

Additive Manufacturing (3D Printing known to the public)

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1987, the 1st Additive Manufacturing (AM) machine by 3D systems, USA.
UV curing of Photo-polymer.



2015, AM is still evolving.
Around 10 AM processes for plastics, metal (stainless steel, titanium alloy, cobalt chrome, etc.), wax, ceramic, etc.

Additive Manufacturing

In the Global Arena

“Additive manufacturing has the potential to revolutionize the way we make almost everything”. 2013 State of the Union Address, US President Obama. “... establish 15 additive manufacturing hubs in US”.

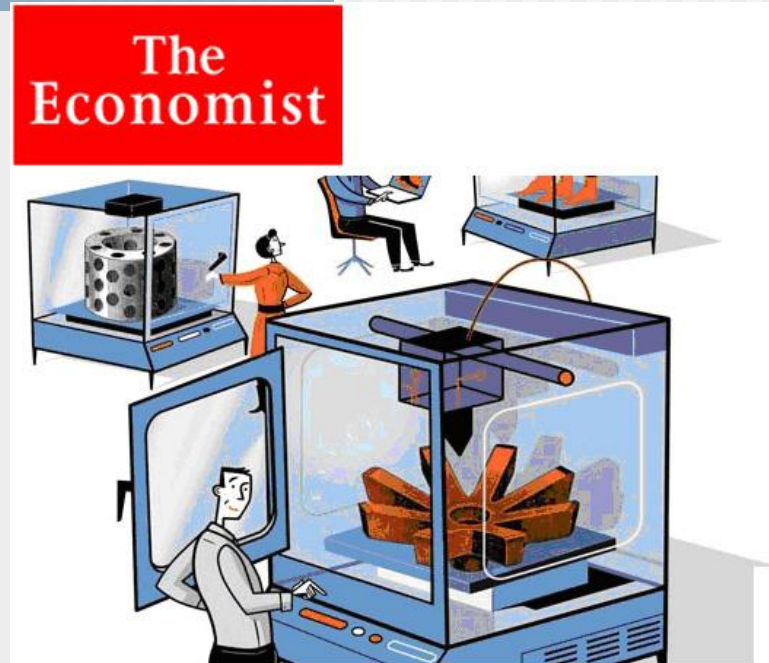


1st in Ohio, early 2014

Additive Manufacturing In the Global Arena

“Additive manufacturing is an enabling technology for the looming third industrial revolution”.
2012, Economist.

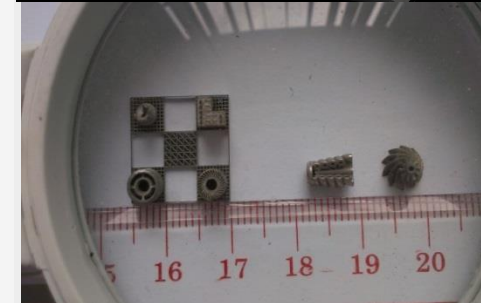
Huge amount of worldwide government funding for AM Research:
Singapore: S\$150M (HK\$900M)
to establish a number of research centres on AM.



Status in Hong Kong

- According to Hong Kong Trade Development Council
Over 35 companies in Hong Kong are developing or distributing additive manufacturing equipment.
- In HK's secondary schools
3D printing is taught in science or technology subjects.
- In HK's higher education institutions
Scattered research projects in all major universities. HKU alone granted more than HK\$16M in 2014 for metal printing, Bio-printing, active material printing research.

<http://www.makerbot.com/>



Current State of the Art

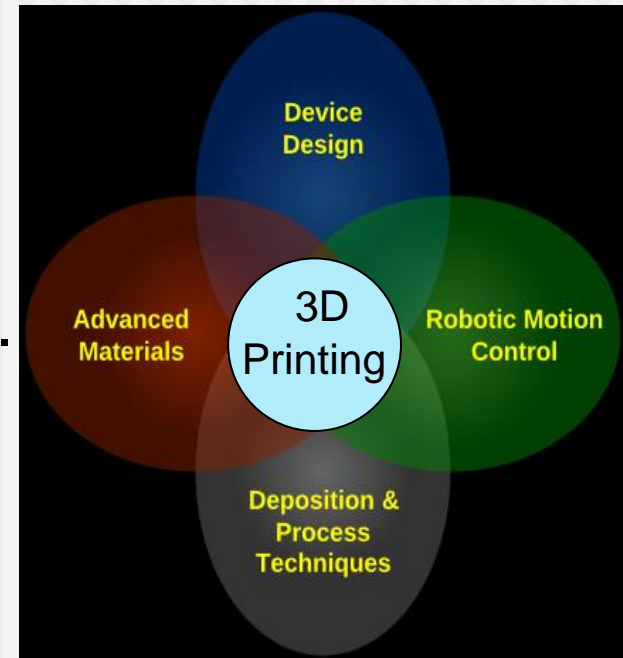
Major Materials: Thermoplastic, photopolymer, titanium alloys, cobalt-chrome, stainless steel, ceramics, etc.

Major Processes: Granular binding, Light polymerization, Extrusion, etc.

Software: No 3D Printing Friendly Software.

Part Quality: Resolution 0.1 mm.
0.01 mm possible for small parts.

Integration with traditional Manufacturing: Various hybrid methods have been developed.



Benefits of Additive Manufacturing

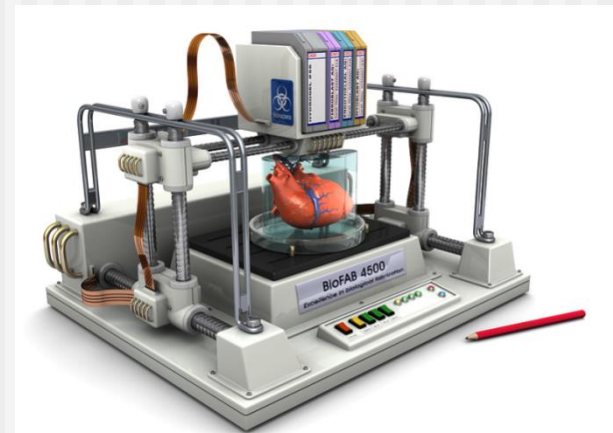
Shape Complexity:

Almost no restriction on part complexity



Material Complexity:

Parts with multi-material, composite materials, and even active materials



<http://www.eos.info/en>

Functional Complexity:

Fabricate Assemblies or parts with different material complexity

Mass Customization:

Example: dozens of dental crowns or bridges can be fabricated in a single build, each for a different patient.



Applications of Additive Manufacturing

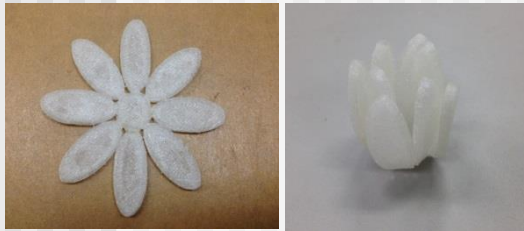
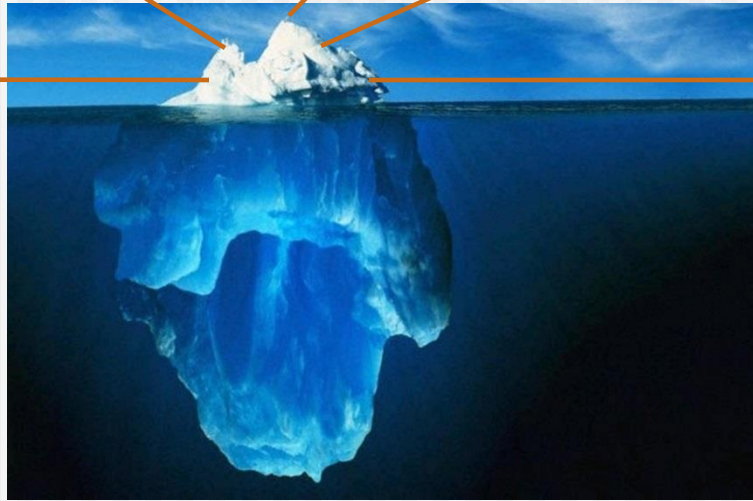
Hi-Tec Industries
(aeronautics, etc)

Education and
Research

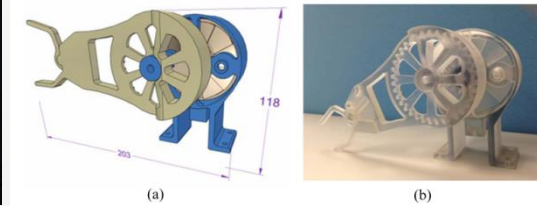
Bio-Printing
Tissue, organ

Medical/dental
implants

Design
Innovation



4D printing :courtesy of HKU



Robot printing: courtesy of HKU

Current list of applications is just the tip of the iceberg. More widespread uses are being actively explored worldwide.

Challenges for AM Research

***Materials:** Materials with better functional properties at low cost are needed.

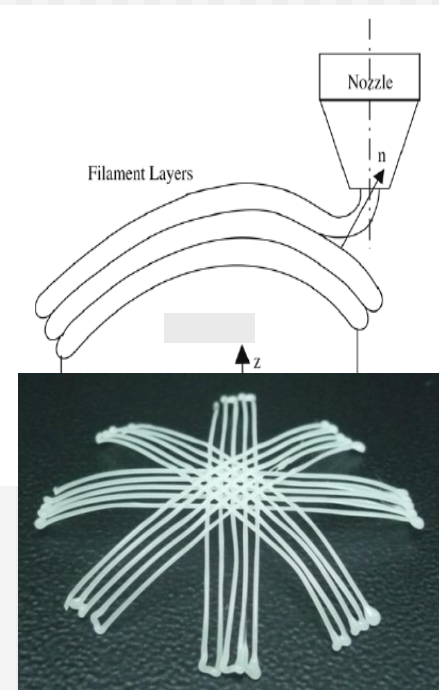
***New Processes:** Processes for printing products with embedded multi-material sensors and actuators; or direct printing of sensors and actuators. Processes for better manufacturing accuracy.

***Software:** For user-friendly modeling of geometry complexity and material complexity.

***Affordability:** Affordable AM machines (only FDM based) can only produce low quality parts.

***Speed:** Currently only for low volume production.

***Applications:** More “Killer Applications” such as 3D printed human kidneys, airplane, or cars.

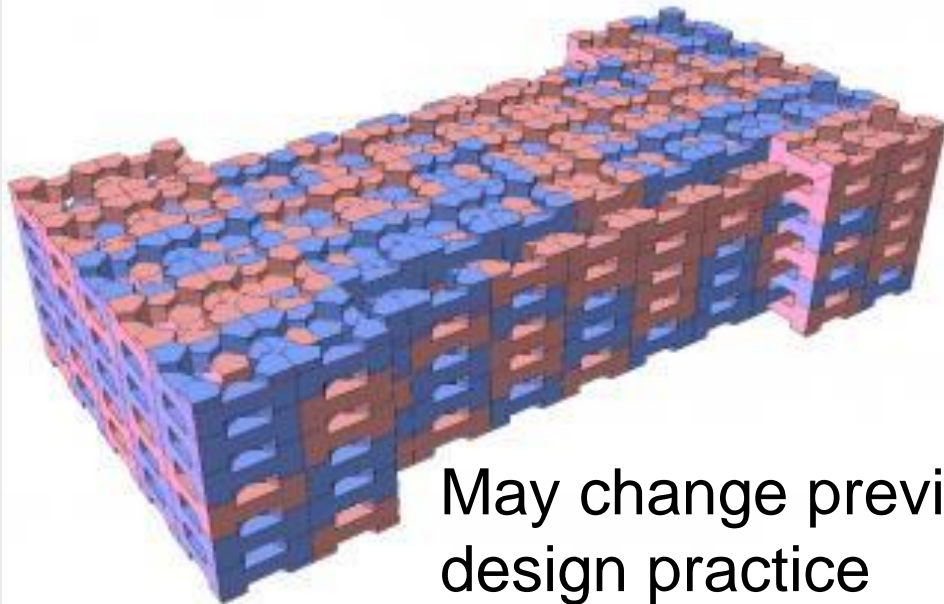


Courtesy of PolyU

Digital Materials

- Only possible in AM -

Digital Material Fabrication:
Fabricate (hundreds of) composite materials with pre-determined visual and mechanical properties at desired location of an object.



May change previous design practice



Multi-material fabrication
Source: Objet Geometries

Why Additive Manufacturing in HK

* AM facilitates Innovation: HK is strong in creative industry.

* AM equipment: a stand-alone micro-fabrication centre may solve HK's space scarcity problem. Thus develop an infrastructure for mass innovation.

* AM is still in its infancy: HK has the chance to develop world leading capability and applications.

* HK is next to the factory of the world. Innovation can be quickly turned to product.

* HK is competitive in related research and applications.

-----Thank You-----