



Aalto University
Media Factory

Digital_Fabrication_Studio.08

3D Printing – from bits to atoms

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16.10.2012



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Today:

- * 3D printing: technologies
- * 3D printing: examples
- * Design techniques

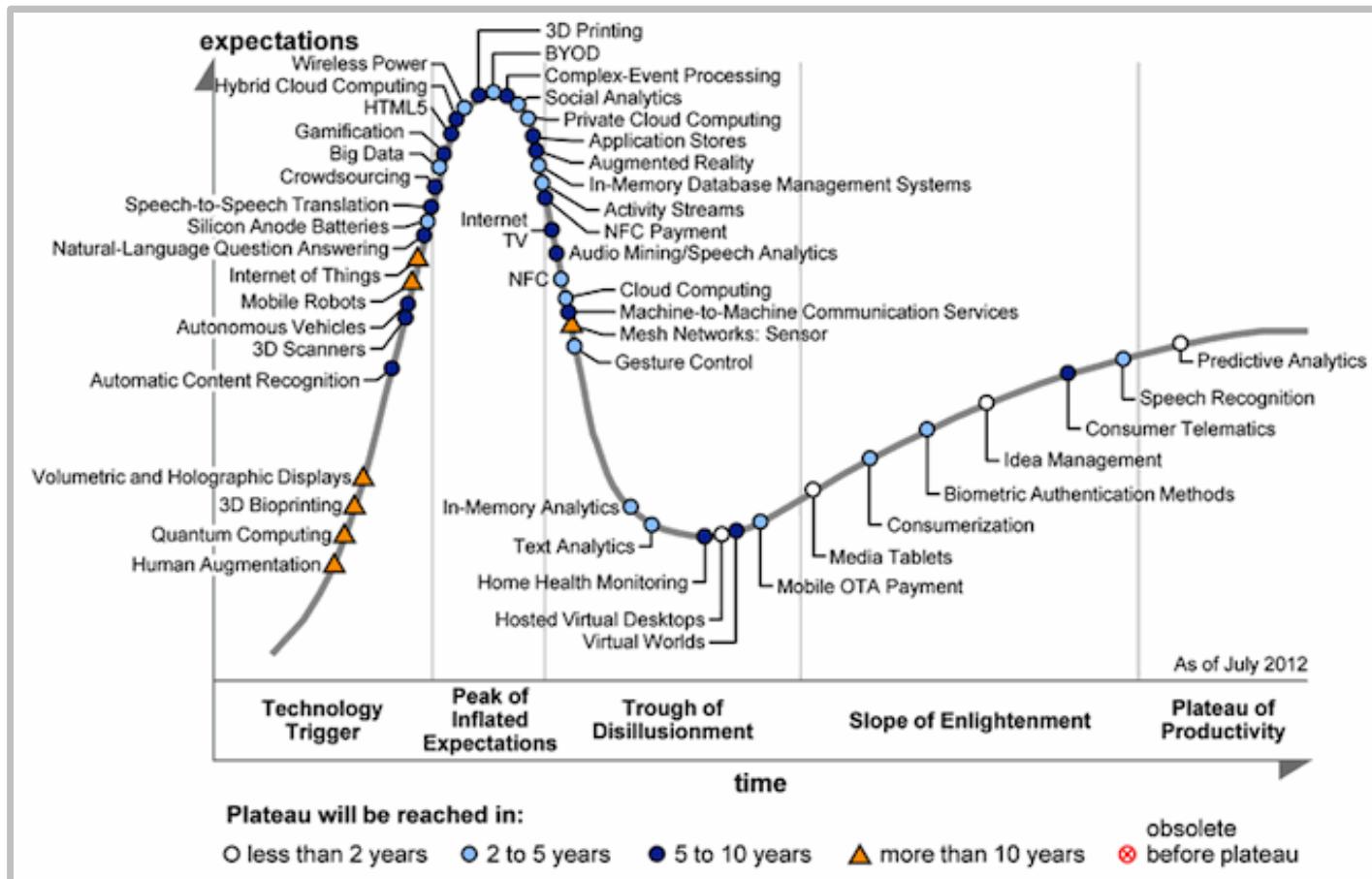


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01.

3D printing technologies: atoms from bits

3D printing: becoming really popular



3D printing is now reaching the peak of the Gartner Hype Cycle.

Technologies: 3D printing



Refers to object made using ink jet technology in 3 dimensions by layering powder and binding it with pigmented glue.

Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://youtu.be/7QP73uTJApw>

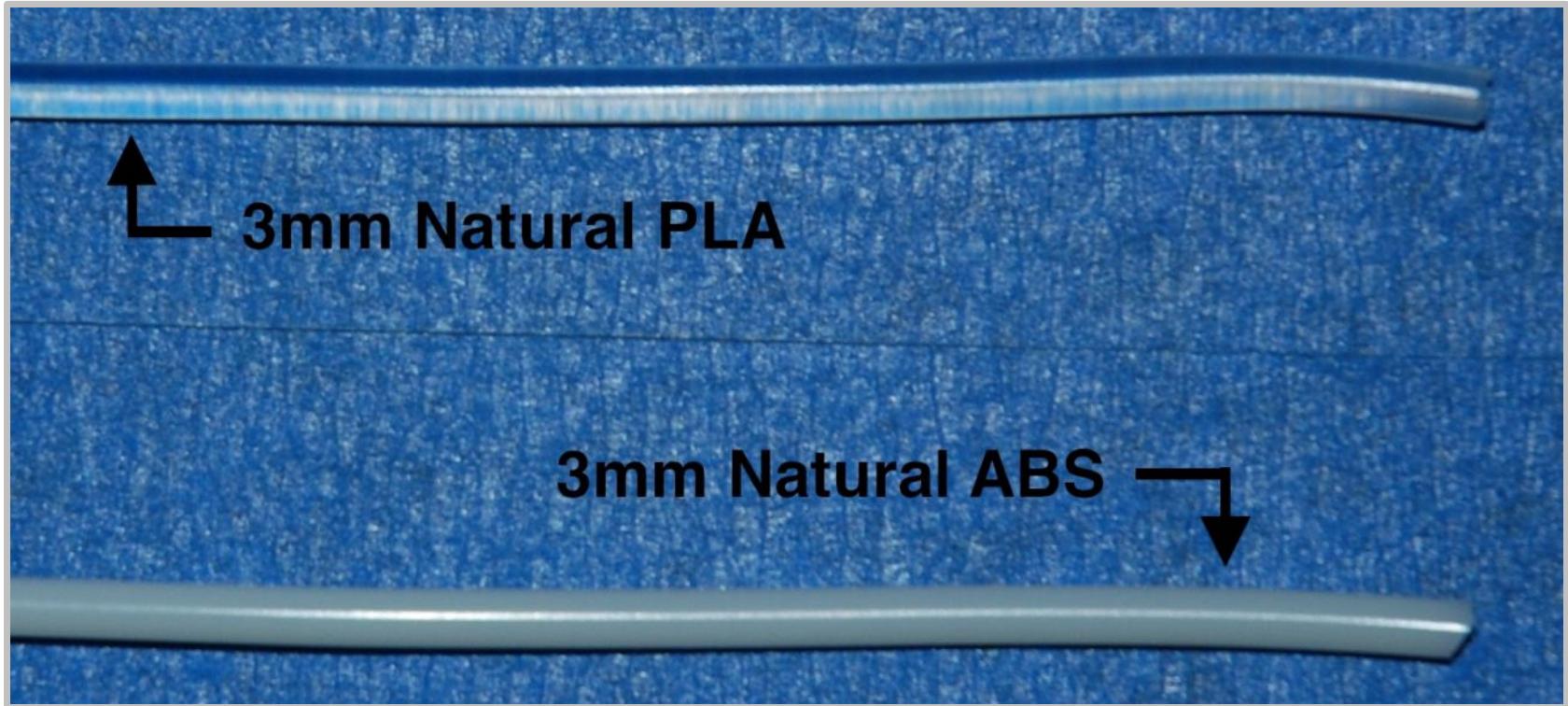
Technologies: Fused Deposition Modeling



Fused Deposition Modeling (FDM) creates models by heating and extruding a filament of plastic material.

Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://youtu.be/h8XJUqHXgls>

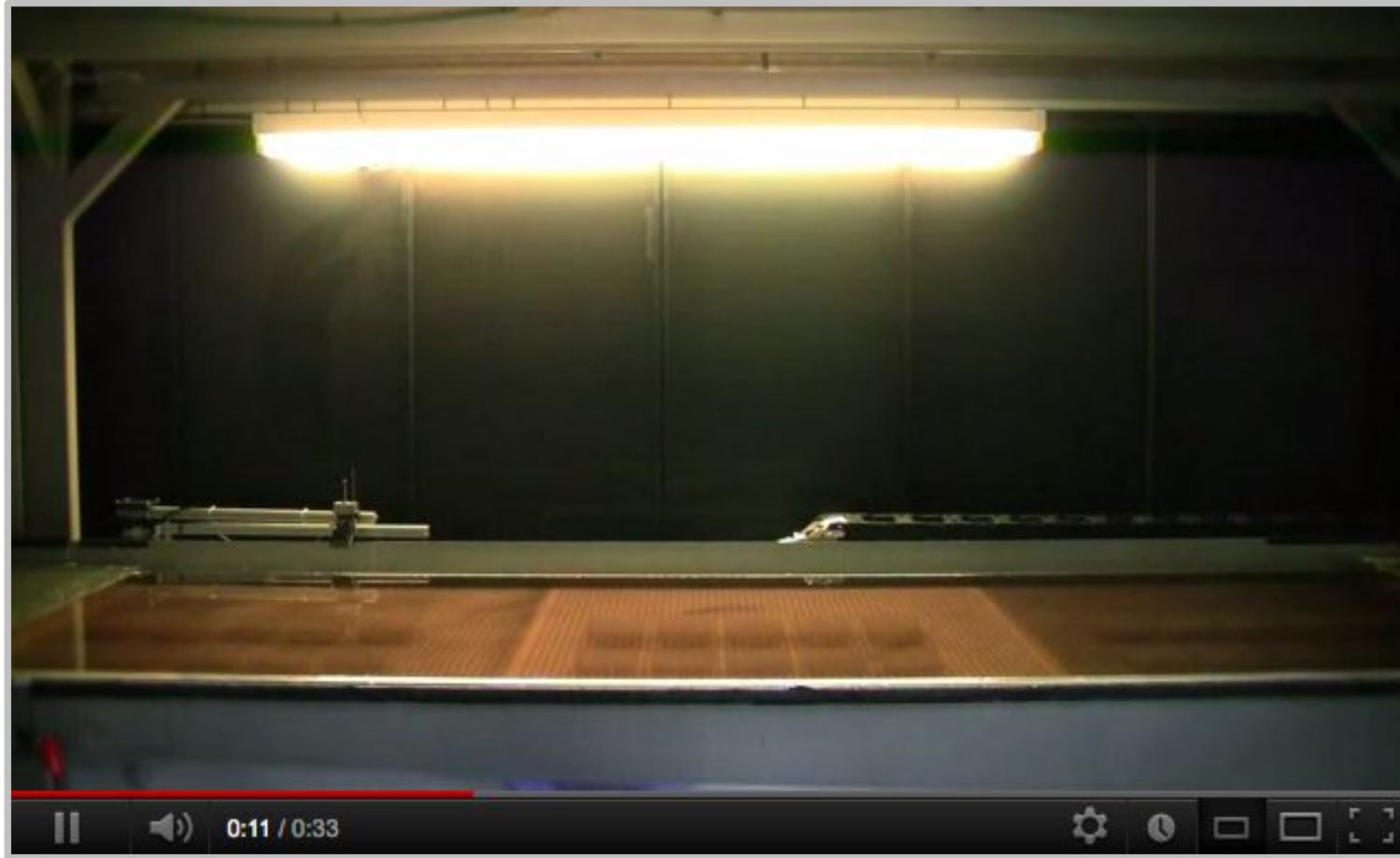
Technologies: materials for FDM



Most of the 3D Printing community uses either ABS or PLA in either 3mm or 1.75mm diameters.

Source: <http://www.protoparadigm.com/2011/11/filament-tolerances-and-print-quality/>

Technologies: Stereolithography



Stereolithography produces models by tracing a beam of UV light over a photosensitive pool of liquid. Over time the part is lowered into the bath.

Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://youtu.be/ygHVVKKkJWI>

Technologies: Stereolithography



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Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://youtu.be/sn0Erp0P5Xk>

Technologies: Selective Laser Sintering



Selective Laser Sintering (SLS) is similar to stereolithography replacing the UV light with a laser and a vat of liquid with a powdered base.

Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
http://youtu.be/lCOuVO_uT0s

Technologies: Laminated Object Manufacturing



Laminated Object Manufacturing (LOM) machines cut and glue thousands of sheets of material together to form solids, sometimes with standard A4 paper.

Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://youtu.be/FjxI2HszHzo>

Technologies: Laminated Object Manufacturing



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Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://www.mcortechnologies.com/gallery>

Technologies: Electron Beam Melting



Electron Beam Melting (EBM) is similar to SLS except the process is far more exact and capable of producing implant grade parts to be used in orthopedic surgery.

Source: <http://replicatorinc.com/blog/2009/02/4-types-of-3d-printing/>
<http://youtu.be/E7--ZWPVVdQ>

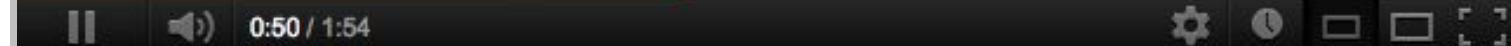
3D Metal printing



Now it is possible to print your model in stainless steel on Shapeways! The material will be finished in a shining stainless steel look and costs \$10 / cm³.

Source: <http://youtu.be/B9V0wqt0glg>
http://www.shapeways.com/themes/stainless_steel_3dprinting_gallery

3D Glass printing

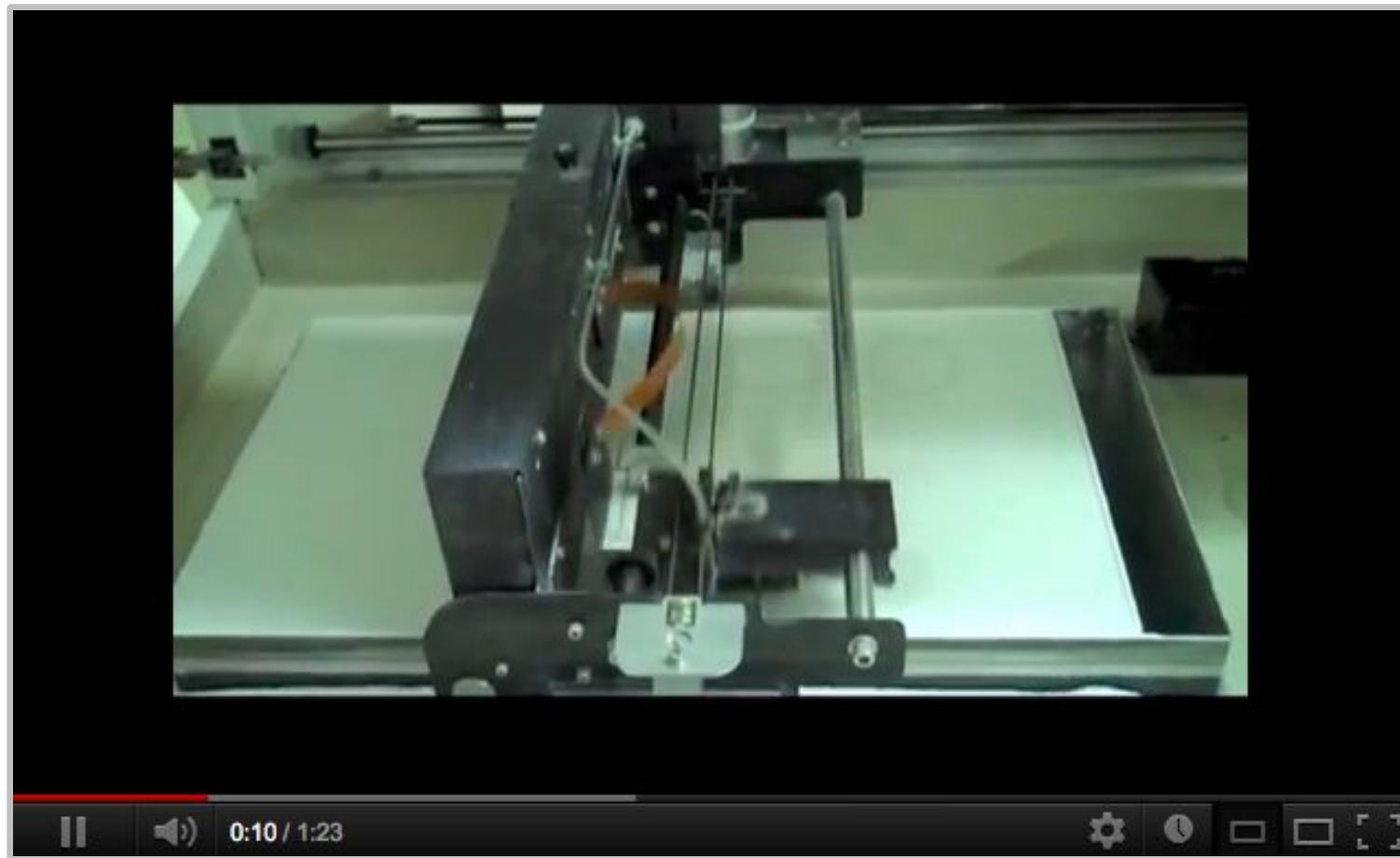


The material is porous, opaque and fragile and made from recycled soda-lime glass, the fine glass powder is glued together with a binder and then sintered.

Source: <http://youtu.be/BtK-Hqd6Q2I>

http://www.shapeways.com/materials/milky_white_matte_glass

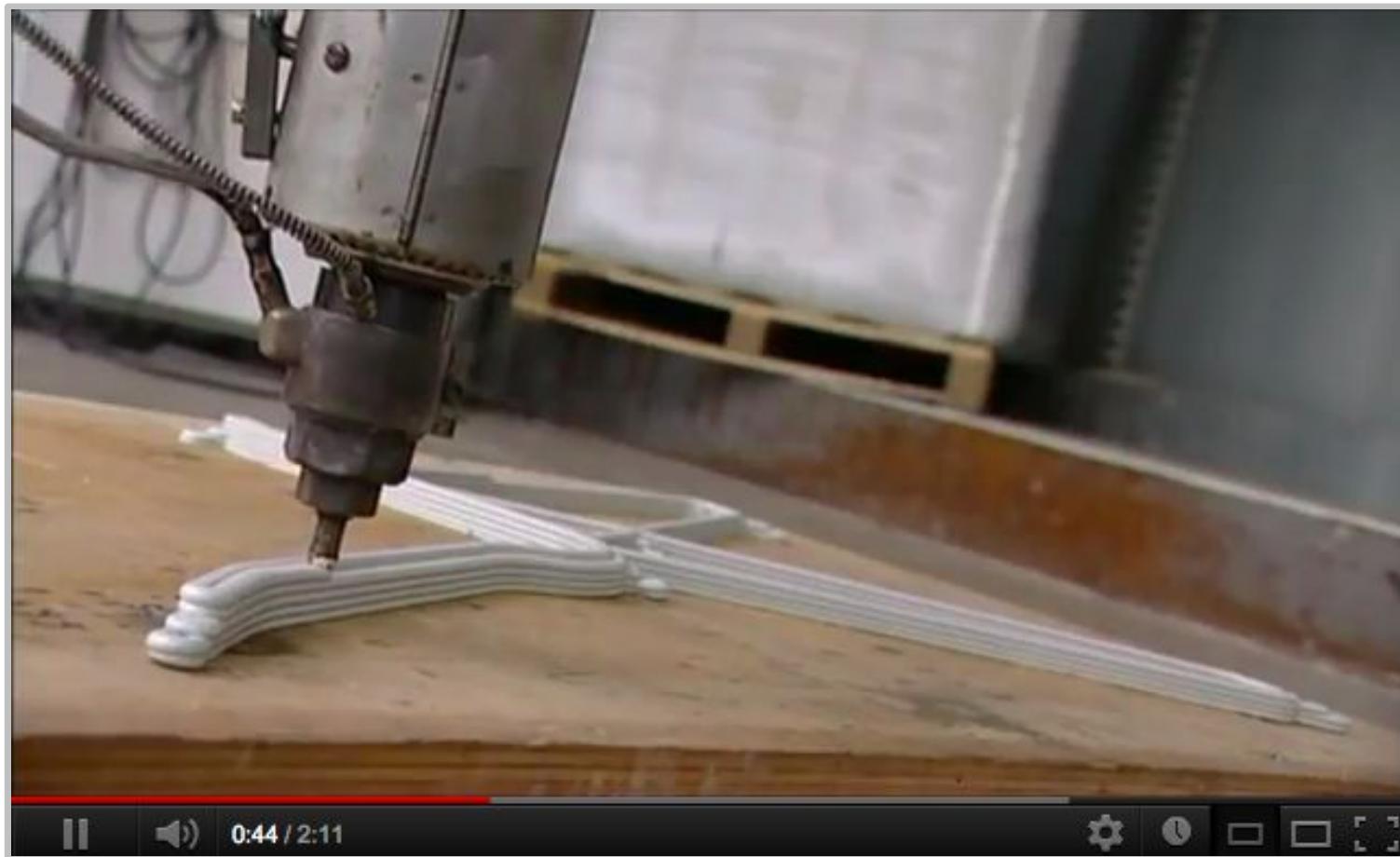
3D Ceramics printing



Material properties are the same as standard ceramics. Fine ceramic powder bound together with binder, fired, glazed with lead-free, non-toxic gloss finish.

Source: <http://youtu.be/zZU701BHfyo>
<http://www.shapeways.com/materials/ceramics>

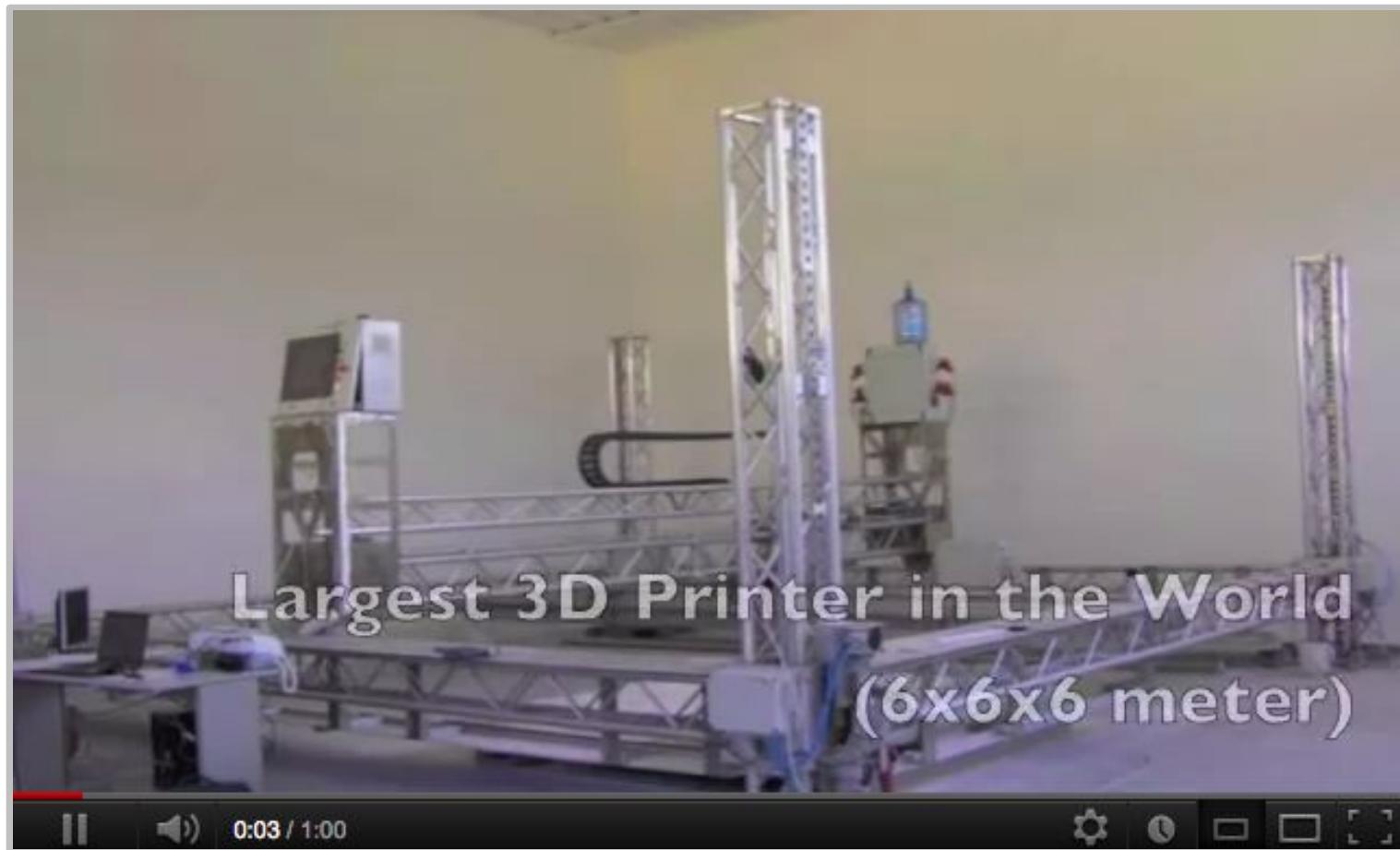
Big size 3D printing: Endless chair



Printing an Endless Chair from recycled refrigerators.
Design by Dirk vander Kooij.

Source: <http://youtu.be/FvRTHynk9KA>
<http://www.dirkvanderkooij.nl/en>

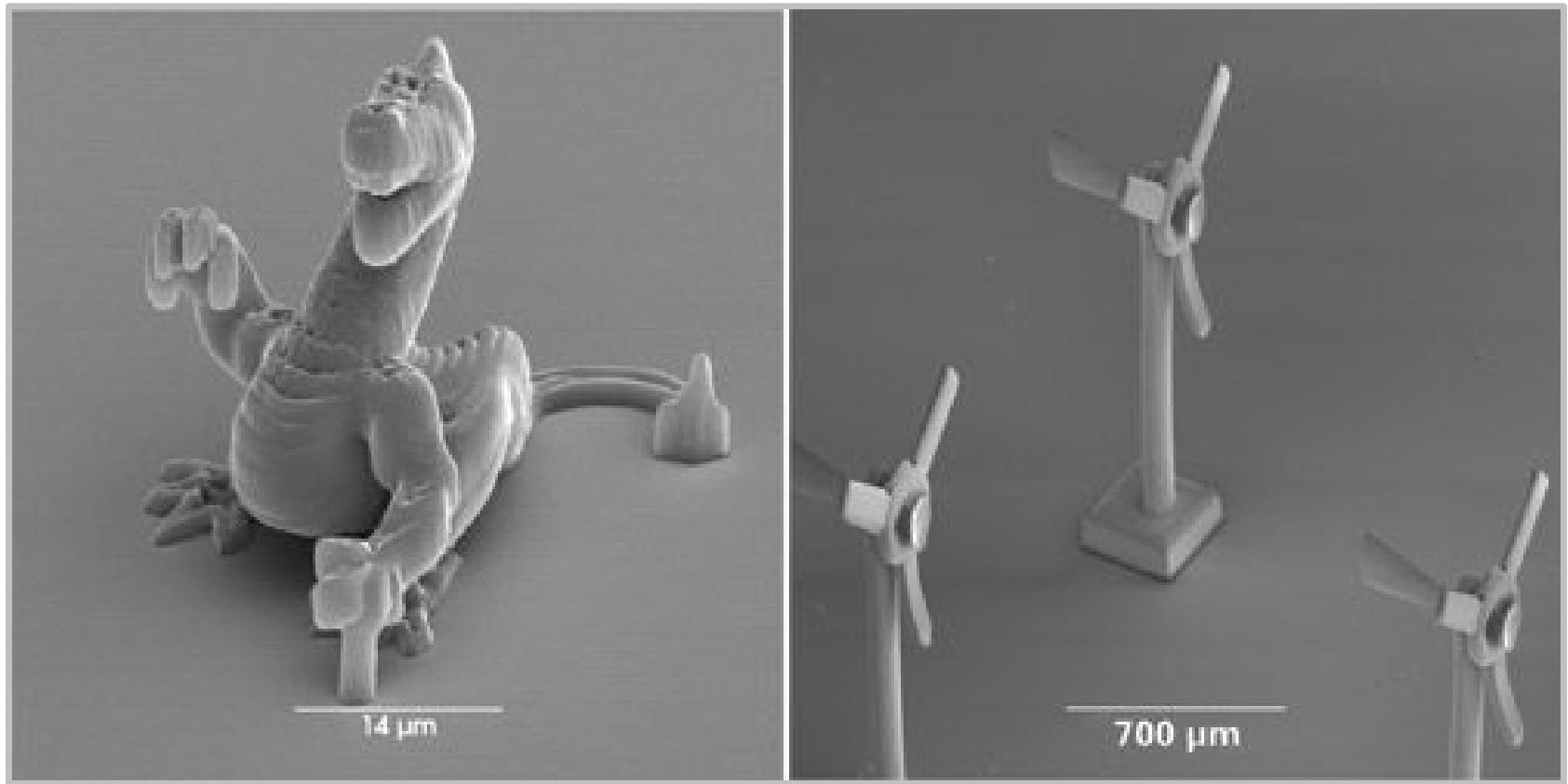
Big size 3D printing: D-Shape



D-Shape is a new robotic building system using new materials to create superior stone-like structures.

Source: <http://youtu.be/HBxx8XTpDZ4>
<http://d-shape.com/>

Small size 3D printing: 2 photons polymerization



A promising 3D microfabrication method that has recently attracted considerable attention is based on two-photon polymerization with ultrashort laser pulses.

Source: <http://www.photonics.com/Article.aspx?AID=26907>

Bio 3D Printing



A new tissue engineering technology now has the ability to arrange culture cells in three dimensions. It is now possible to manufacture tissue in demand.

Source: <http://youtu.be/YOnIxcc0DW8>

Bio 3D Printing: Organovo

The screenshot shows the Organovo website homepage. At the top left is the Organovo logo. To its right is a search bar. Below the header, a large banner features the tagline "Tissue on demand." and a brief description of the company's bioprinting platform. Two news items are listed below the description: "April 25, 2012: Organovo Expands Management Team, Announces Promotion" and "April 2, 2012: Organovo Reports 2011 Financial Results". To the right of the banner is a graphic titled "tr50 The 50 Most Innovative Companies in 2012" from MIT Technology Review, showing Organovo's position in the biomedicine sector. Below this is a smaller box stating "Named to MIT Technology Review's List of Most Innovative Companies". The footer contains links for About, Products, Science, Newsroom, Investors, and Contact.

organovo™

Search

Tissue on demand.

Organovo's powerful NovoGen Bioprinting platform creates human tissues starting with any cell source. From disease models to tissue creation, bioprinting solves urgent needs in biological research.

April 25, 2012: [Organovo Expands Management Team, Announces Promotion](#)

April 2, 2012: [Organovo Reports 2011 Financial Results](#)

tr50 The 50 Most Innovative Companies in 2012

Organovo BIOMEDICINE

Named to MIT Technology Review's List of Most Innovative Companies

ABOUT
Our Management
Careers

PRODUCTS
NovoGen MMX Bioprinter™
Support

SCIENCE
Publications
Collaborations
Links

NEWSROOM
Overview
Press Releases
Media Coverage
Media Contact

INVESTORS

CONTACT

Organovo is focused on delivering breakthrough three-dimensional biology capabilities to create tissue on demand for research and surgical applications.

Source: <http://www.organovo.com/>

Bio 3D Printing: Organovo



The screenshot shows the Organovo website's products page. At the top, the Organovo logo is visible next to a search bar. Below the header, a navigation menu includes links for ABOUT, PRODUCTS, SCIENCE, NEWSROOM, INVESTORS, and CONTACT. A large, dark blue banner features the word "products" in white text. To the right of the banner, there is a photograph of the NovoGen MMX Bioprinter machine. On the left side of the main content area, there is a sidebar with links for Overview, NovoGen MMX Bioprinter™, and Support. The main content area is titled "NovoGen MMX Bioprinter™" and includes a sub-headline "Human biology, *in vitro* convenience." and a detailed description of the machine's capabilities.

Overview

NovoGen MMX Bioprinter™

Support

NovoGen MMX Bioprinter™

Human biology, in vitro convenience.

The NovoGen MMX Bioprinter™ is a novel hardware and software platform at the forefront of bioprinting research and development. The NovoGen MMX™ was developed to meet challenges in biological research. The platform takes primary or other human cells and shapes them into 3D tissue, with tremendous cellular viability and biology that is superior to even an animal model. The platform is being used by Organovo's Pharma partners today to enable cutting edge research into drug discovery.

The NovoGen MMX Bioprinter™ is a novel hardware and software platform at the forefront of bioprinting research and development.

Source: <http://www.organovo.com/products/novogen-mmx-bioprinter>

Drug 3D Printing

The image is a screenshot of a news article from Gizmodo UK. At the top, the 'GIZMODO' logo is displayed in a stylized blue font, with 'UK' written in smaller letters to its right. Below the logo is a collection of various pharmaceutical drugs, including several large, colorful capsules and numerous smaller tablets in different colors like yellow, green, and brown. The article is categorized under 'SCIENCE'. The title of the article is 'Who Needs a Pharmacy When You Can Just Print-Out Your Own Drugs at Home?'. The date of publication is April 19, 2012, at 12:45pm. Social sharing icons for Google+ and Facebook are located at the bottom right of the article area.

SCIENCE

April 19, 2012 - 12:45pm

[Who Needs a Pharmacy When You Can Just Print-Out Your Own Drugs at Home?](#)

Researchers from Scotland have made their own DIY 3D-printing drugstore and you'll be able to use them to print your own drugs right at your own home.

Source: <http://www.gizmodo.co.uk/2012/04/who-needs-a-pharmacy-when-you-can-just-print-out-your-own-drugs-at-home/>

Food 3D Printing



Choc Creator, the world's first 3D chocolate printer was developed by a team of researchers at the University of Exeter and is now available to purchase.

Source: <http://laughingsquid.com/choc-creator-the-chocolate-3d-printer-is-now-available-to-purchase/>
<http://youtu.be/r7xs-cHAt3I>

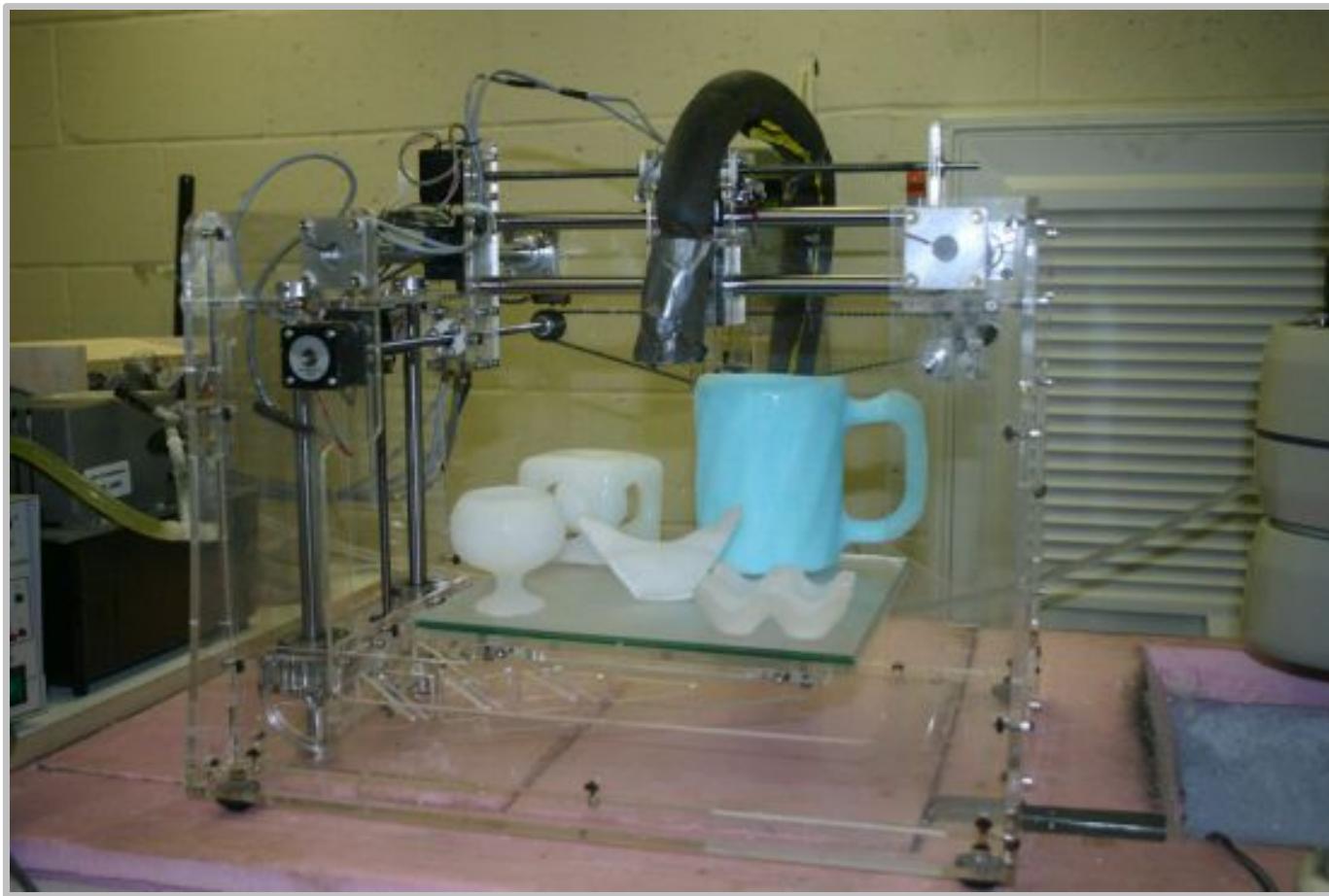
Food 3D Printing



CandyFab is a machine that can make arbitrary 3D solid objects at low cost from a variety of low-melting point materials including pure sugar.

Source: <http://laughingsquid.com/choc-creator-the-chocolate-3d-printer-is-now-available-to-purchase/>
<http://youtu.be/r7xs-cHAt3I>

Ice 3D Printing



Pieter Sijpkes, a professor at McGill University, has discovered since cobbling together a machine that prints objects by building up ultrathin layers of ice.

Source: http://www.wired.com/magazine/2011/12/st_3diceprinting/
<http://www.3ders.org/articles/20120103-3d-ice-printer.html>

Recycle plastic for your FDM machine

KICKSTARTER Discover Start BLOG HELP SIGN UP LOG IN

Filabot: Plastic Filament Maker

A Technology project in Milton, VT by Tyler McNaney · send message

PROJECT HOME UPDATES 14 BACKERS 156 COMMENTS 239



PLAY

156 BACKERS
\$32,330 PLEDGED OF \$10,000 GOAL
0 SECONDS TO GO

FUNDING SUCCESSFUL
This project successfully raised its funding goal on January 23.

PLEDGE \$1 OR MORE
41 BACKERS

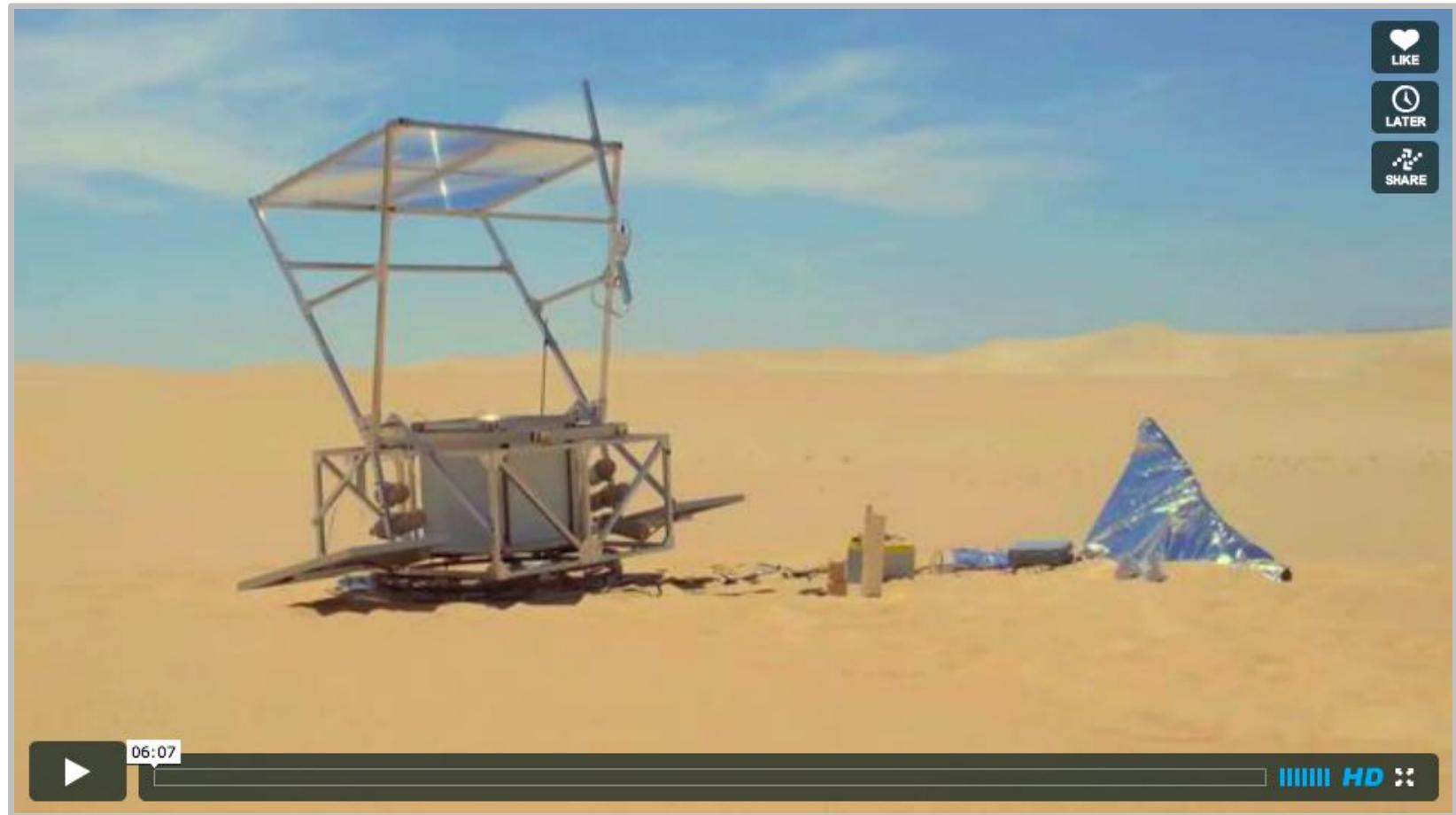
Like 243 people like this. Be the first of your friends.

Tweet Embed http://kck.st/uYHFdj

A 3D plastic extrusion system for mostly any type of recyclable plastic, to make usable 3D printing filament by grinding, melting, extruding the plastic filament.

Source: <http://www.kickstarter.com/projects/rocknail/filabot-plastic-filament-maker>

Markus Kayser - Solar Sinter Project

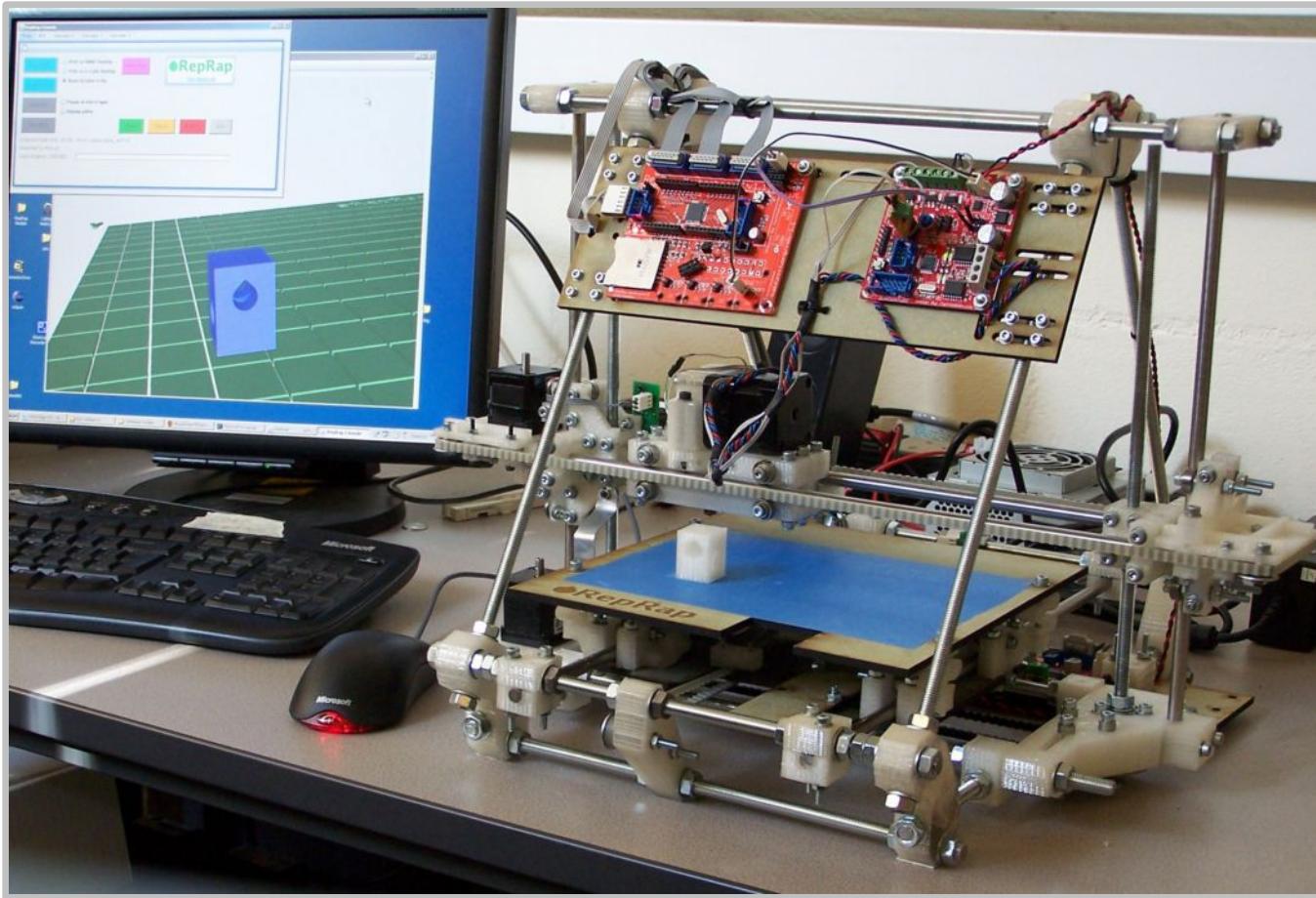


LIKE
LATER
SHARE

In this experiment sunlight and sand are used as raw energy and material to produce glass objects using a 3D printing process.

Source: <http://vimeo.com/25401444>

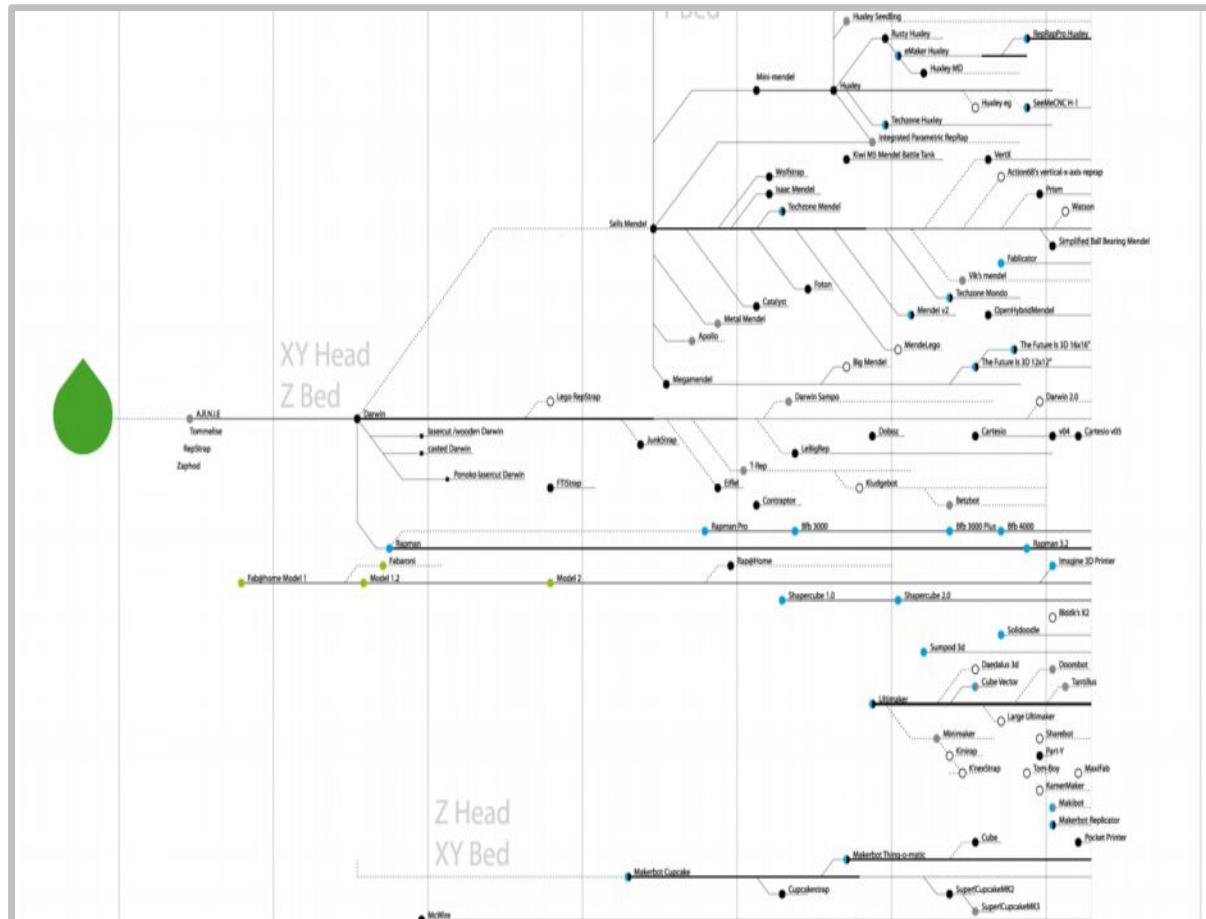
Open Source 3D printers: RepRap



It's the second, improved version of RepRap: small enough to fit on your desk, but with a print volume large enough for you to make big things.

Source: <http://reprap.org/wiki/Mendel>

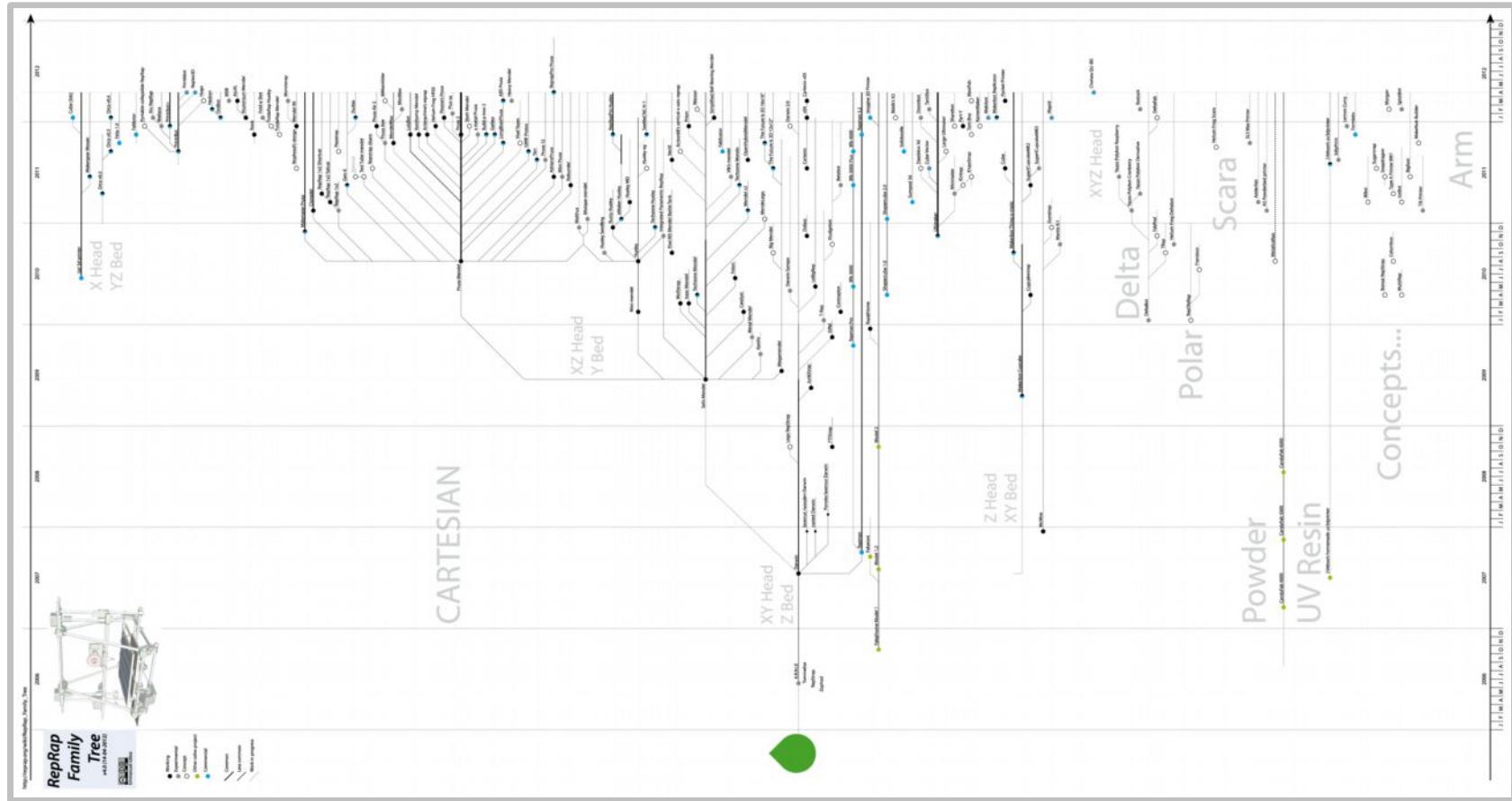
Open Source 3D printers: RepRap



Again, the evolution of an open source project that's too big to fit into one slide...

Source: http://reprap.org/wiki/RepRap_Family_Tree

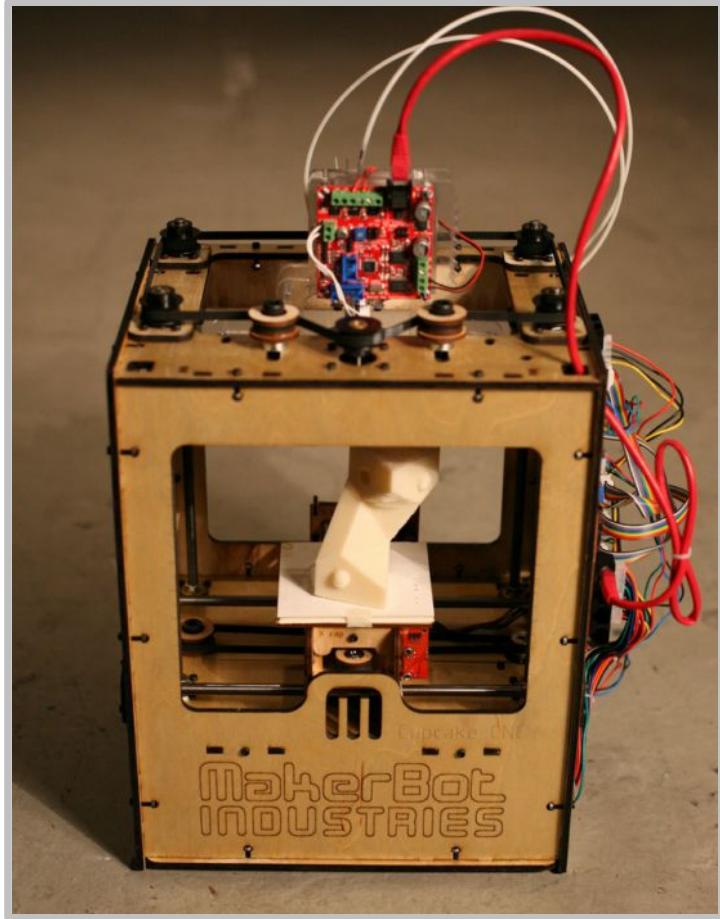
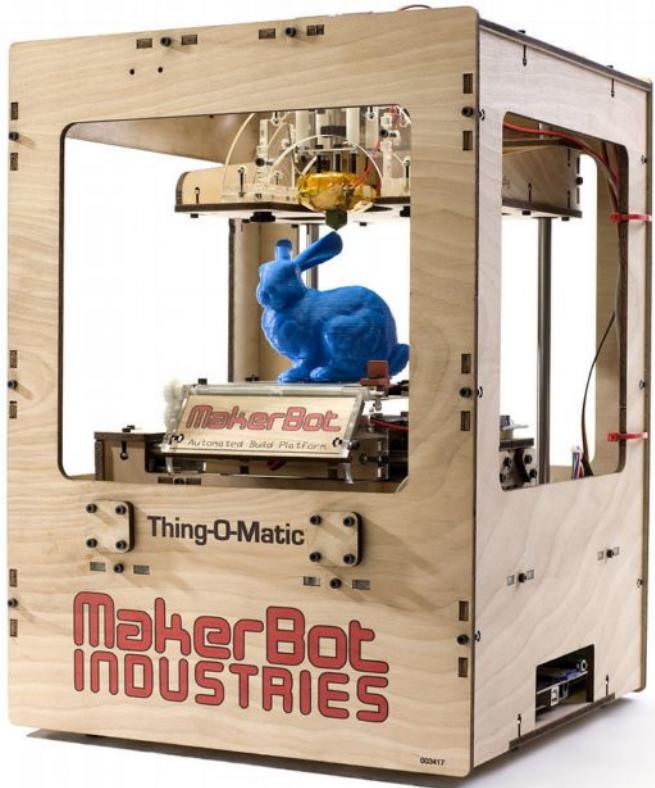
Open Source 3D printers: RepRap



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Source: http://reprap.org/wiki/RepRap_Family_Tree

RepRap and its children... Makerbot



Again, the evolution of an open source project that's too big to fit into one slide...

Source: <http://en.wikipedia.org/wiki/Makerbot>

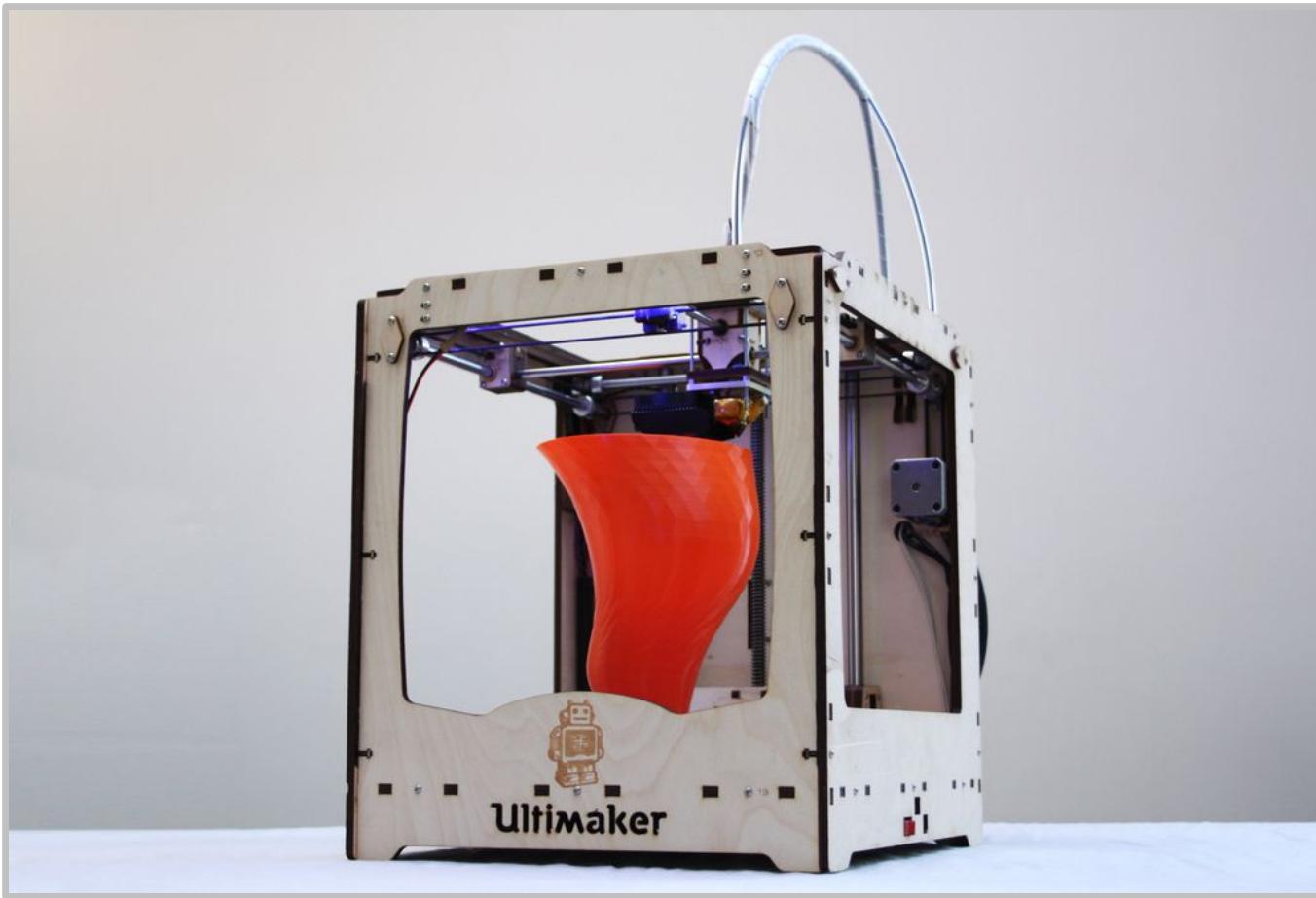
RepRap and its children... Makerbot



Again, the evolution of an open source project that's too big to fit into one slide...

Source: <http://store.makerbot.com/replicator-404.html>

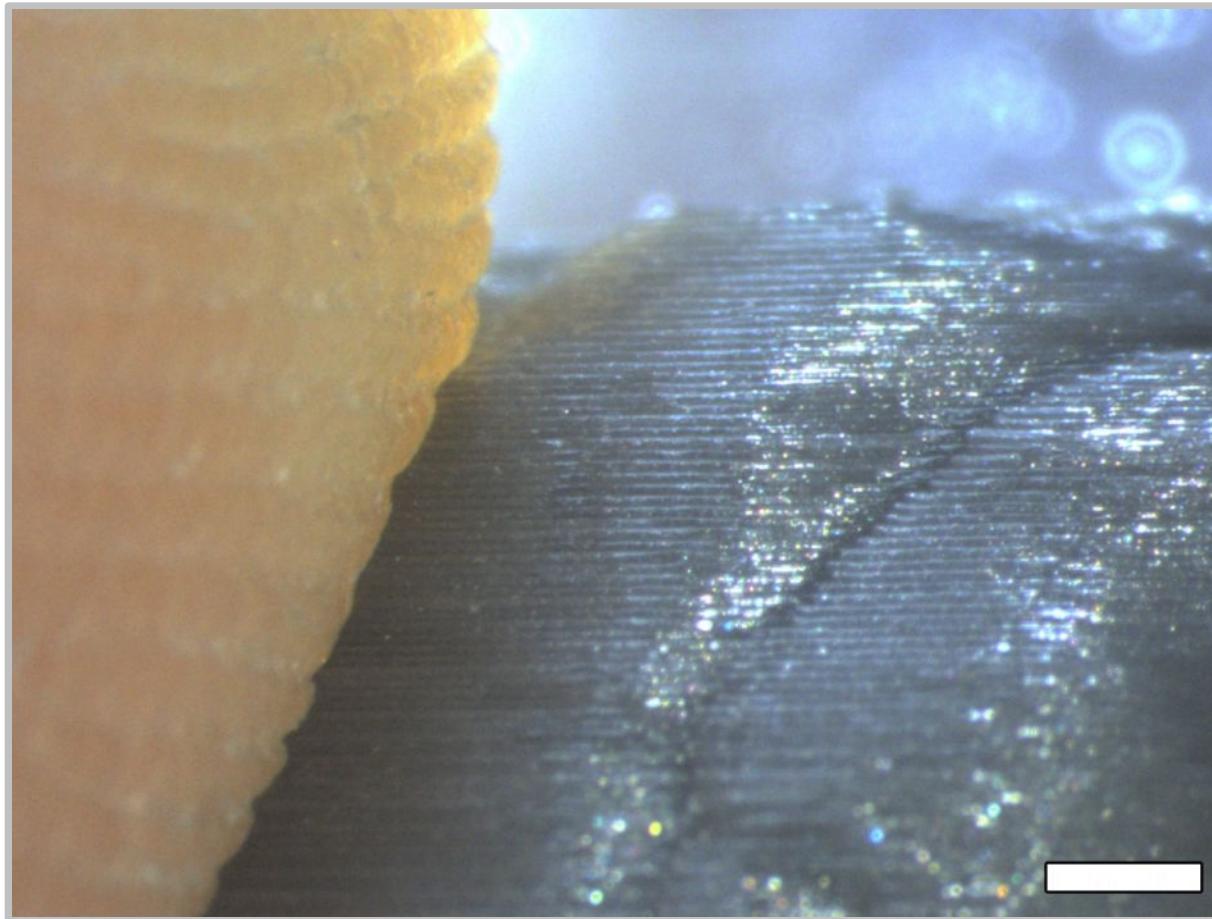
RepRap and its children... Ultimaker



Again, the evolution of an open source project that's too big to fit into one slide...

Source: <http://reprap.org/wiki/Ultimaker>
<http://blog.ultimaker.com/>

RepRap and its children... Ultimaker



The average layer height in that pic is around 0.074 mm (that is 74 microns).

Source: <http://www.hive76.org/insane-3d-printing-resolution-ultimaker-under-the-micro>

A portable 3D printer...



PopFab: at its heart is a computer-controlled motion platform and a means of attaching various toolheads.

Source: http://www.core77.com/blog/digital_fabrication/a_suitcase-sized_3-in-1_cnc_multi-tool_23007.asp
<http://vimeo.com/45911972>



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02.

3D printing: examples what people are doing with it

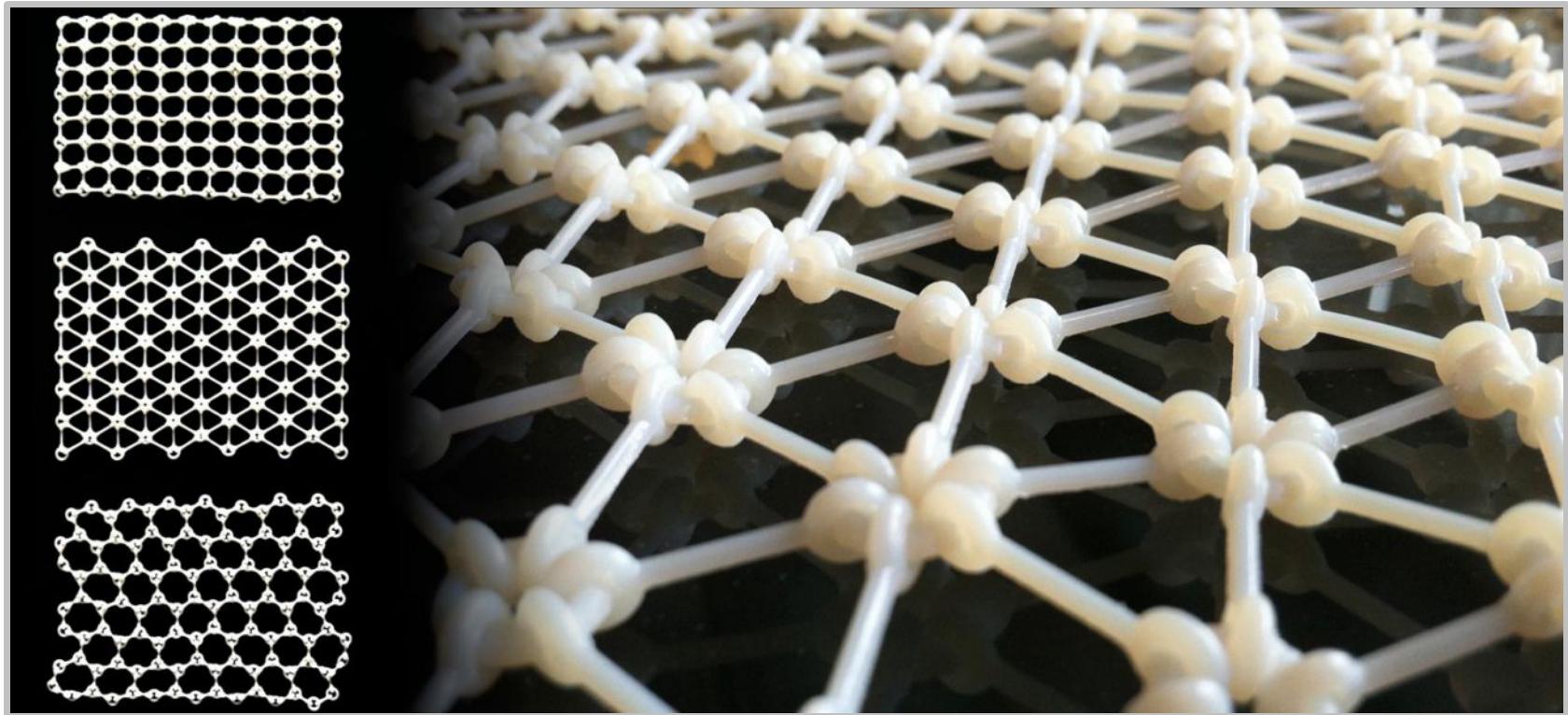
Printable VELCRO



The velcro is printed with 0.3mm ABS with a
MK6 extruder on a Makerbot.

Source: <http://www.thingiverse.com/thing:12798>

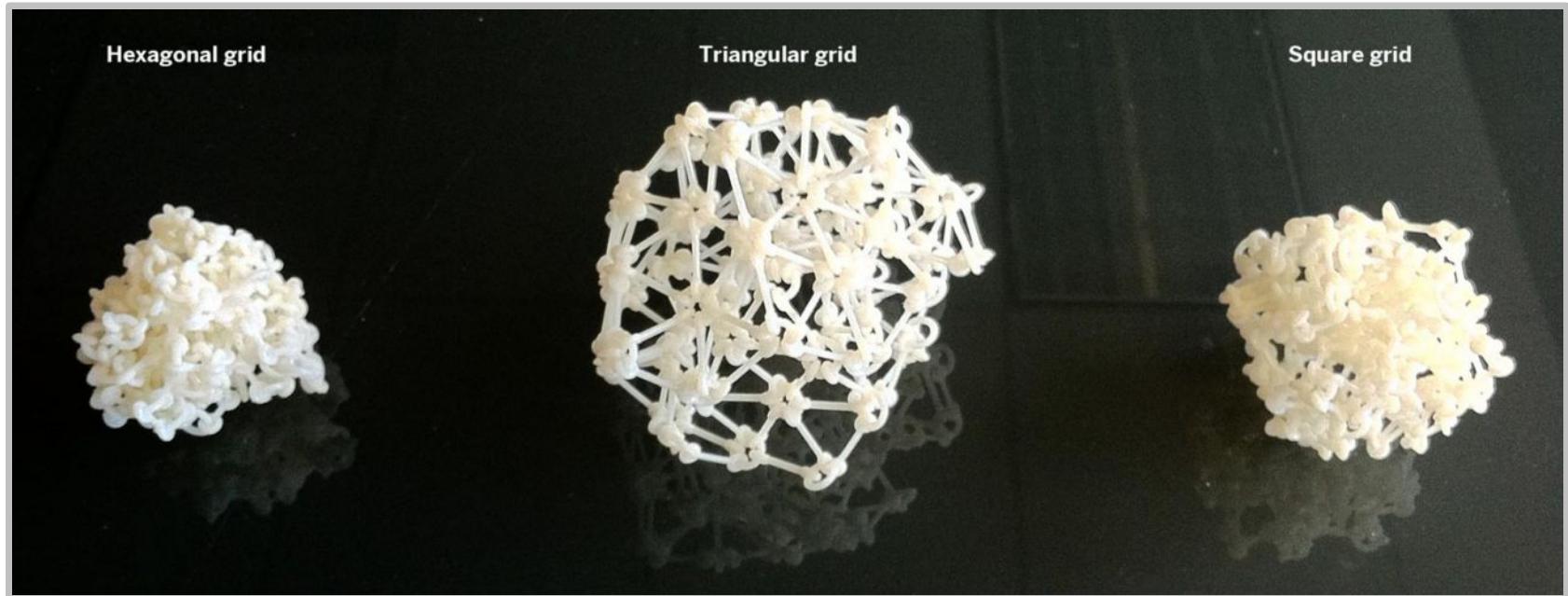
3D Printing Flexible Grids



Done with a Grasshopper definition that used the grid components to create a set of flexible triangular, square, and hexagonal grids.

Source: <http://lmnts.lmnarchitects.com/fabrication/printed-flexgrids/>

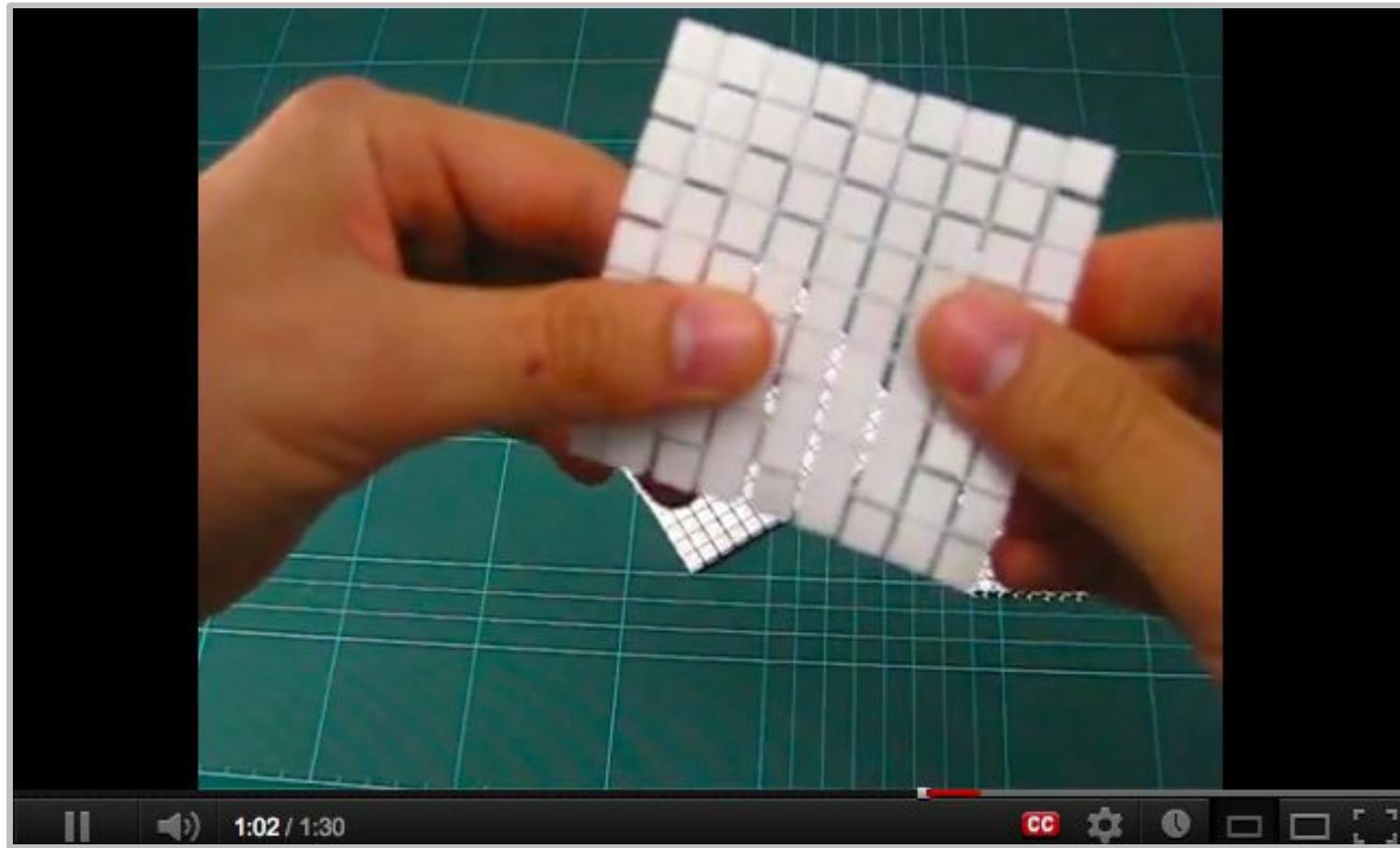
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Source: <http://lmnts.lmnarchitects.com/fabrication/printed-flexgrids/>

Digi-Fabrics



A test done by Shapeways with their White Strong & Flexible material.

Source: <http://youtu.be/JSCDw6mThk4>

<http://www.shapeways.com/blog/archives/525-White-Strong-and-Suuuper-Flexible..html>

3D printed bikini



The N12 bikini is the world's first ready-to-wear, completely 3D-printed cloth. All of the pieces are snap together without any sewing.

Source: <http://www.continuumfashion.com/N12.html>

3D printed fashion design



Dutch designer Iris Van Herpen uses 3-D printers to create designer fashion for Björk and Lady Gaga.

Source: <http://www.wired.com/design/2012/04/10-things-3d-printers-can-do-now?pid=167>

3D printed fashion design



A collection of 3D printed hats and accessories were shown on the runway as part of the Materialise World Conference in Leuven, Belgium.

Source: <http://blog.ponoko.com/2012/04/24/a-fashion-show-of-3d-printed-hats/>
<http://i.materialise.com/challenge/the-hats-off-to-3d-printing-challenge/>

3D printed shoes



Melissas' shoes are among the most amazing examples of what 3D printing can do for style and design. Designer Andreia Chaves created the Invisible Shoes

Source: <http://blog.sculpteo.com/2012/03/29/3d-printing-for-green-fashion-melissas-footwear-experiments/>

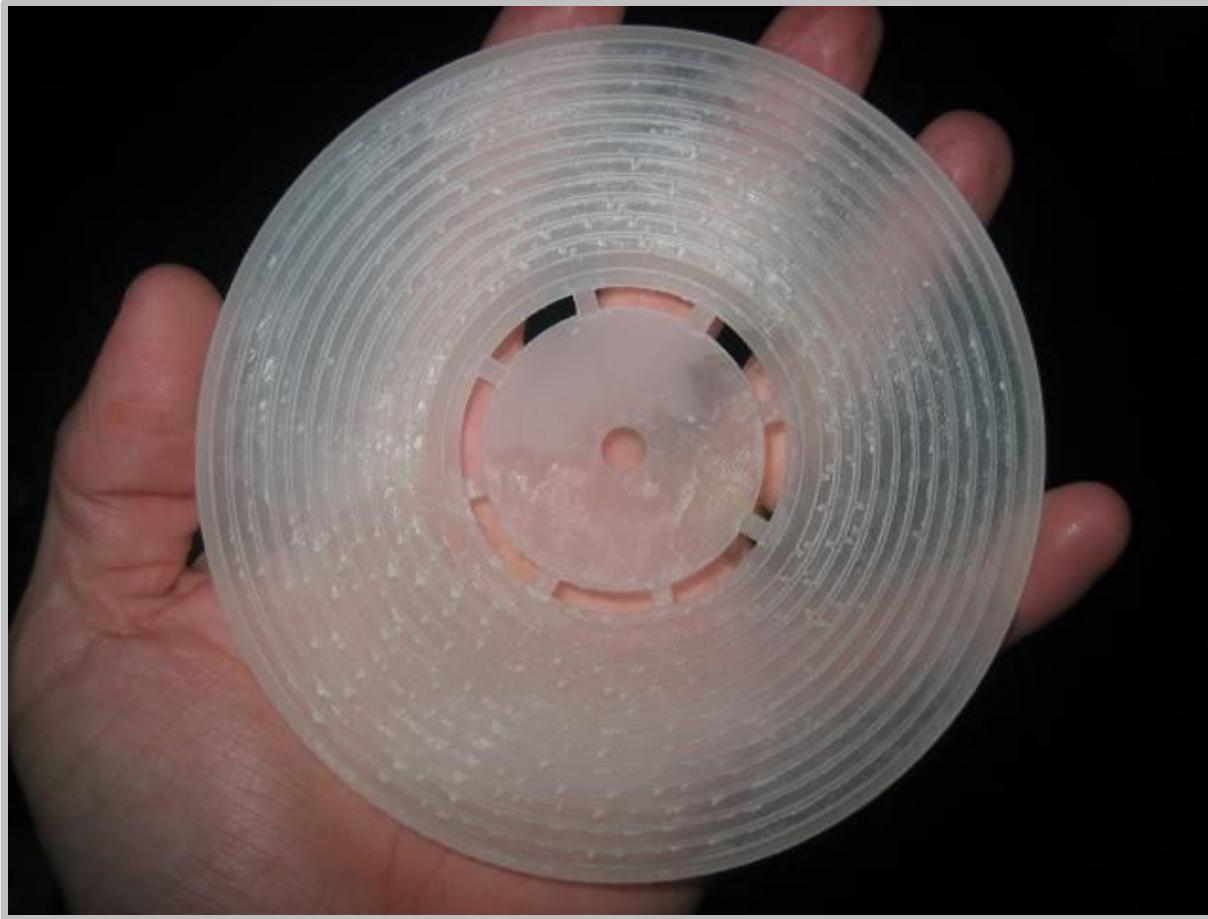
3D printed characters



Yoni Binstock is using front and side portrait photos together with 123D Catch to reconstruct a facial model and texture this on to a cake topper design.

Source: <http://www.shapeways.com/blog/archives/1332-Lifes-Memorable-Moments-Captured-In-3D.html>

3D printing media...



A 3D printed record for the Fisher-Price record player playing 'Still Alive'. The tune and model were all generated in Processing. Sold on Shapeways.

Source: <http://www.shapeways.com/blog/archives/1179-Video-of-3D-Printed-Record-Playing-Still-Alive-from-Portal.html>

3D printing media...



A 3D printed record for the Fisher-Price record player playing 'Still Alive'. The tune and model were all generated in Processing. Sold on Shapeways.

Source: <http://youtu.be/EIAJJnSvQtk>

3D printing media...



The first 3D printed prototype of the programmable kalimba sequencer.
Pegs can be set to produce different 16-step sequences of 5 tones.

Source: <http://youtu.be/ERiw664xMKE>

3D printing media...



3D printing of film props has long been common in big budget movies, but now its increased affordability is aiding its introduction to smaller budget productions.

Source: <http://youtu.be/aMfSGt6rHos>

<http://blog.ponoko.com/2011/12/11/3d-prints-in-stop-motion-animation/>

3D printing media...



With the help of technologies from Objet Geometries, the creative team behind the feature film, Coraline, broke new ground in stop-motion animation.

Source: http://youtu.be/_2F0PA7qUQE

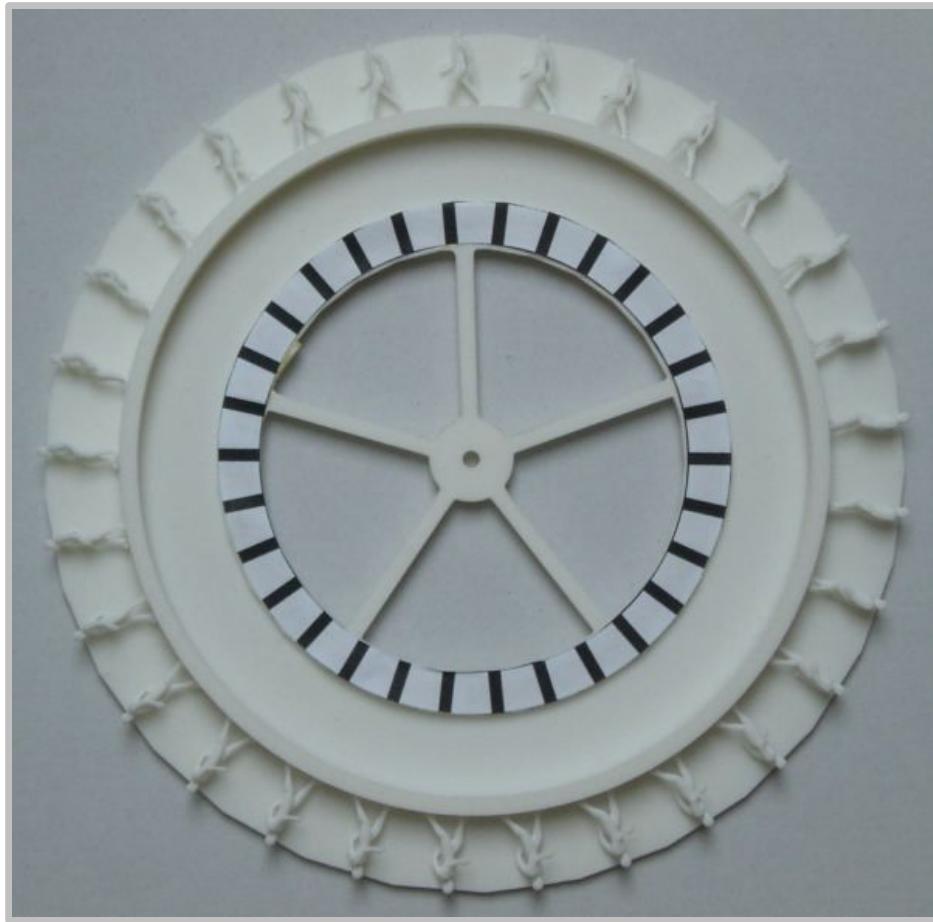
3D printing media...



3Drehkino took an animation in Blender, 3D printed it with Shapeways, hacked some electronics and created his own zeotrope under a CC license.

Source: http://drehkino.de/3Drehkino_en.php

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Source: http://youtu.be/LVa_WwBFtA4

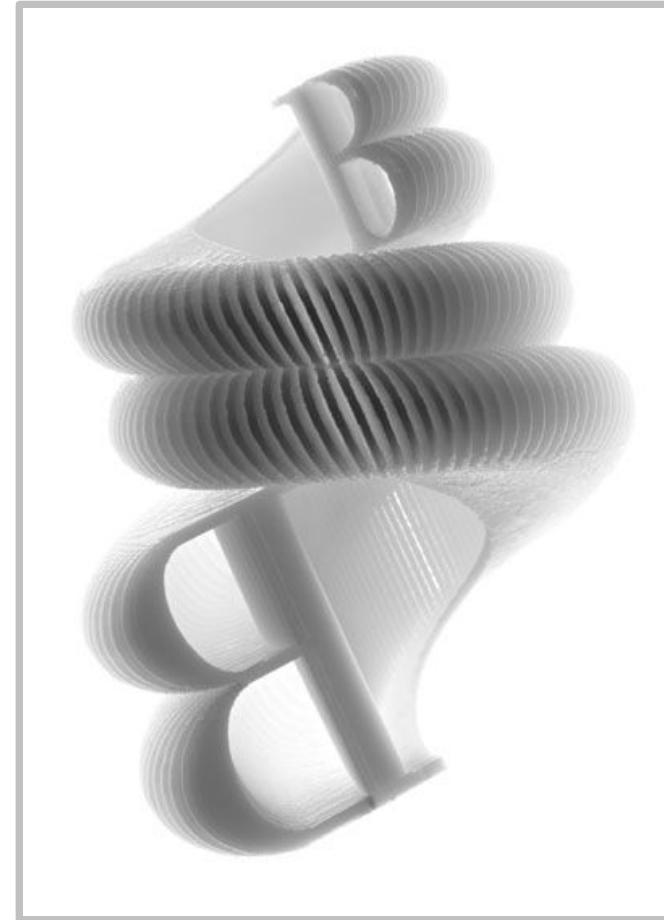
3D printing in media: Print magazine cover



Print magazine August 2008 cover design generated with Processing and 3D printed.

Source: http://postspectacular.com/process/20080702_printmagcover

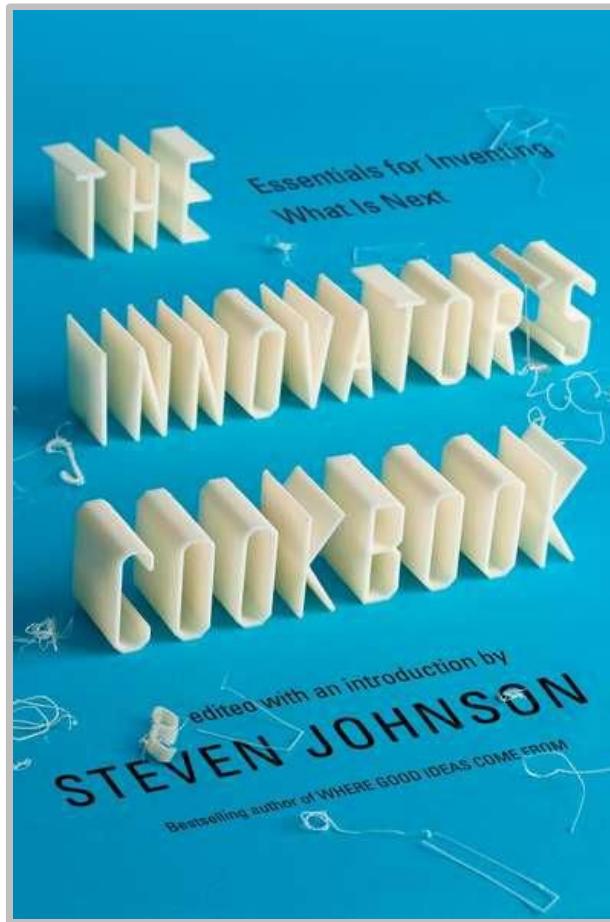
3D printing in media: Arkitypo



The idea was to 3D-print an entire alphabet derived from the historical story of how a typeface beginning with the same letter came to be.

Source: <http://johnsonbanks.co.uk/thoughtfortheweek/index.php?thoughtid=711>

3D printing in media



Printing the cover of the book *The Innovator's Cookbook* by Steven Johnson with a Makerbot.

Source: <http://www.casualoptimist.com/2011/10/18/the-innovators-cookbook/>

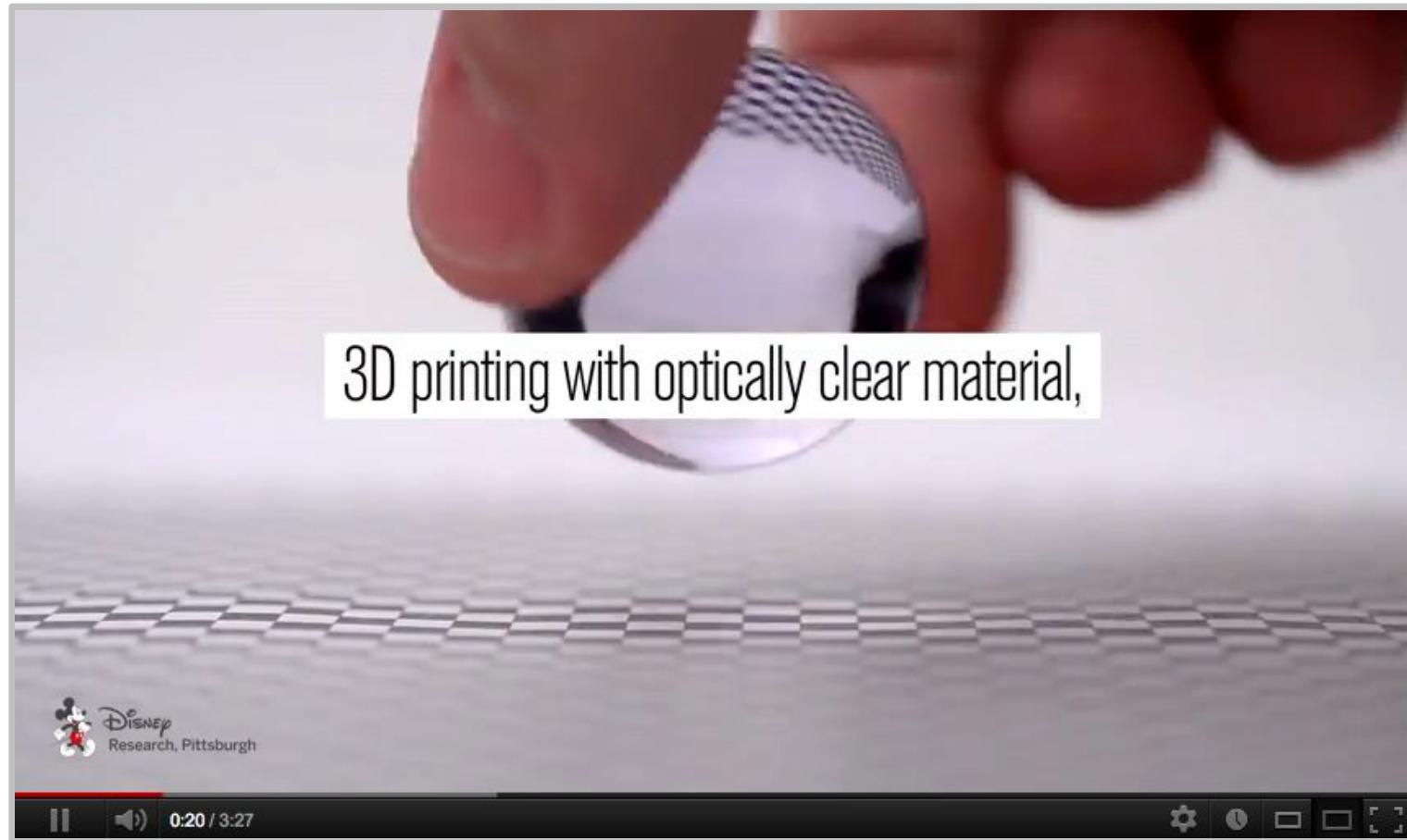
3D printing in media



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<http://www.casualoptimist.com/2011/10/18/the-innovators-cookbook/>

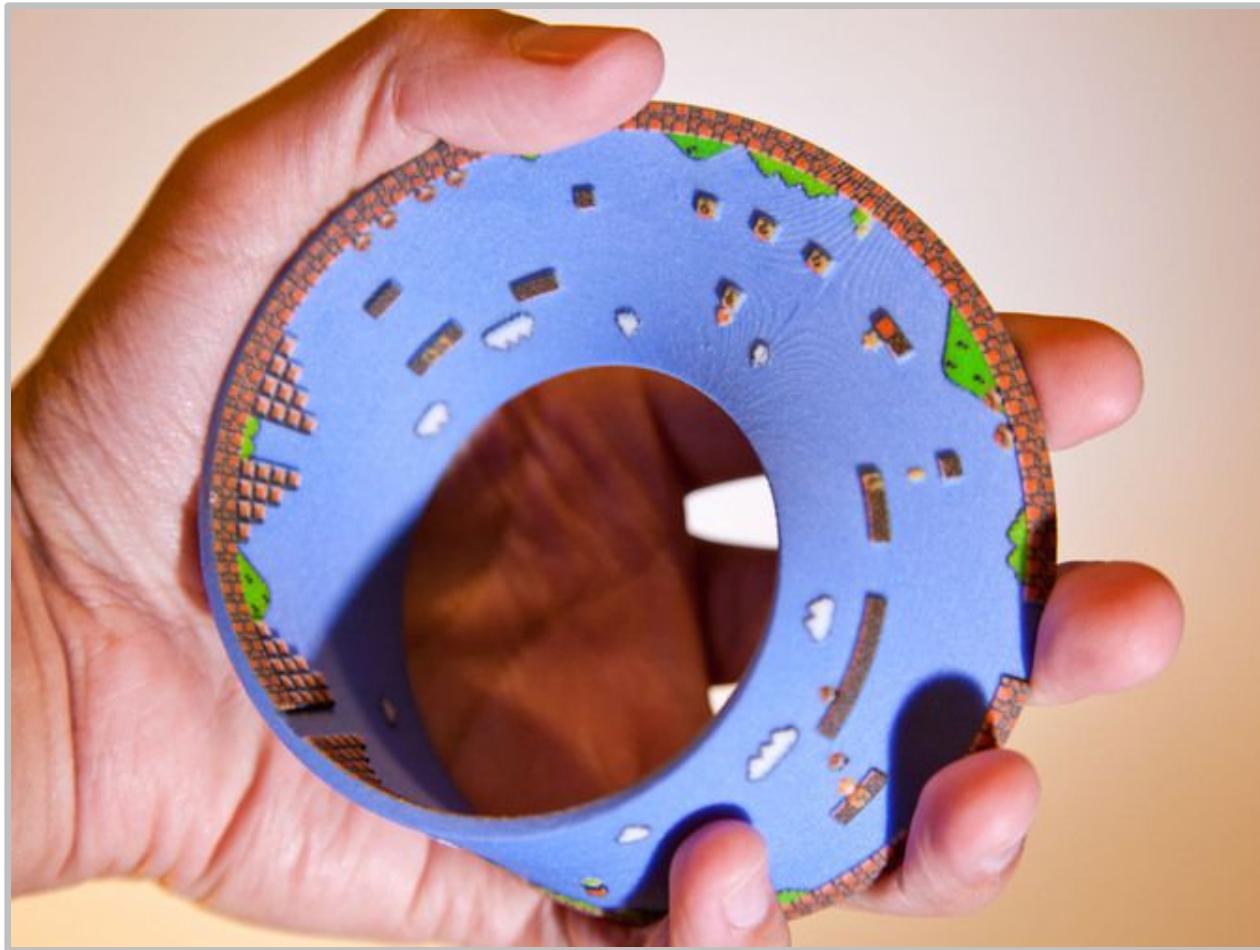
3D printing optics



Disney Research is 3D printing optics, in order to create more interesting and interactive product interface.

Source: <http://www.shapeways.com/blog/archives/1671-Disney-Research-3D-Printed-Optics-and-Interfaces-VIDEO.html>
http://www.youtube.com/watch?feature=player_embedded&v=eTeXTbXA6-Y

3D printing media from Video games



A moebius strip out of a Super Mario videogame!

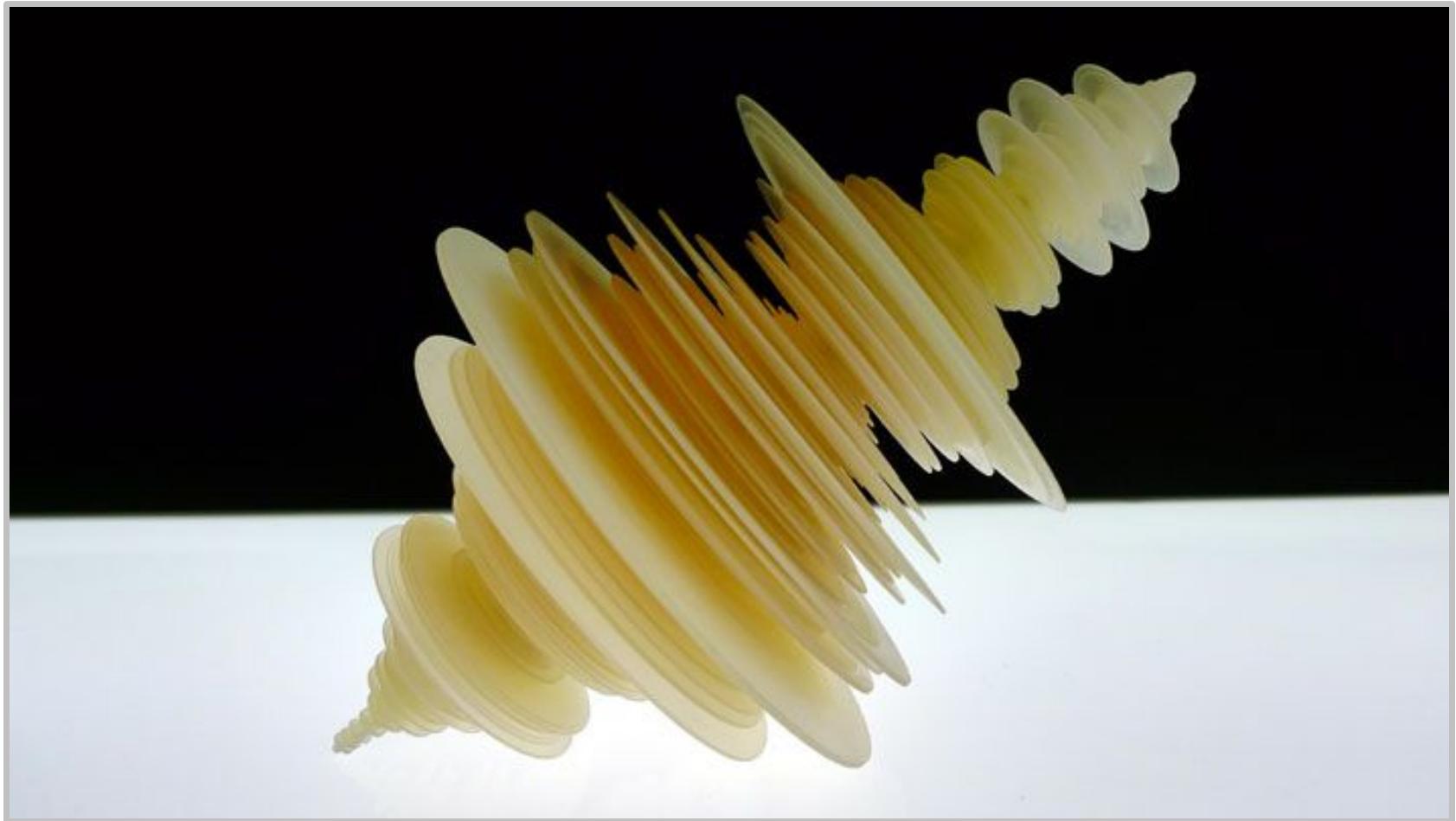
Successful transplant of a 3D printed jaw



A 3D printer-created lower jaw has been fitted to an 83-year-old woman's face in what doctors say is the first operation of its kind.

Source: <http://www.bbc.co.uk/news/technology-16907104>

3D printing data: Luke Jerram



To create the sculpture a seismogram of the earthquake, was rotated and then printed in 3 dimensions using rapid prototyping technology.

Source: http://www.lukejerram.com/projects/t%C5%8Dhoku_earthquake

3D printing data: sound

The screenshot shows the homepage of the Shapeways 'the vibe' service. At the top, there's a logo consisting of the Shapeways and SoundCloud logos plus a plus sign, followed by an equals sign and the 'the vibe' logo. Below this, the main title 'Sound You Can Touch' is displayed in large, bold, dark letters. A subtitle below it reads '3D print a custom iPhone case with your favorite sound from SoundCloud'. A large orange 'Get Started!' button is centered. Below the button, a link says 'Never heard of SoundCloud? [Find out more.](#)'. The bottom section, titled 'Here's How It Works...', shows three steps: connecting to SoundCloud (illustrated with a plug icon and a SoundCloud waveform), choosing a sound (illustrated with a screenshot of the Shapeways website showing a sound visualization and a price of \$19.95), and getting the custom iPhone case (illustrated with a hand holding a phone with a 3D-printed soundwave pattern on its back).

shapeways + SOUNDCLiND = the vibe

Sound You Can Touch

3D print a custom iPhone case with your favorite sound from SoundCloud

Get Started!

Never heard of SoundCloud? [Find out more.](#)

Here's How It Works...

Connect to SoundCloud.

Choose your favorite sound.

Get your custom iPhone case!

“Welcome to the era of mass customization in which anyone can build a unique iPhone case for \$25.”

Source: <http://www.shapeways.com/creator/thevibe>

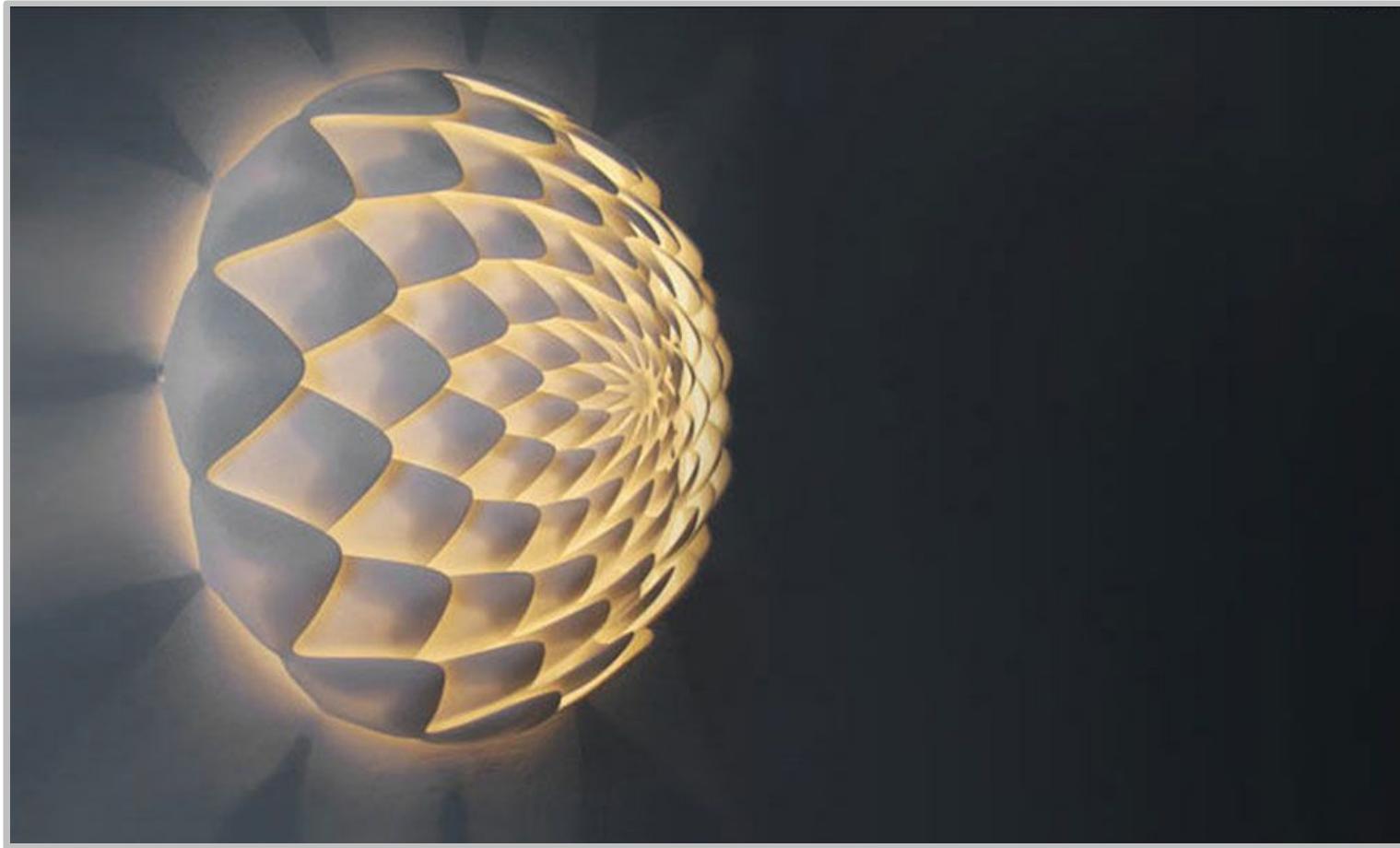
3D printing data: sound



“Welcome to the era of mass customization in which anyone can build a unique iPhone case for \$25.”

Source: <http://www.protoparadigm.com/2011/11/filament-tolerances-and-print-quality/>

3D printed lamps



Freedom Of Creation is an edition of exclusive design objects, furnishing complements, lighting and accessories.

Source: <http://www.freedomofcreation.com/>

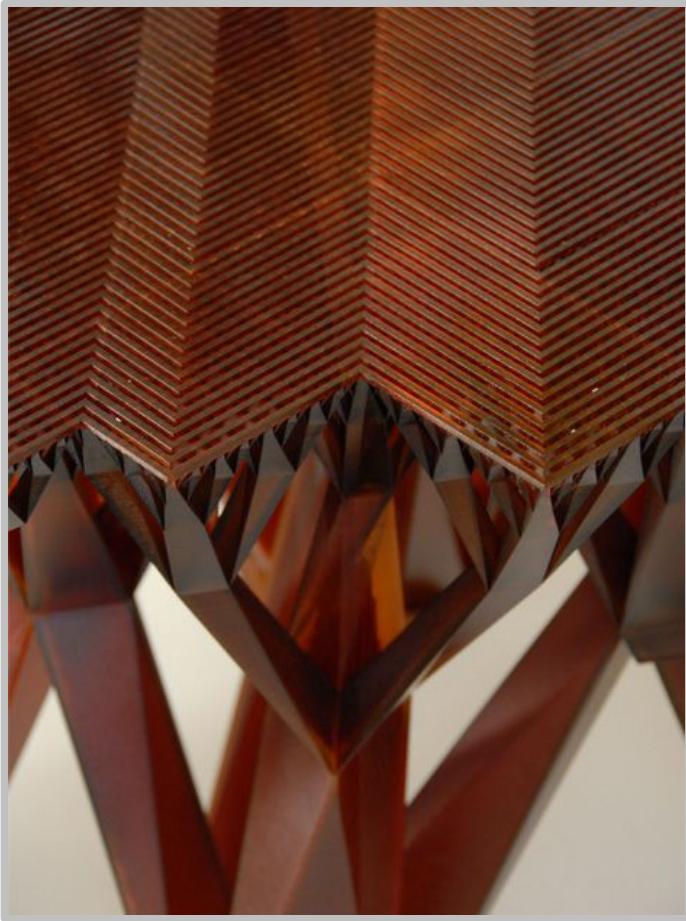
3D fractal furniture design



Fractal Table is a generative design table produced by Materialise as a single piece SLA in epoxy resin. Its dimensions in cm are: L98 x W61 x H42.

Source: <http://www.platform-net.com/>

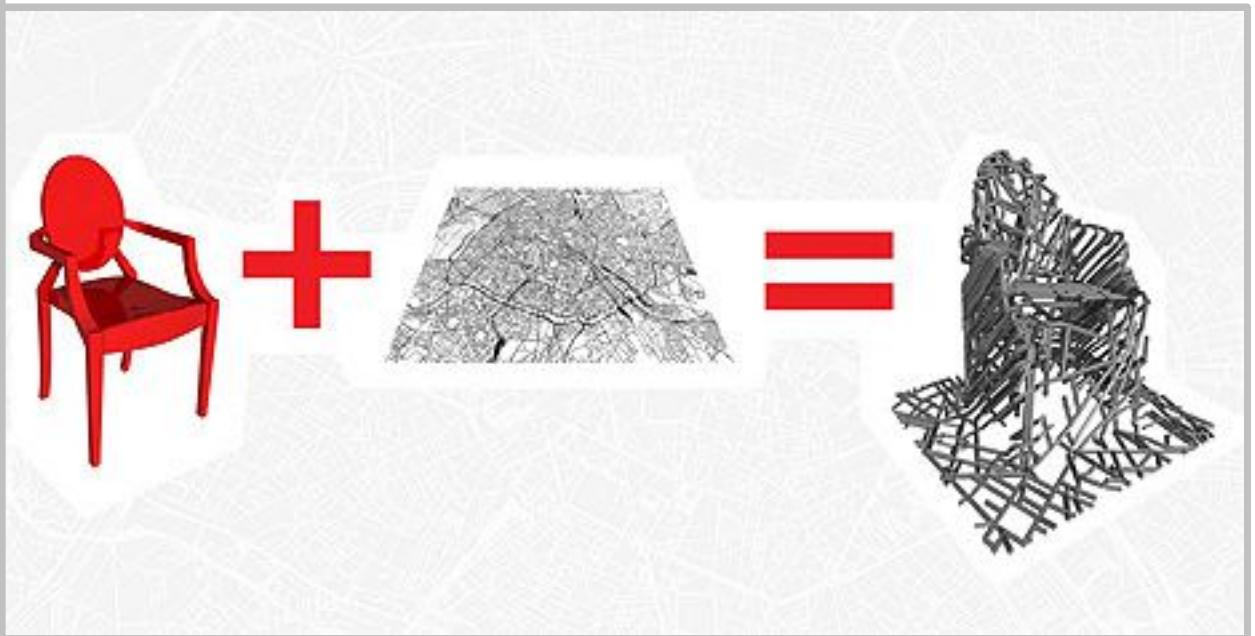
3D fractal furniture design



Fractal Table is a generative design table produced by Materialise as a single piece SLA in epoxy resin. Its dimensions in cm are: L98 x W61 x H42.

Source: <http://www.platform-net.com/>

3D printed furniture design



The Throne of Paris (John Briscella)

Source: <http://i.materialise.com/blog/entry/5-amazing-full-sized-furniture-pieces-made-with-3d-printing>

3D printed guitar



Each guitar is fully customizable, as the designers remove or insert various segments from the 3D model before each printing, with selectable colour.

Source: <http://www.designboom.com/weblog/cat/16/view/20135/skeletal-3d-printed-guitar.html>

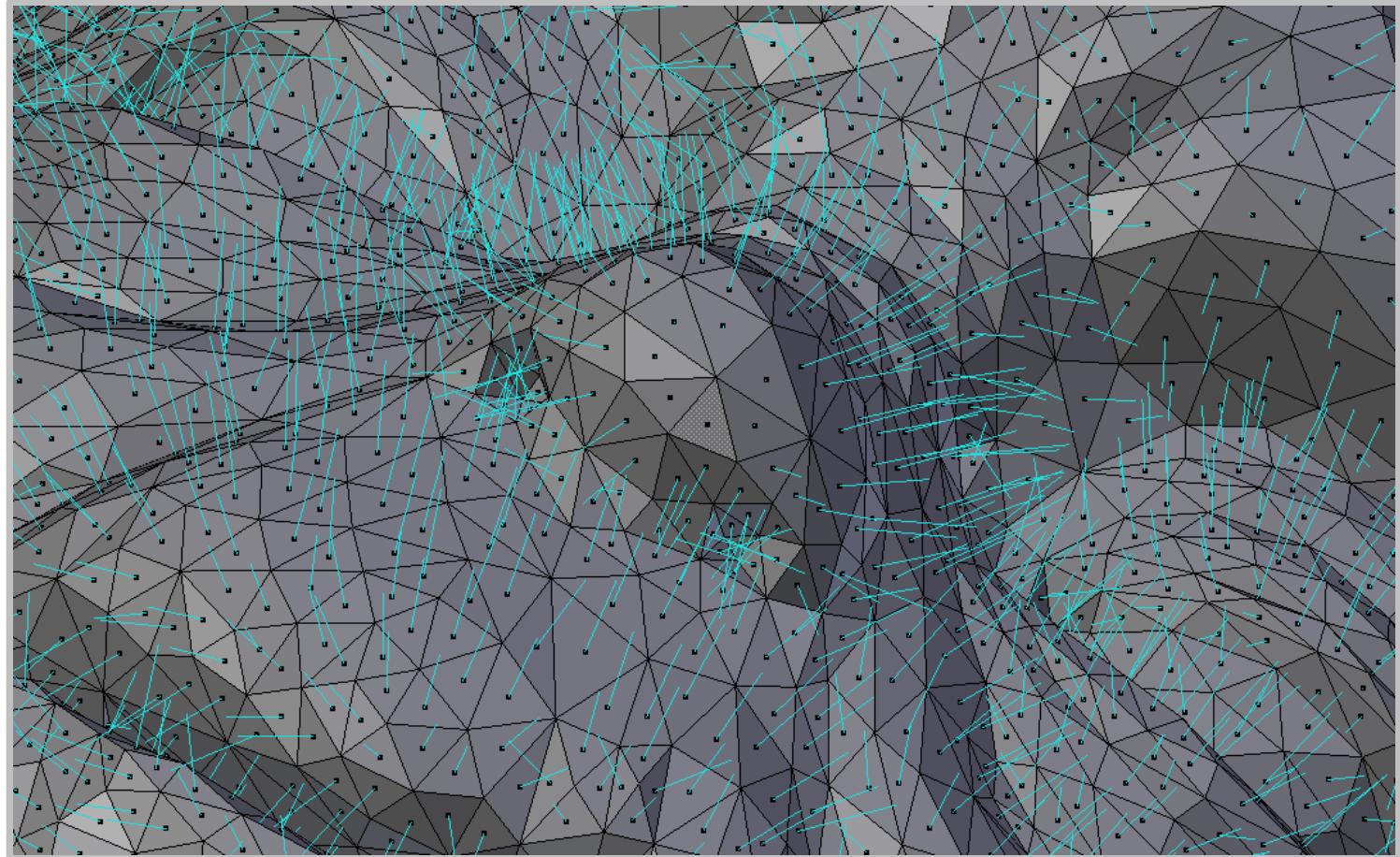


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03.

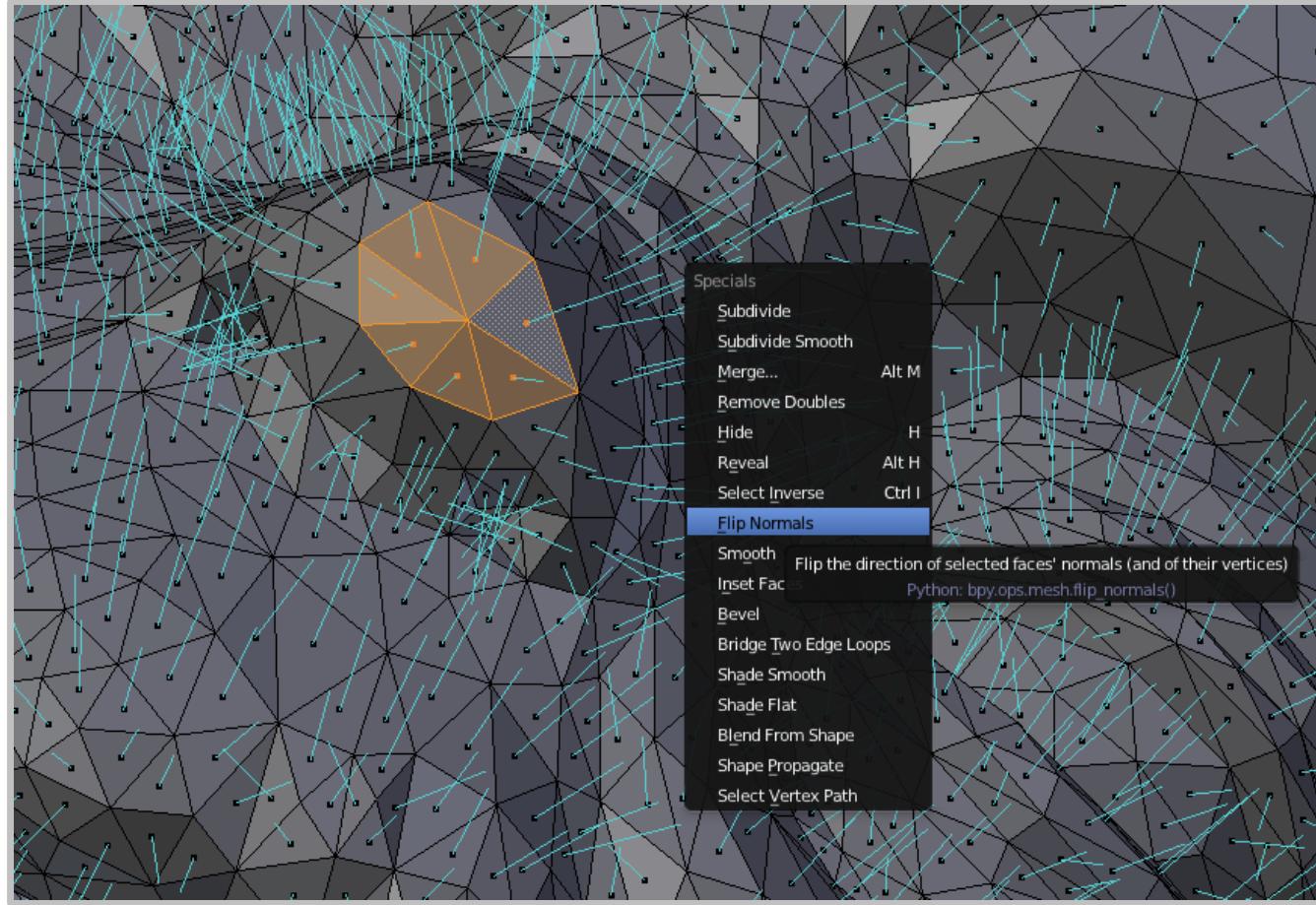
3D printing: design techniques things to consider...

01: check the normals



They should point outwards! The faces of a mesh are only 1-side.

01: check the normals



Edit mode > W > Flip normals

02: check your technology

Watch out with very thin connections

The droplet below necks down to a very thin cross-section. The droplet on the end is too large then goes to a small cross-section. This will crack or tear.

"Water Crown Chopsticks stand", by [wuct88](#)



Check your specific material and technology,
Shapeways is a good resource.

Source: http://www.shapeways.com/tutorials/design_rules_for_glass_3d_printing

03: Yes to moving parts and undercuts



But not with FDM!!!

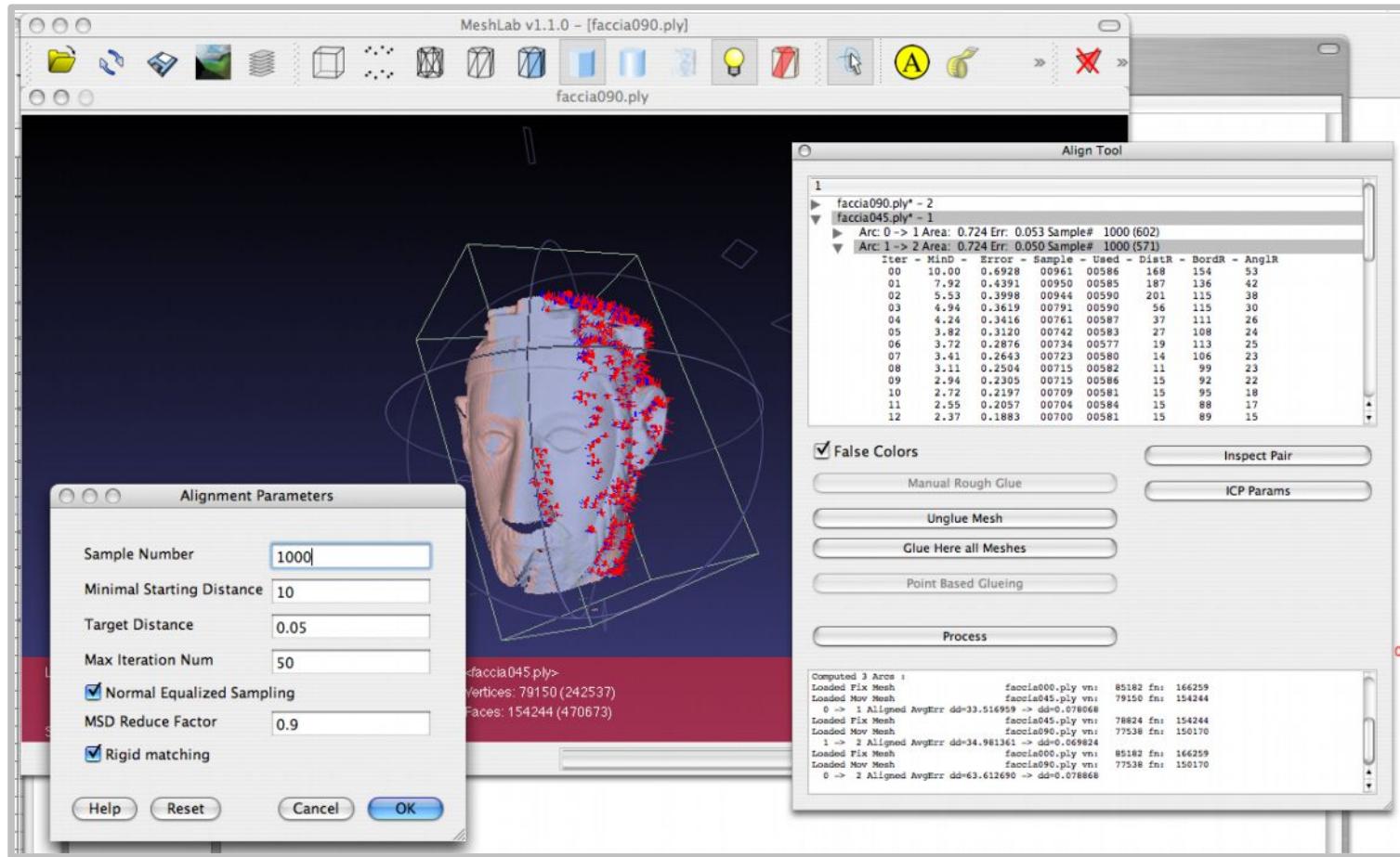
03: FDM: use support material



PVA is the best option, it is water soluble.

Source: <http://youtu.be/FqhBmNyvNhQ>
<http://store.makerbot.com/makerbot-pva-1kg-spool.html>

04: Clean it with Netfabb / Meshlab



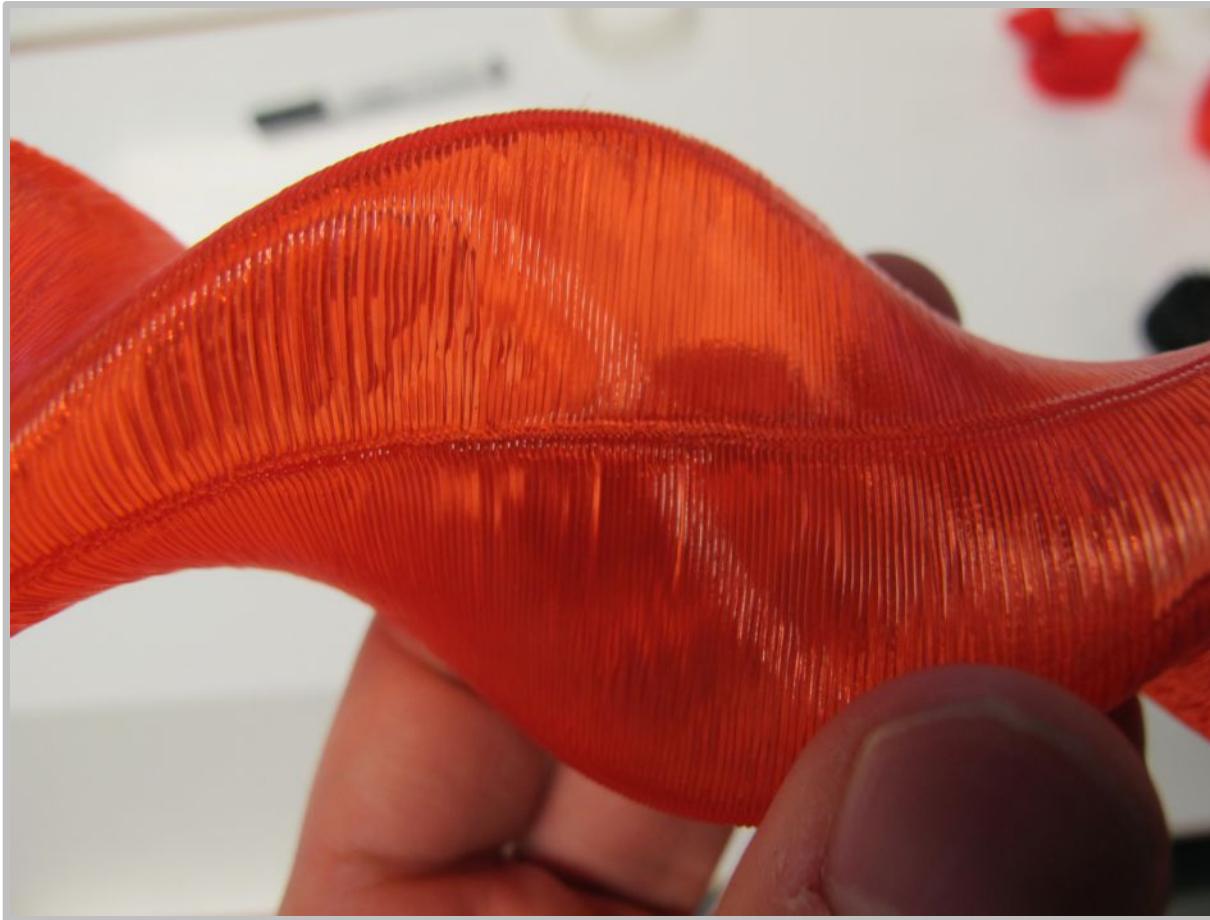
And you may need to import it into Blender again.

3D printing: what could go wrong?



Too fast: we cannot achieve the full cylinder.
We had to slow the speed down and rise a bit the temperature.

3D printing: what could go wrong?



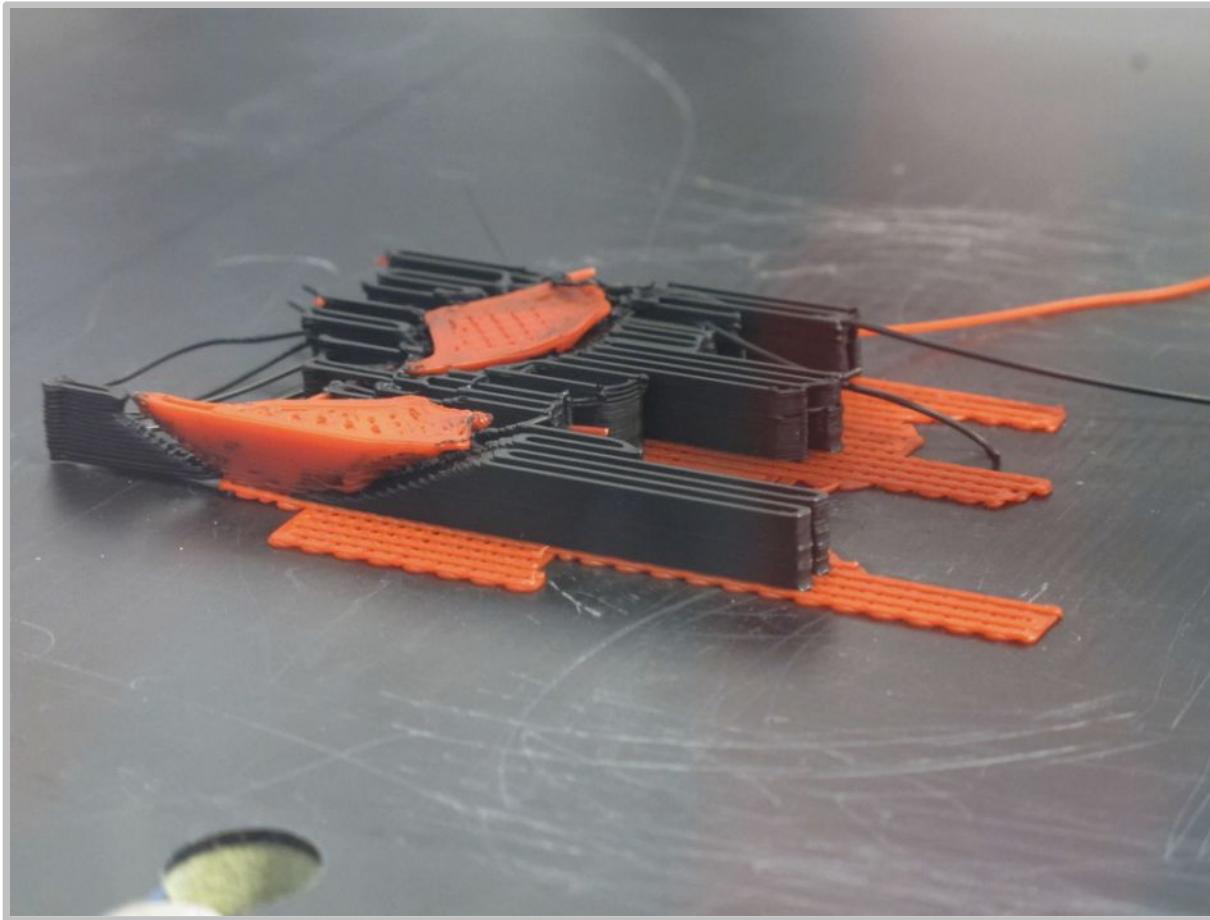
Too fast: we cannot achieve the full cylinder.
We had to slow the speed down and rise a bit the temperature.

3D printing: what could go wrong?



Too fast: the material does not have the time to solidify.
Also: too thin, and the roof collapses. On the right: slower and bigger detail.

Think about the speed



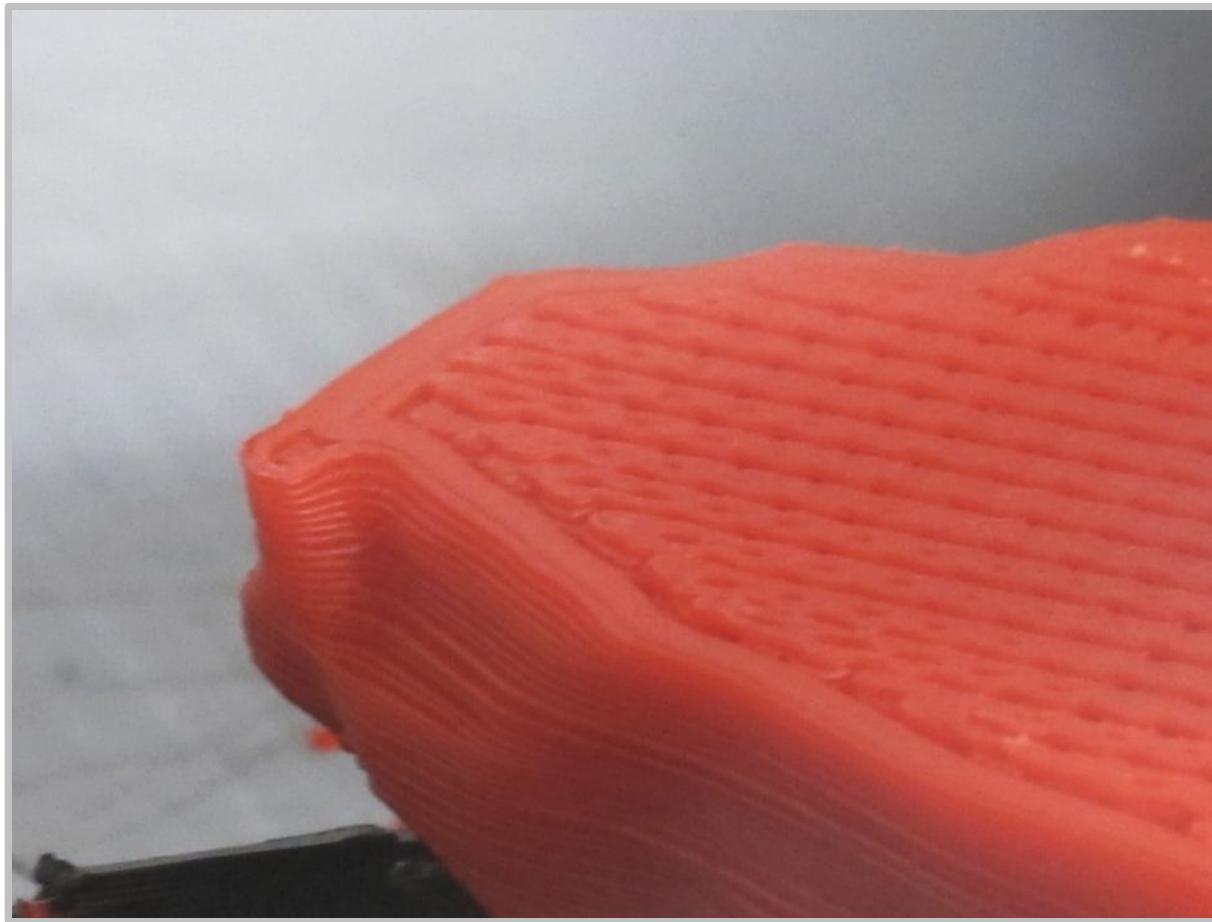
Each different material melt at a different temperature,
mixing them means slowing down the process.

Resolution



0.5 or 0.25 or 0.125 mm? Higher resolution =
more time for printing.

Skins and filling



You can add extra skins and reduce the density of the filling, if you just need a shell.

123D Catch: result



See the orientation of the layers?

123D Catch: result



Support material (PLA) and object material
(ABS) mixed a bit.



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04.

Exercise:

**3D print your 3D scan that you
created yesterday...**

A”

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Thank you!!

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