

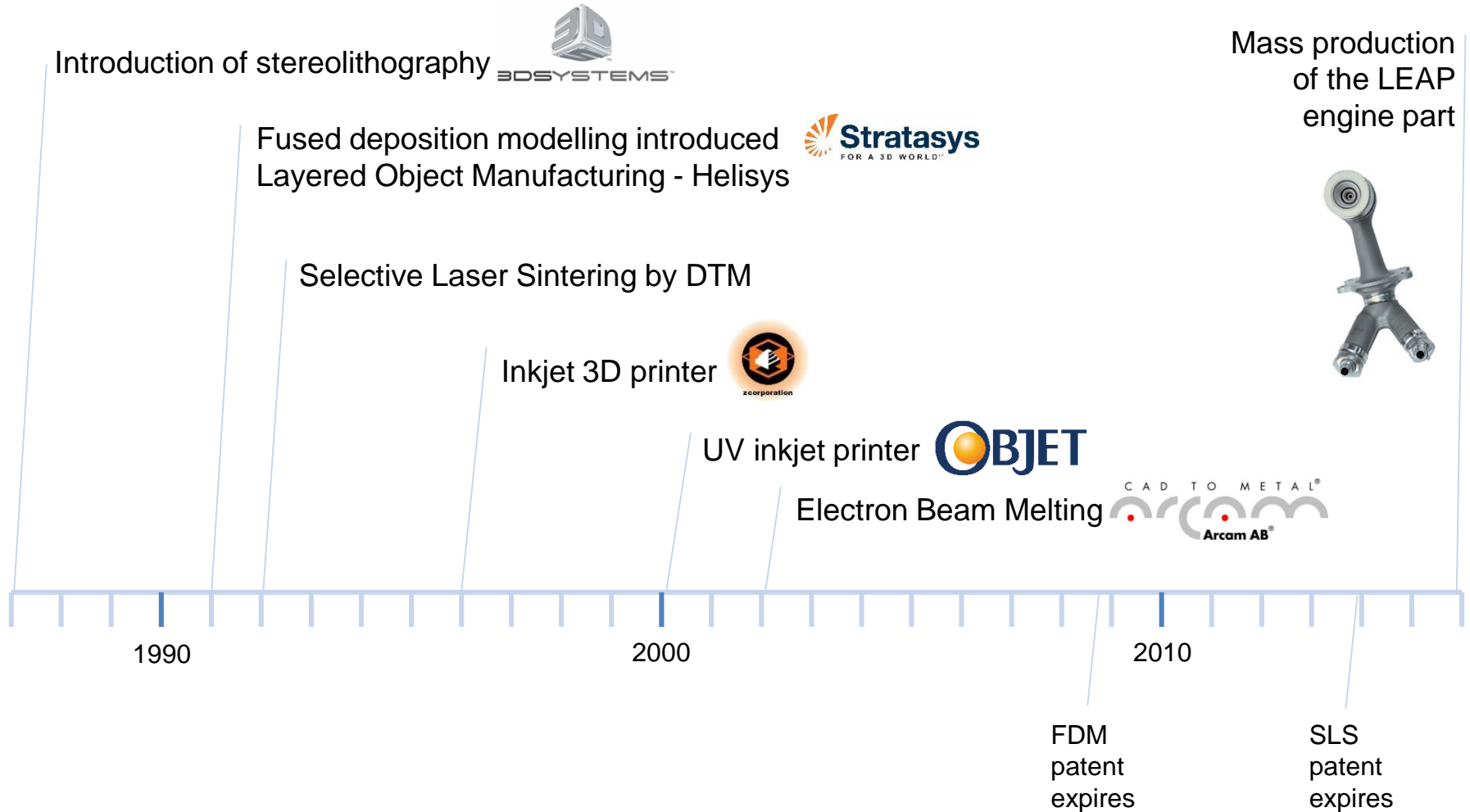
3D Manufacturing for Zero Waste Introduction

Pete Raby

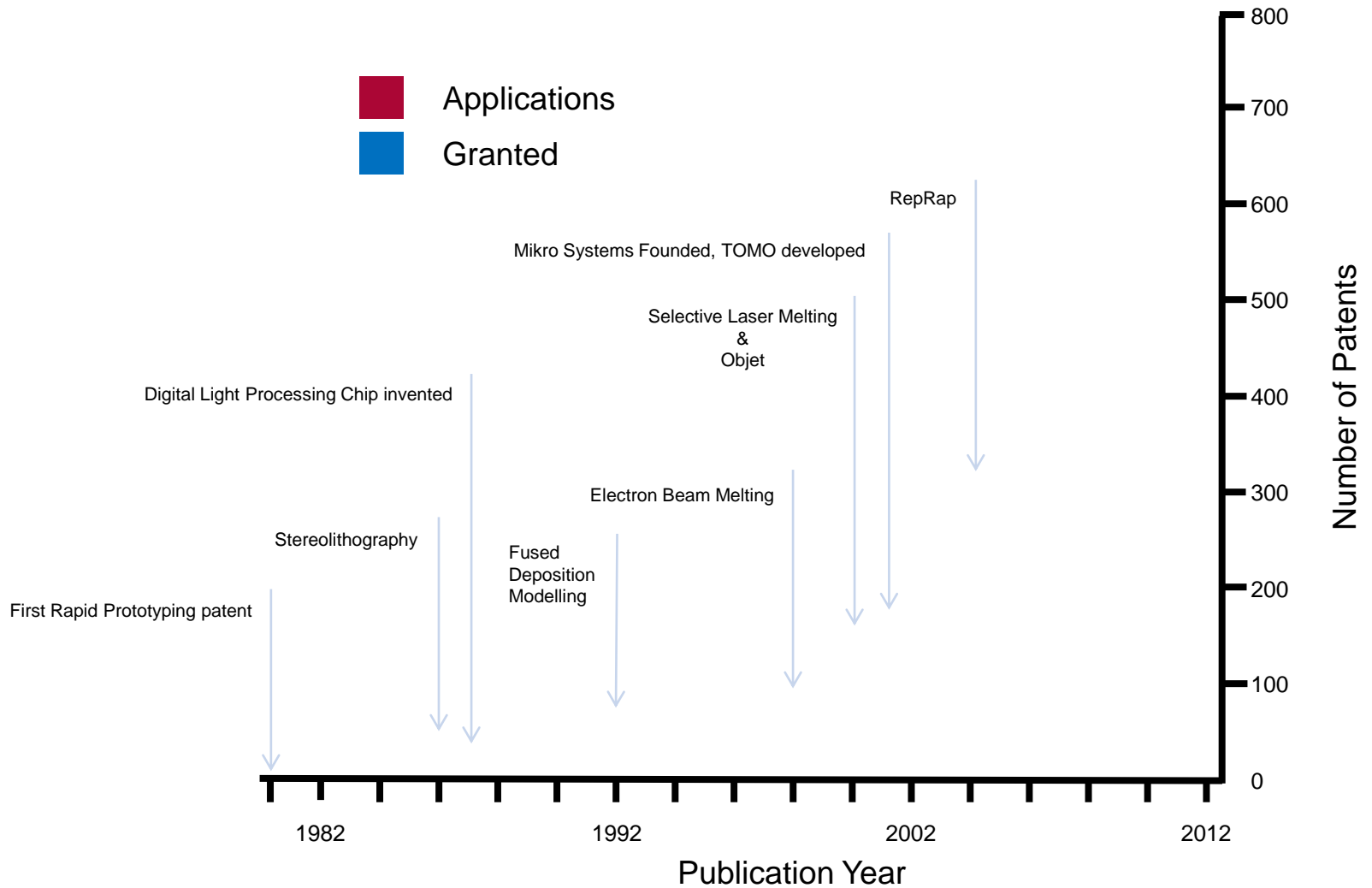
9-10th June 2016

History of Additive Manufacturing

A focus on key commercial technologies



Additive Manufacturing Patents



Data From: <https://www.gov.uk/government/publications/3d-printing-a-patent-overview>

7 AM Technology families

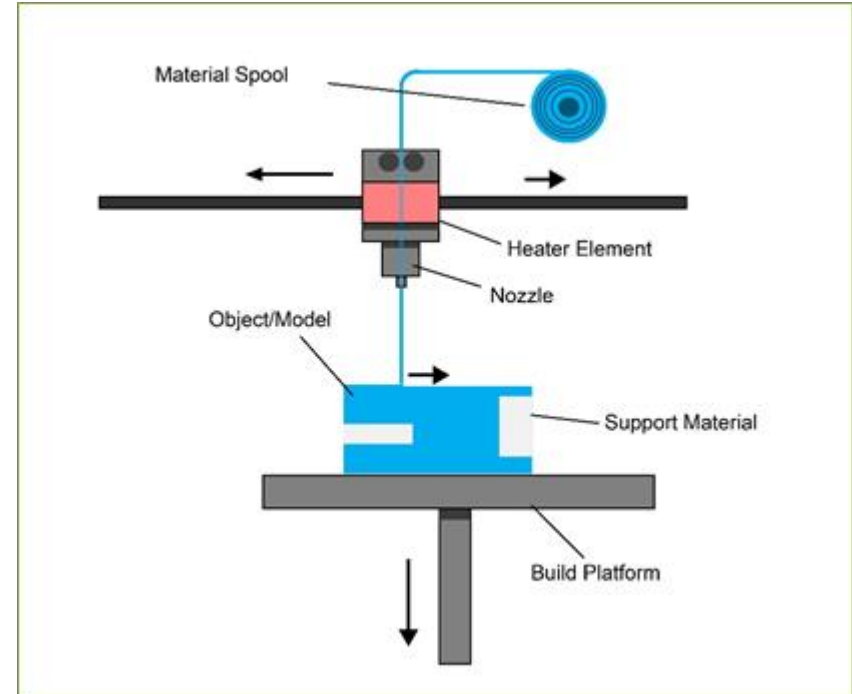
Feedstock Form	AM Technology	Polymers	Metals	Ceramics
SLURRY	Material Extrusion	✓		✓
	Material Jetting	✓	✓	✓
	Vat Polymerisation	✓	✓	✓
POWDER	Binder Jetting	✓	✓	✓
	Powder Bed Fusion	✓	✓	✓
WIRE	Directed Energy Deposition		✓	
SHEET	Sheet Lamination		✓	✓

Materials Extrusion

- Molten filament or paste material extruded through nozzle, controlled in x-y plane.
- Mostly used for polymers, demonstrated for ceramic pastes.

Sales (\$m)	CAGR – 2013-18
789	94.2%

Pros	Cons
Low Cost	Surface Finish
	Manufacturing Time

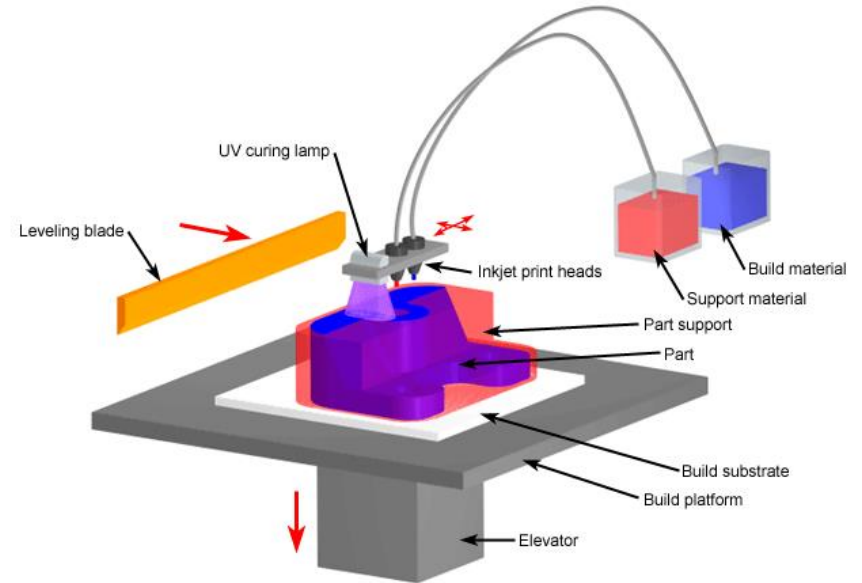


<http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/materialextrusion/>



Materials Jetting

- Polymers and waxes jetted through a print head, different polymers can be blended to grade properties across an object.



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<http://www.custompartnet.com/wu/jetted-photopolymer>

Sales (\$m)	CAGR – 2013-18
217	100%

Pros	Cons
Surface finish	Heat & light sensitive
Multi materials	

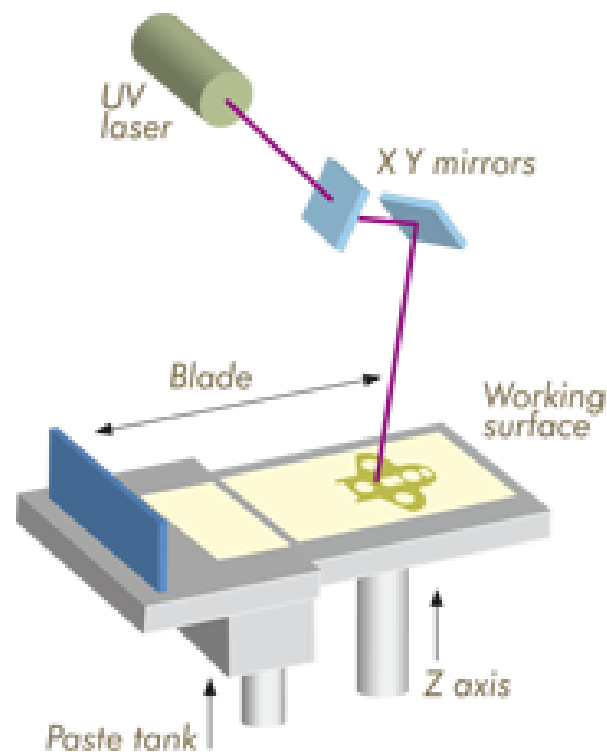


Vat Polymerisation

- High quality polymer parts can be produced, suitable for the production of technical ceramic components too.

Sales (\$m)	CAGR – 2013-18
273	109%

Pros	Cons
Surface State	Heat & light sensitive



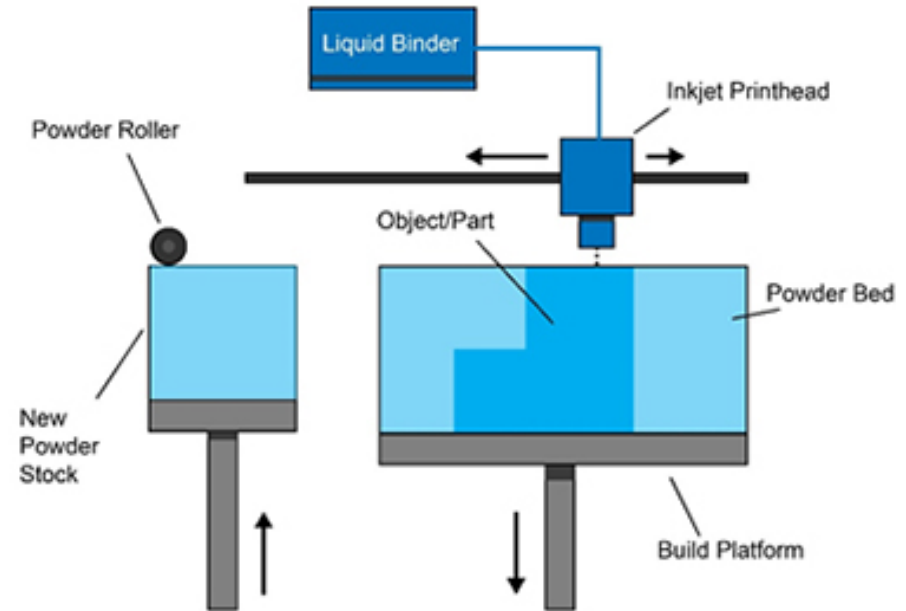
LITHOZ®

Binder Jetting

- An adhesive component is jetted through a printhead to selectively bind areas of a powder bed.
- Used for sand casting moulds, large scale parts can be produced.

Sales (\$m)	CAGR – 2013-18
87	77%

Pros	Cons
High volume	Average surface finish
Multicolour printing	



<http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/binderjetting/>

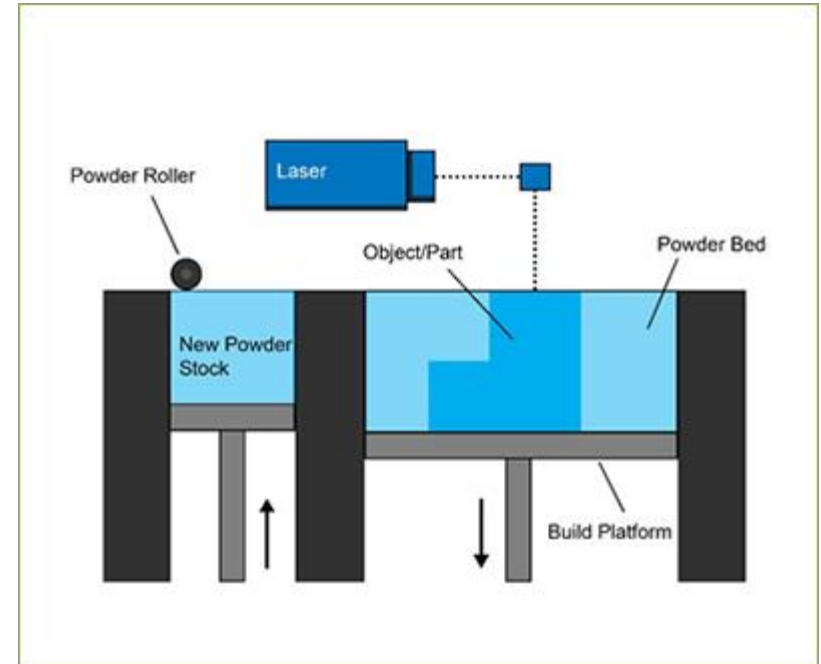
voxeljet

Powder Bed Fusion

- Areas of a powder bed are selectively melted using a laser or other energy source.
- Used for metals like stainless steel and titanium.

Sales (\$m)	CAGR – 2013-18
199	30%

Pros	Cons
Big, complex parts	Surface finish
Mechanical resistance	



<http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/powderbedfusion/>

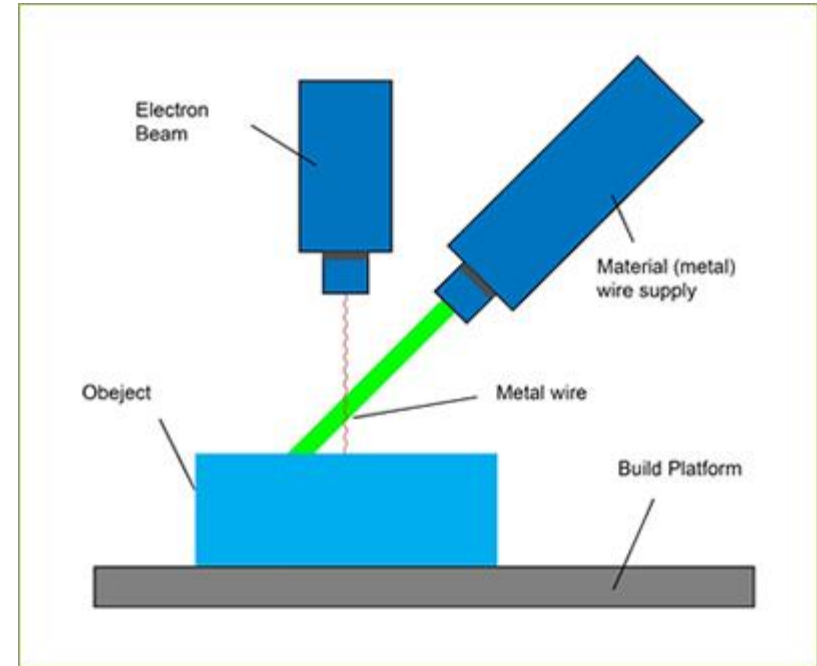
BeAM
BE ADDITIVE MANUFACTURING

Direct Energy Deposition

- Used to cost effectively repair, rework and manufacture metal components.

Sales (\$m)	CAGR – 2013-18
19	57%

Pros	Cons
Additive to existing parts	Surface finish



<http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/directedenergydeposition/>

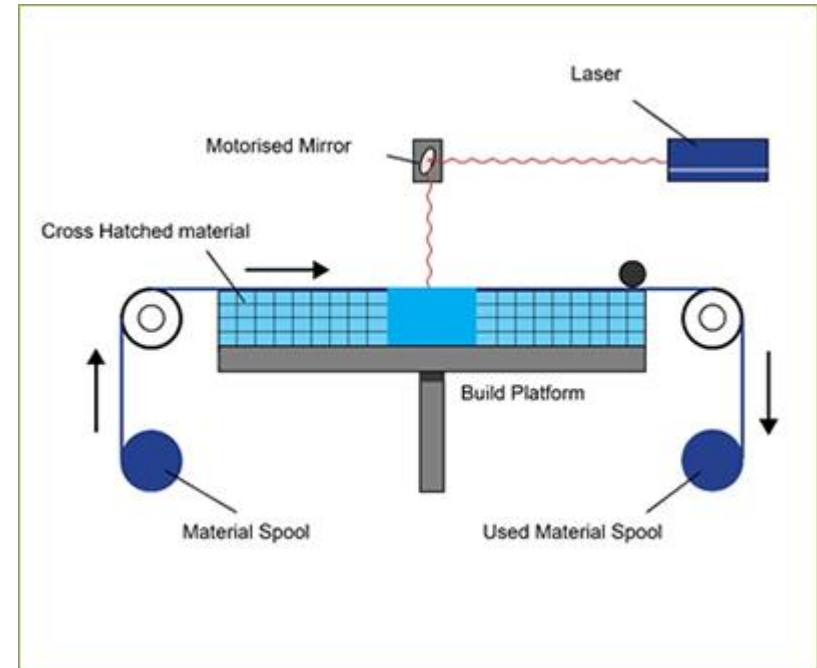
OPTOMECH[®]
Production Grade 3D Printers... with a Material Difference

Sheet Lamination

- Paper based models for architecture etc.

Sales (\$m)	CAGR – 2013-18
25	86%

Pros	Cons
Low cost	Surface finish
	Manufacturing time
	Materials options



<http://www.lboro.ac.uk/research/amrg/about/the7categoriesofadditivemanufacturing/sheetlamination/>

