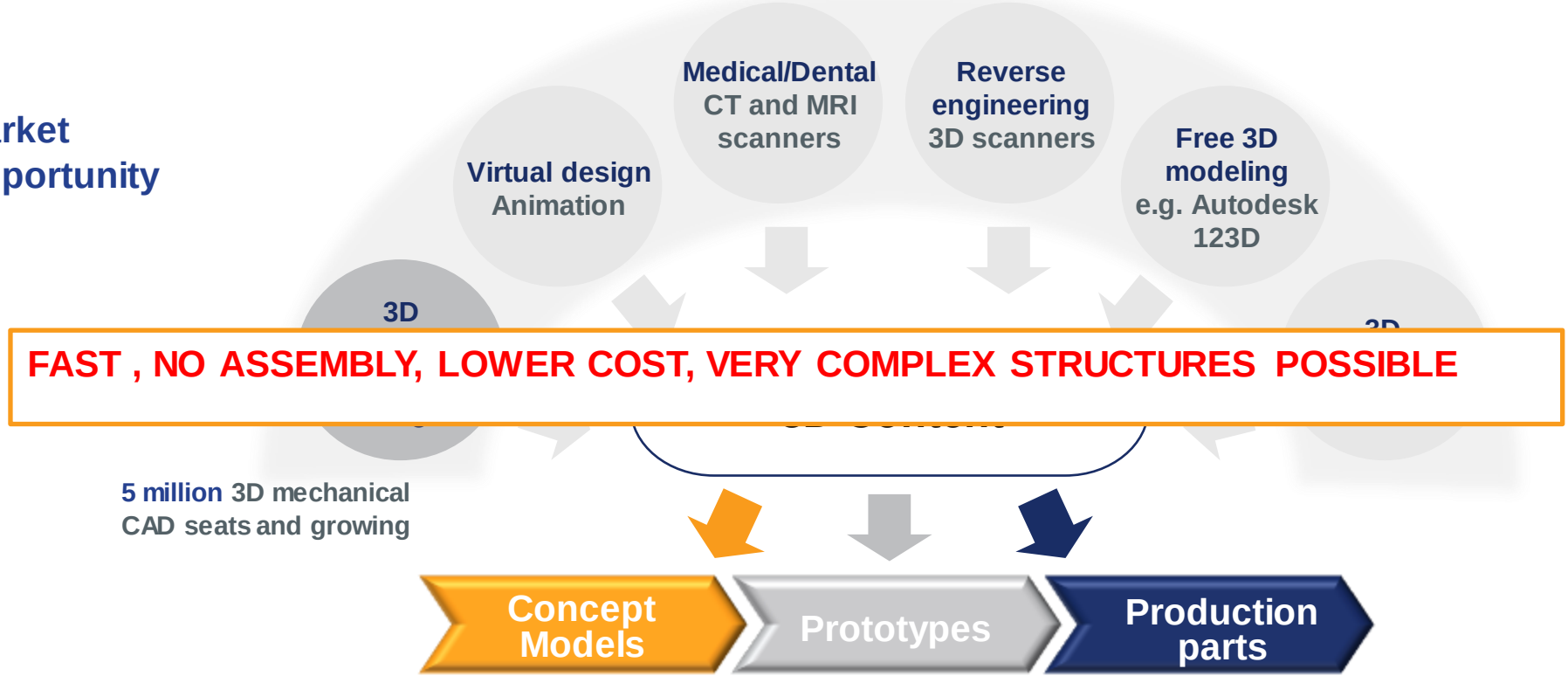
Market Opportunity

Millions of 2D & 3D CAD seats worldwide



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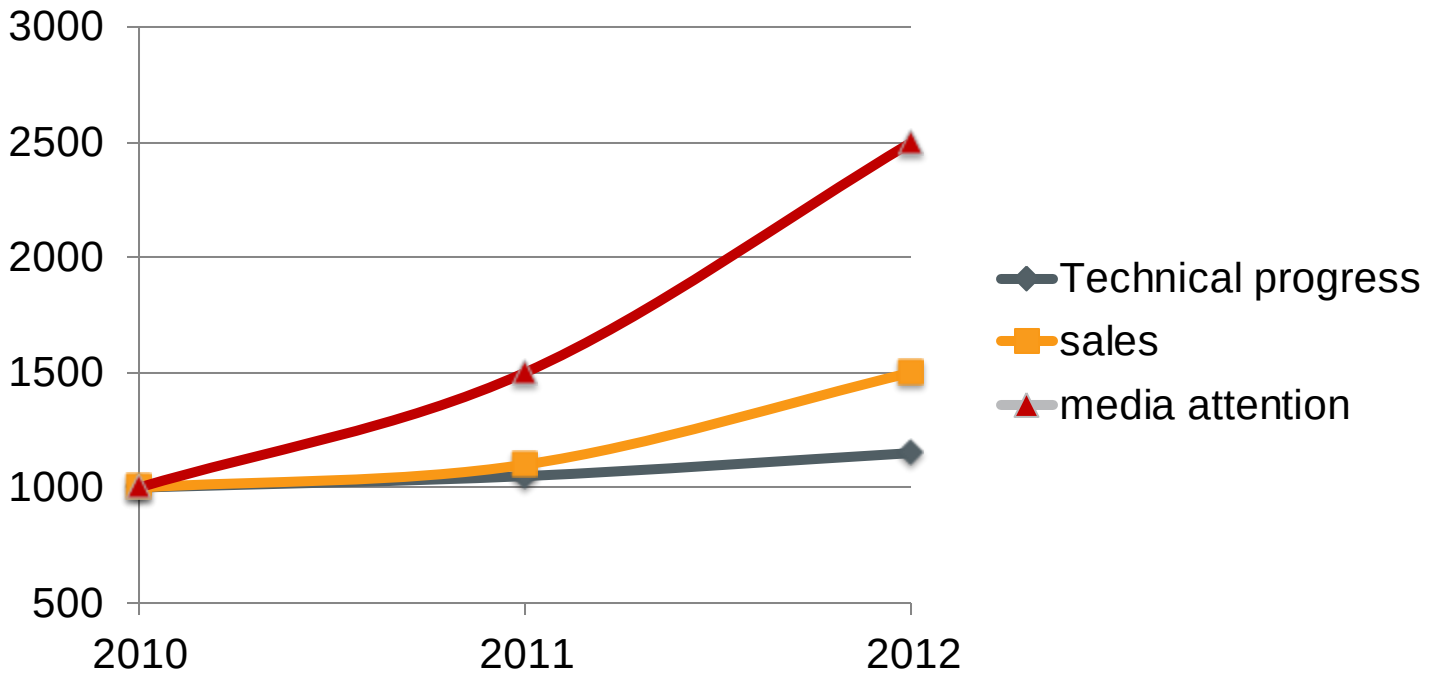
“3D printing” – Additive Manufacturing

Layer by layer production

Additive process

3D printing – Additive Manufacturing

In the center of attention



Reaching $ 2 Billion sales in 2013

Terry Wohlers
RAPID 2013

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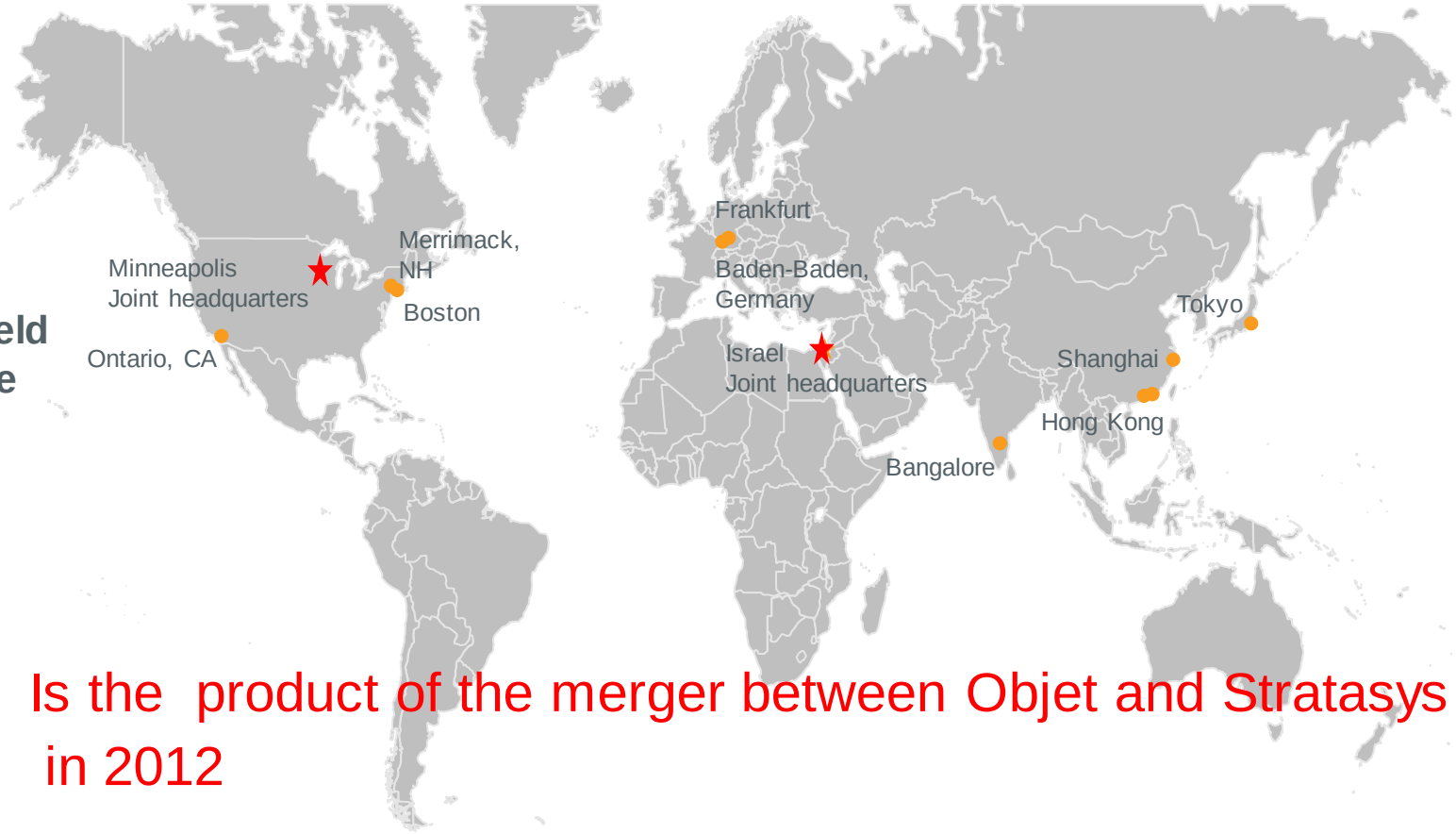
Stratasys: A leader in the field of 3D – additive manufacturing



Is the product of the merger between Objet and Stratasys in 2012

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Professional Market Opportunity

- More than **8,000 customers** worldwide
- **32,245** units through Q1-2013
- Global brands as well as smaller companies
- Our customers are from multiple industries

Automotive
Aerospace
Industrial & commercial
Consumer products
Medical
Government
Education and research
Architecture
Dental
Jewelry

Additive Manufacturing: Common technologies

FDM - fused deposition modeling: very fine extrusion of thermoplastics (ABS, Nylon, Ultem)

SLS – selective laser sintering - solidification of powders by laser (metals, thermoplastic polymers)

SLA - stereo lithography – solidification of liquid in a bath by laser (Curable monomers/polymers)

Polyjet - multiple head - Ink jet 3D printing (UV curable monomers)

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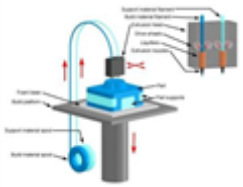
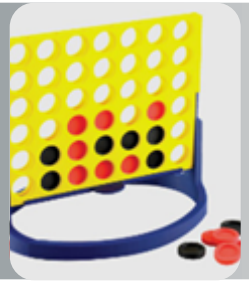
Three distinct technologies

Complementary platforms

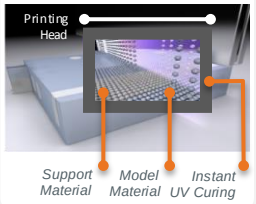
FDM



- Thermoplastic output
- Durable
- Office friendly

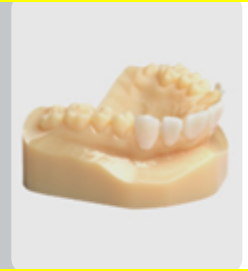




Polyjet

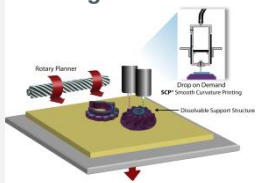


- Resin output
- High feature and surface finish
- **Multi-material capabilities**
- Scalable





Smooth Curvature Printing



- Wax output
- High precision and detail
- Castable



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The Leap to Leadership

1988: Scott Crump invents Fused Deposition Modeling (FDM) in the family kitchen by mixing wax and plastic formulas

1994: Stratasys begins selling the first thermoplastic available for a 3D printing process: ABS plastic

1998: Objet founded by former printing industry entrepreneurs: Polyjet technology

2002: Stratasys introduces the Dimension, the first 3D printer sub-$30,000

2007: Objet introduces world's first Objet Connex multi-material 3D printing technology

2008: Stratasys launches the first machine for production; the Fortus 900mc

2012: Objet announces world's first desktop 3D printer with 7 materials

2012: First UAV prototype to fly with entire ng

2012: Objet Connex – the first machine to 3D print over 100 materials

2012: A leader is born: Stratasys and Objet complete merger to lead t 3D printing industry

2013: MakerBot merger

The promise of multi material printing

2014: Introduction of world's first 3 model materials capability – Connex 3

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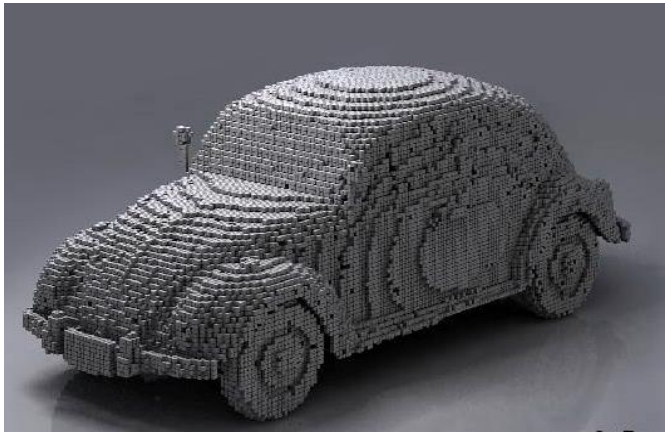
Digitizing a Shape

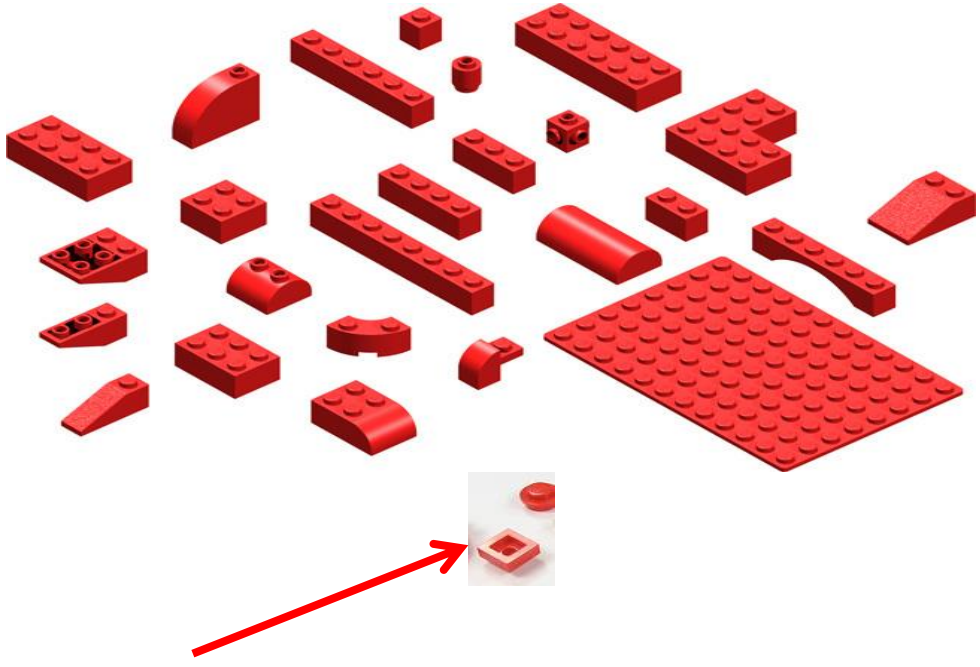


Voxel (volumetric pixel):

a volume element representing a value on a regular grid in three dimensional space.

This is analogous to a pixel, which represents 2D image data in a bitmap.

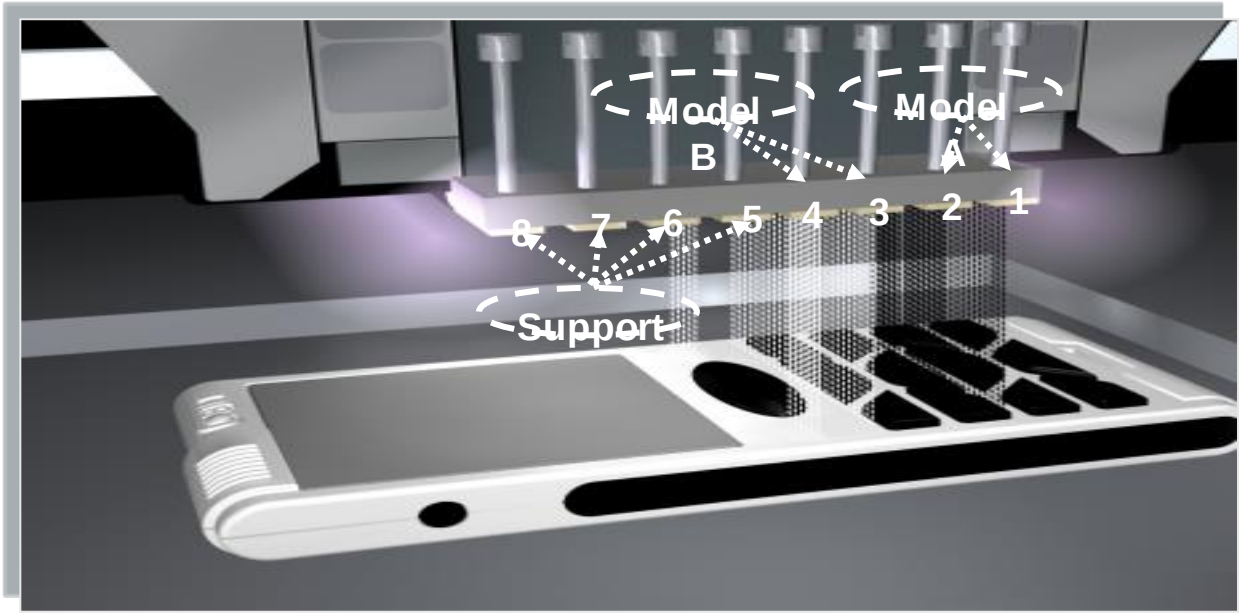
Polyjet's voxel vs. Lego bricks



The smallest Lego brick consist of
~ 4 million of Polyjet's voxels

Multi-material printing

3D Printing…



…and dispensing different materials at the same time

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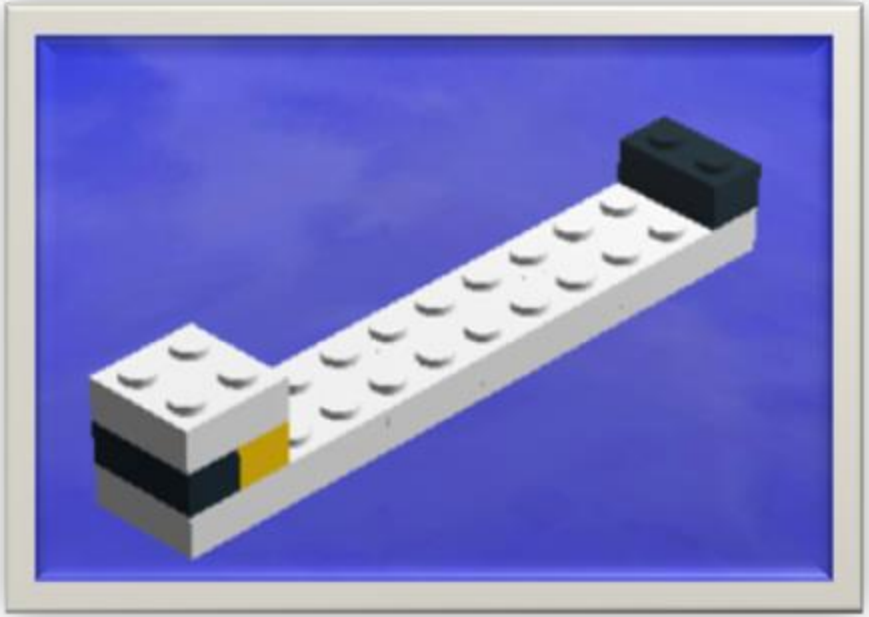
Multi-material printing

Model 1

Model 2

Model 3

Support



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Multi material printing: Objects and Digital Materials

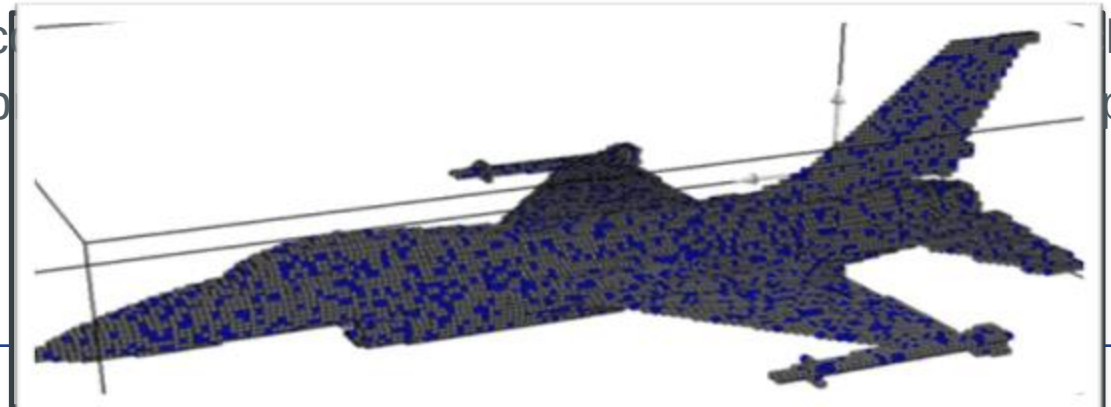
Multi material objects : are combined of macroscopic parts

wi ob.

Digital materials: Materials in which each voxel composition is

c hieved by

p position.



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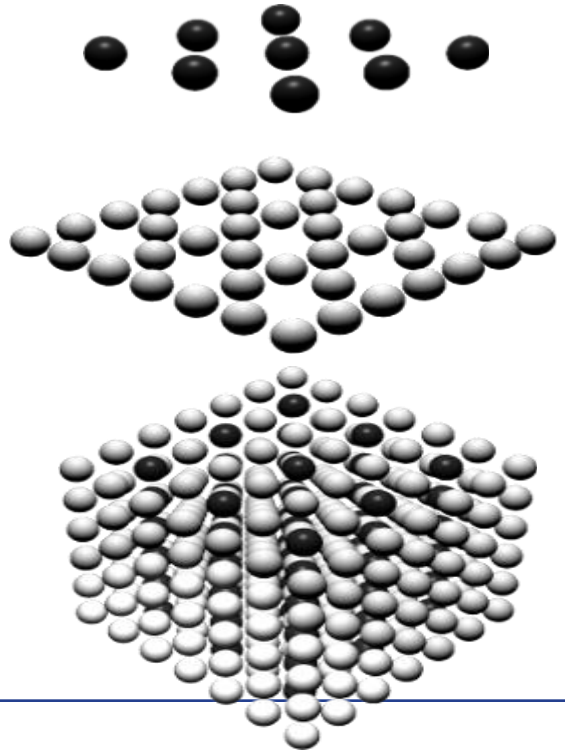
Multi Materials – What For?

New features
New designs
Better performance

Digital material: Enabled by a multi material printer



- Black rubbery material (Tango +)
- White rigid material (Vero white)
- ✓ Grey scale
- ✓ Shore hardness scale

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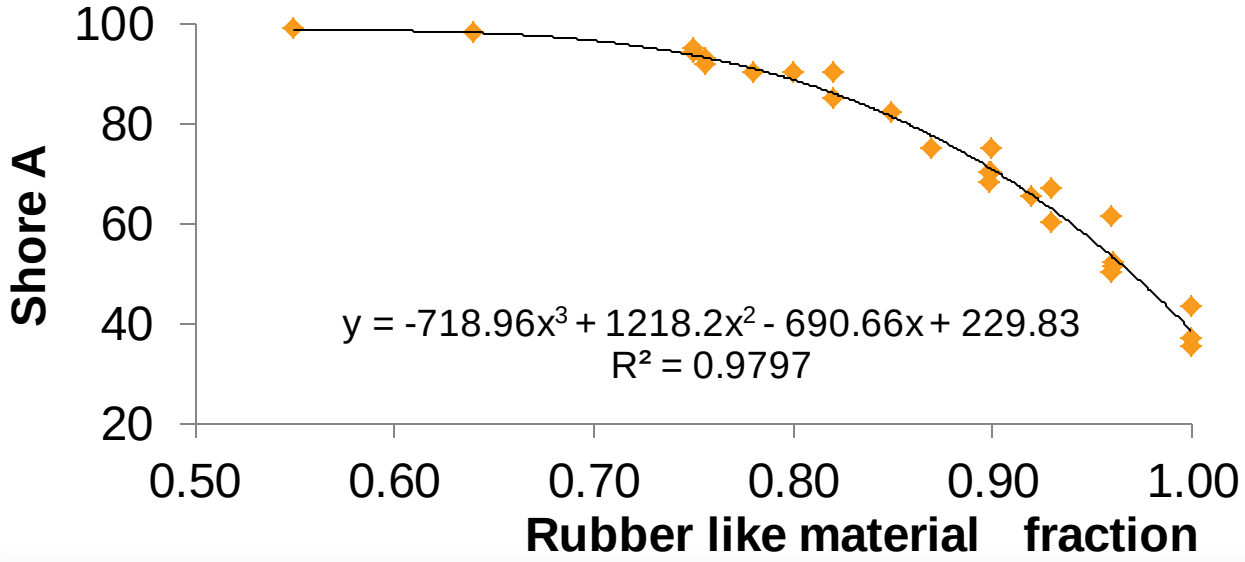
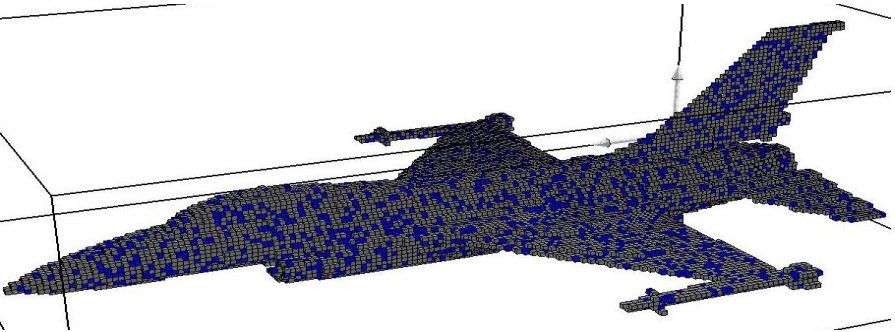
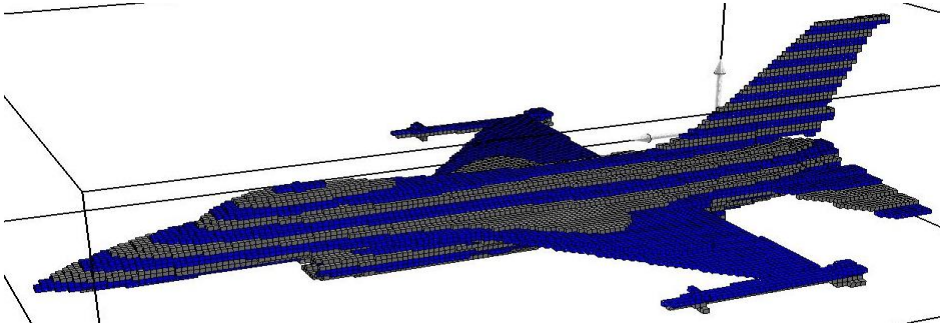
Predicting the Propertied of Simple DM Structures

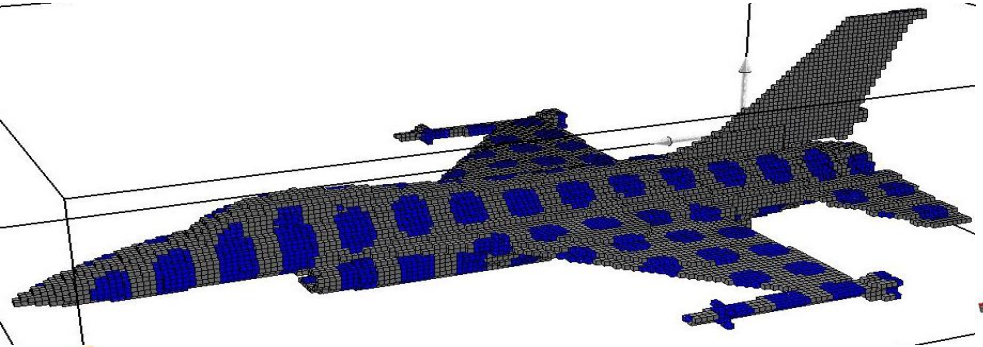


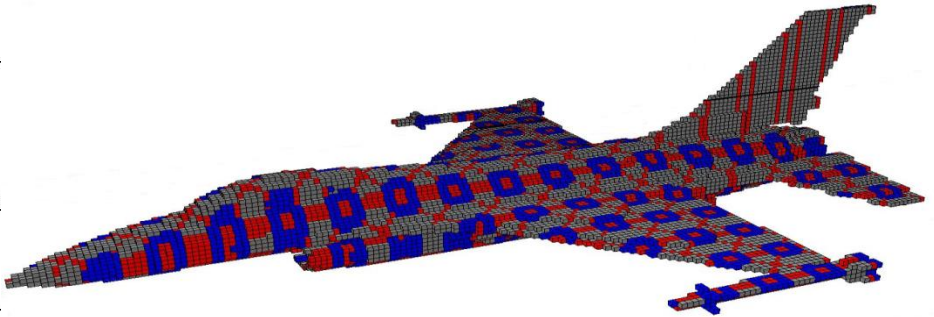
Prediction for Complex DM Structures





Random distribution, Domains, specific order , etc.





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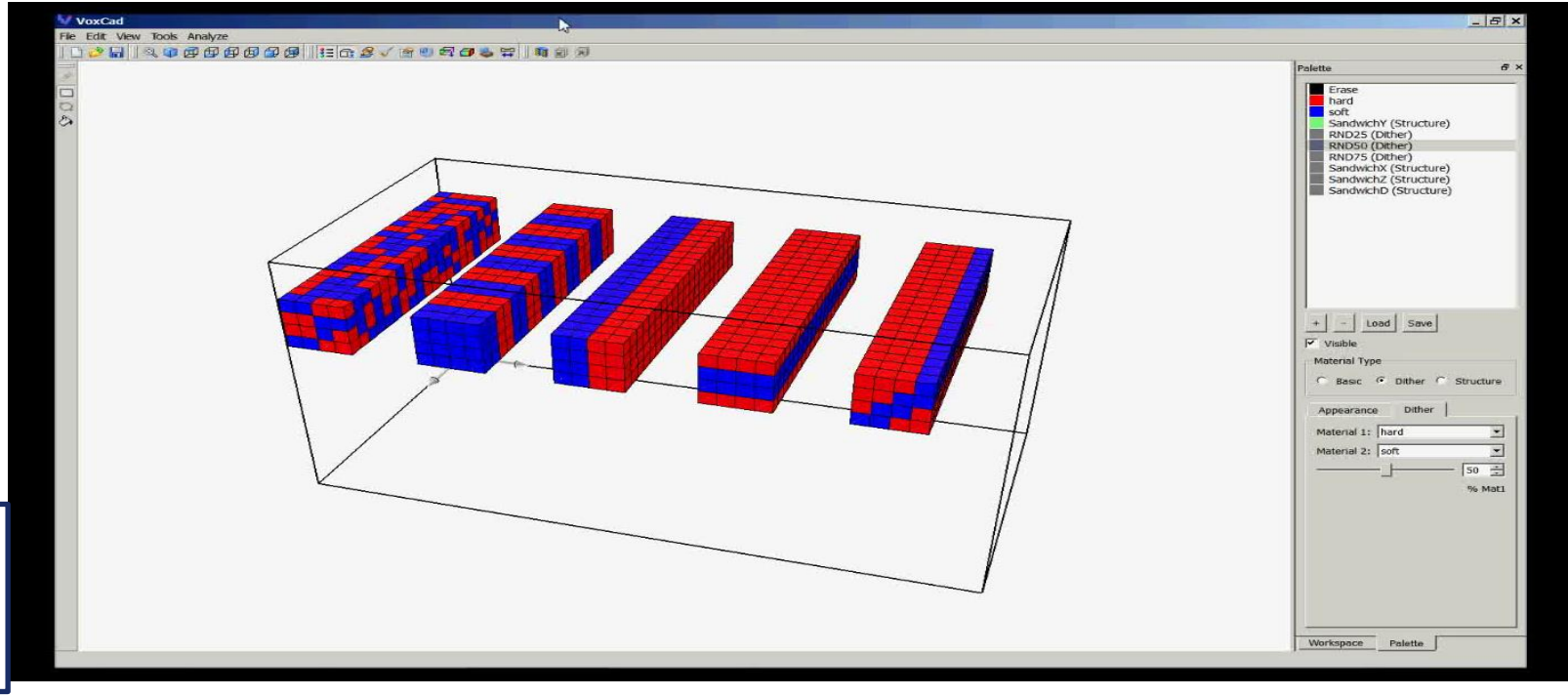
VoxCad Testing: Bending Test



Cooperation with Hod Lipson's group at Cornell

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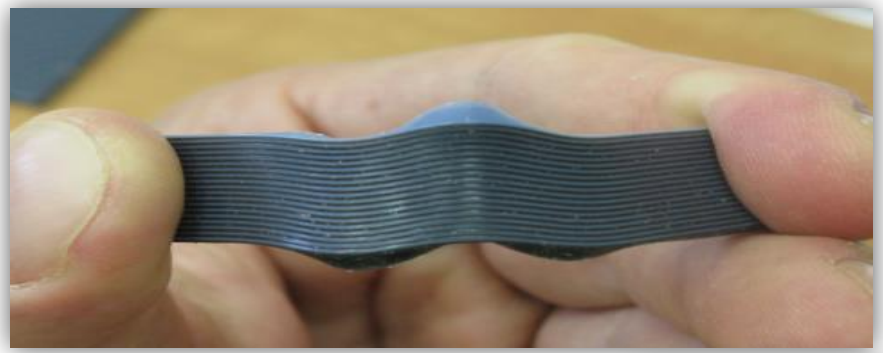
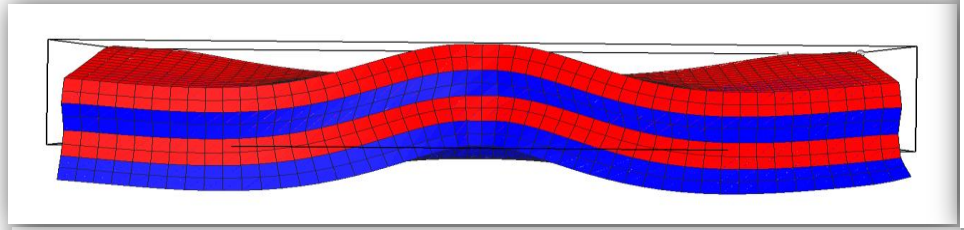
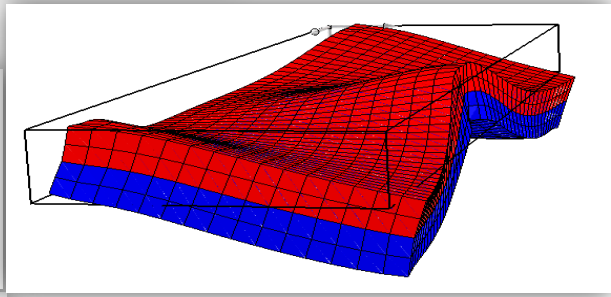
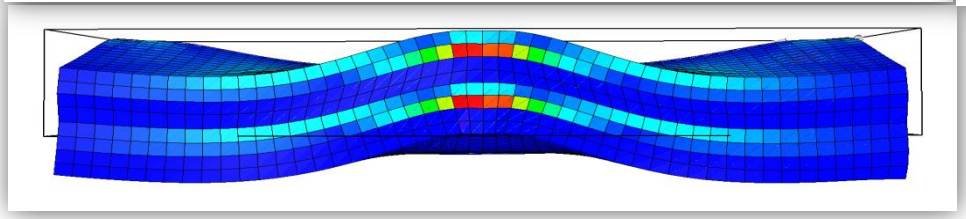
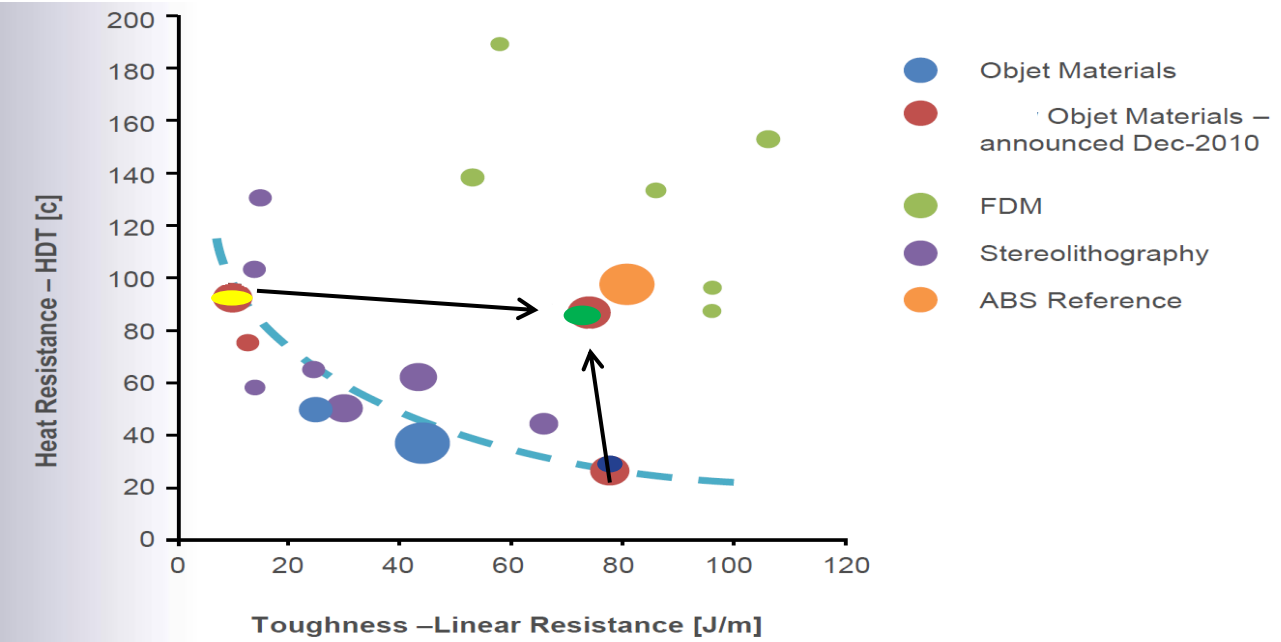
VoxCad Testing: Anisotropic Distortions











High Toughness
Objet RGD515

High Temperature
Objet RGD535

Objet ABS-like
RGD5160-DM

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Gradual Compositional Variations

MIT MEDIA LAB

Cooperation with Neri Oxman at MIT

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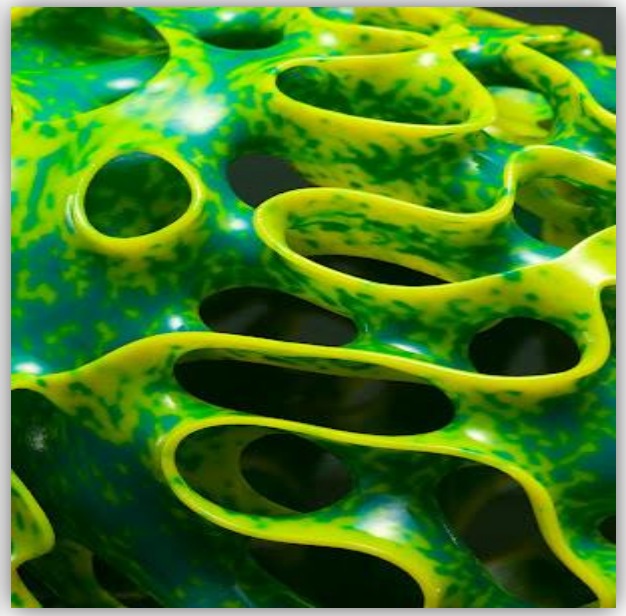
Color Graded Materials



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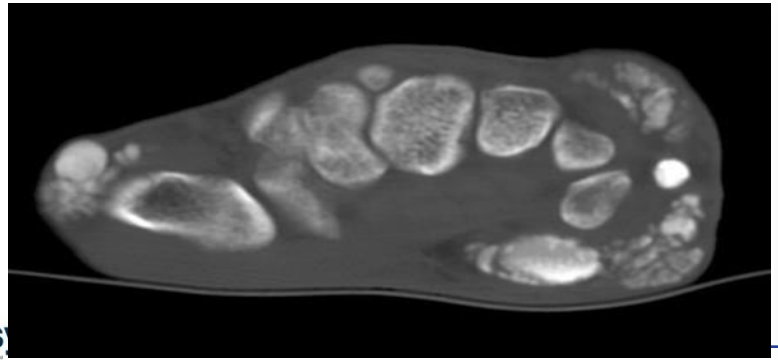
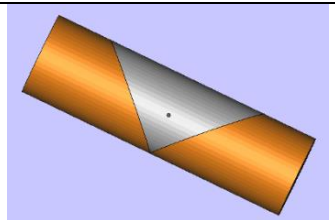
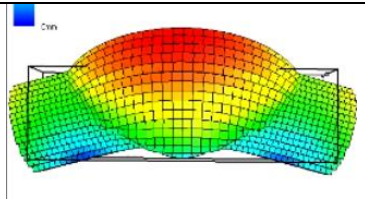
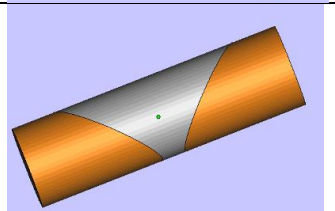
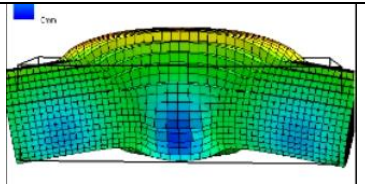
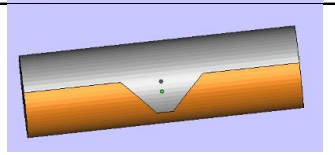
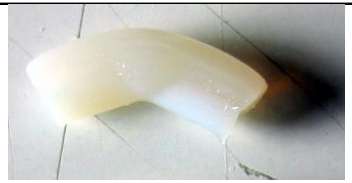
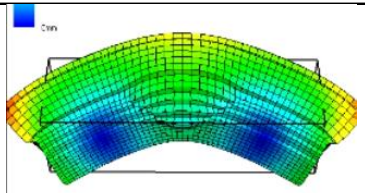
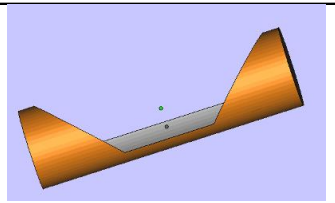
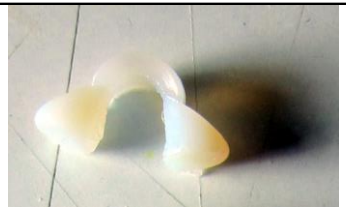
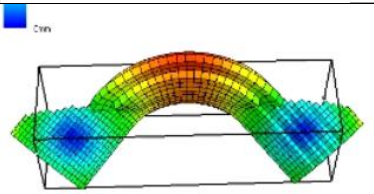
Density graded materials



Self assembly:

water Swelling + non swelling parts

structure	CAD	experiment	simulation
Simple elbow			
Elbow+space			
Elbow+extra expander			
Elbow-“bi”			

Cooperation with Skylar Tibbits at MIT

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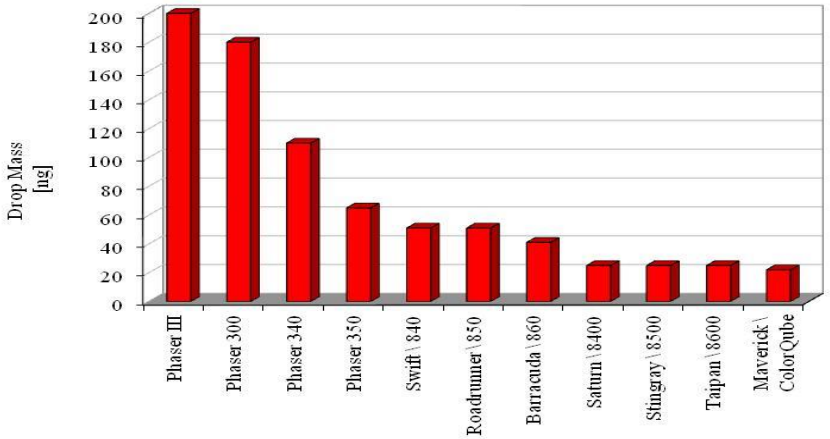
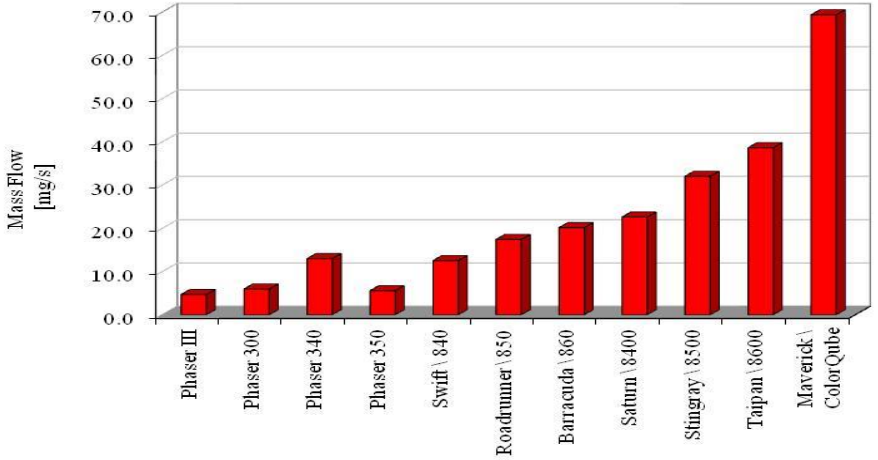
Inkjet
“Moore law”

Drop size



Yield - speed



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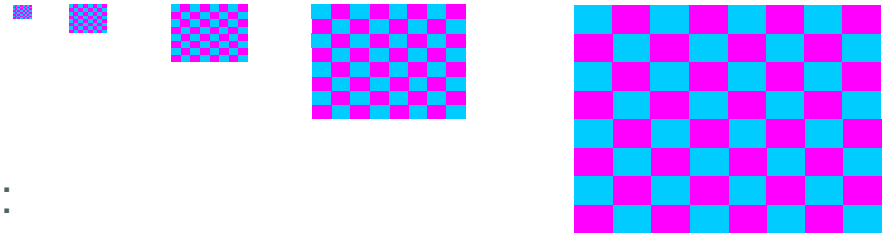
Ink-jet Color : Full color 3D printing

Digital colors – Dithering
C + M -> Blue



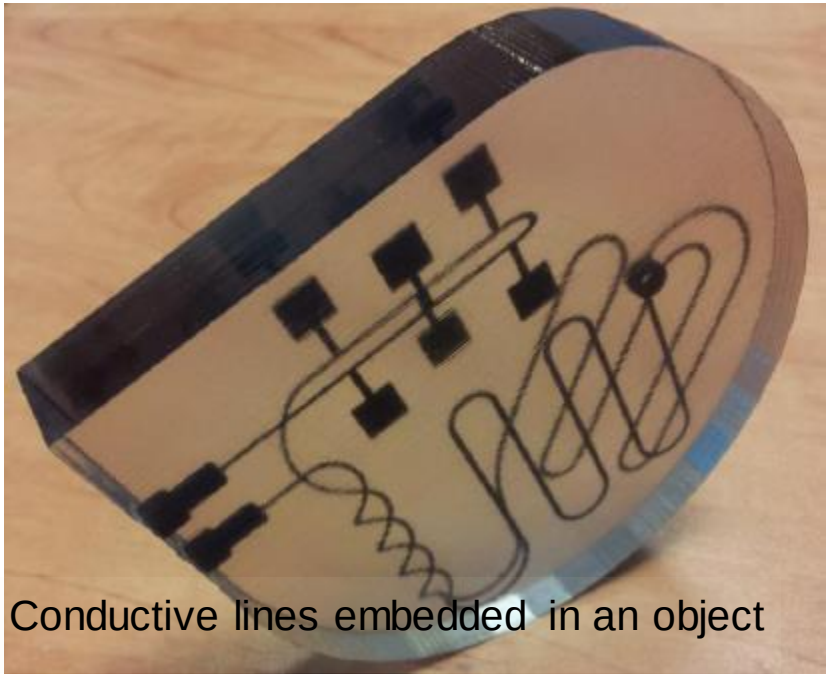
Base color for 3D printing:

CMYK + White + Clear: full color + opacity

CMYK subtractive

New functional objects and materials:

- Conductive
- Other electrical functions
- bio active
- Moving parts
- Chemically active
- nano scale shapes and functions?



Conductive lines embedded in an object

We invite you to use your imagination

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Thank you

special thanks to:
Dr. Ofer Shochet
Dr. Daniel Dikovsky
and the other excellent scientists in Stratasys Ltd.

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