Materiali - prihodnost AM

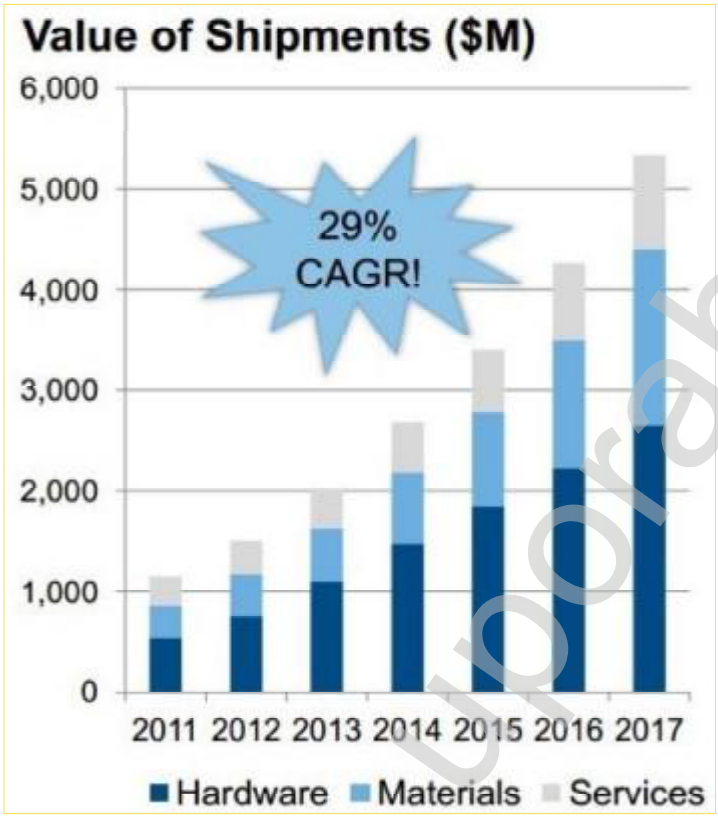
Aditivne tehnologije (AM) gradijo objekte neposredno iz 3D CAD z dodajanjem tekočine, folije, žice ali prahu. 3D-tisk je AM segment za domačo uporabo (EC).

Aditivna proizvodnja - 3D tisk

- Združitve, prevzemi in stečaji.
- 40.000 zasebnih uporabnikov,
- Trend: hiše, avto, elektronika
- Ekstrudiranje plastike, betona
- Hiša v 24 urah (Winsun 40 x 10 x 6,7 m)
- 3D tisk v fazi odraščanja: uspeh na trgu

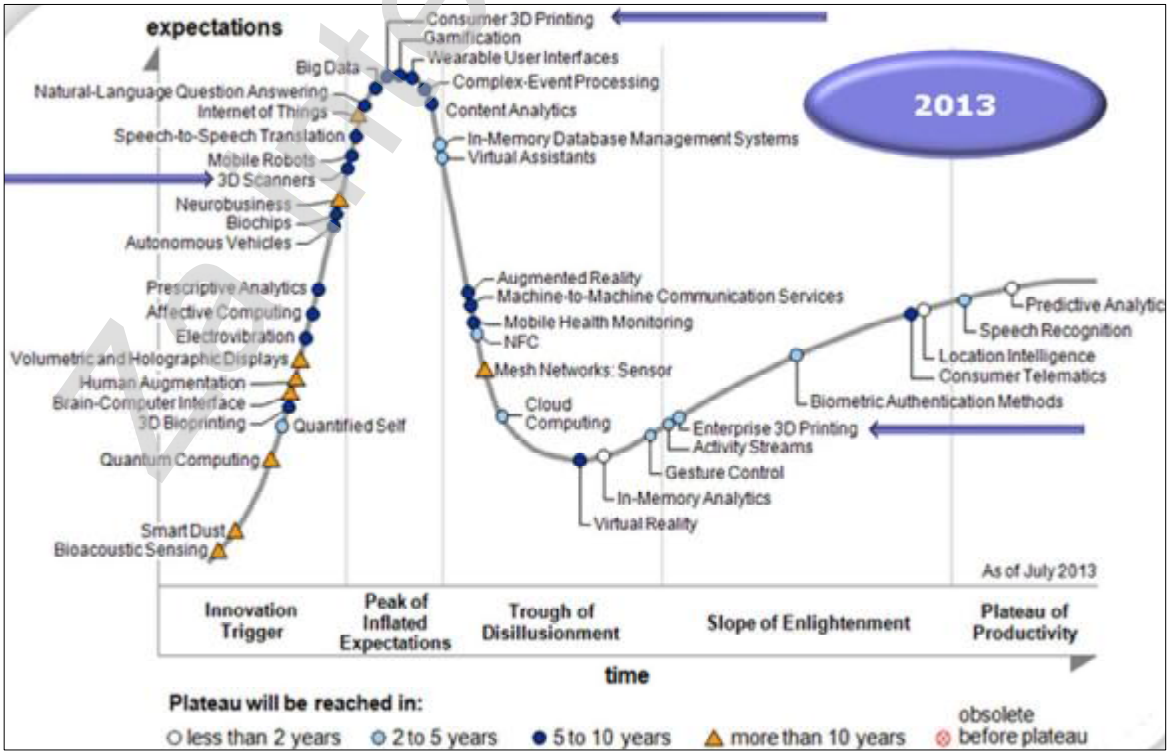
Trg

Visoka rast v svetu **34,9%**. L. 2016: 7 md$, l. 2020 do 105 md$.(EC 2015)



Trg

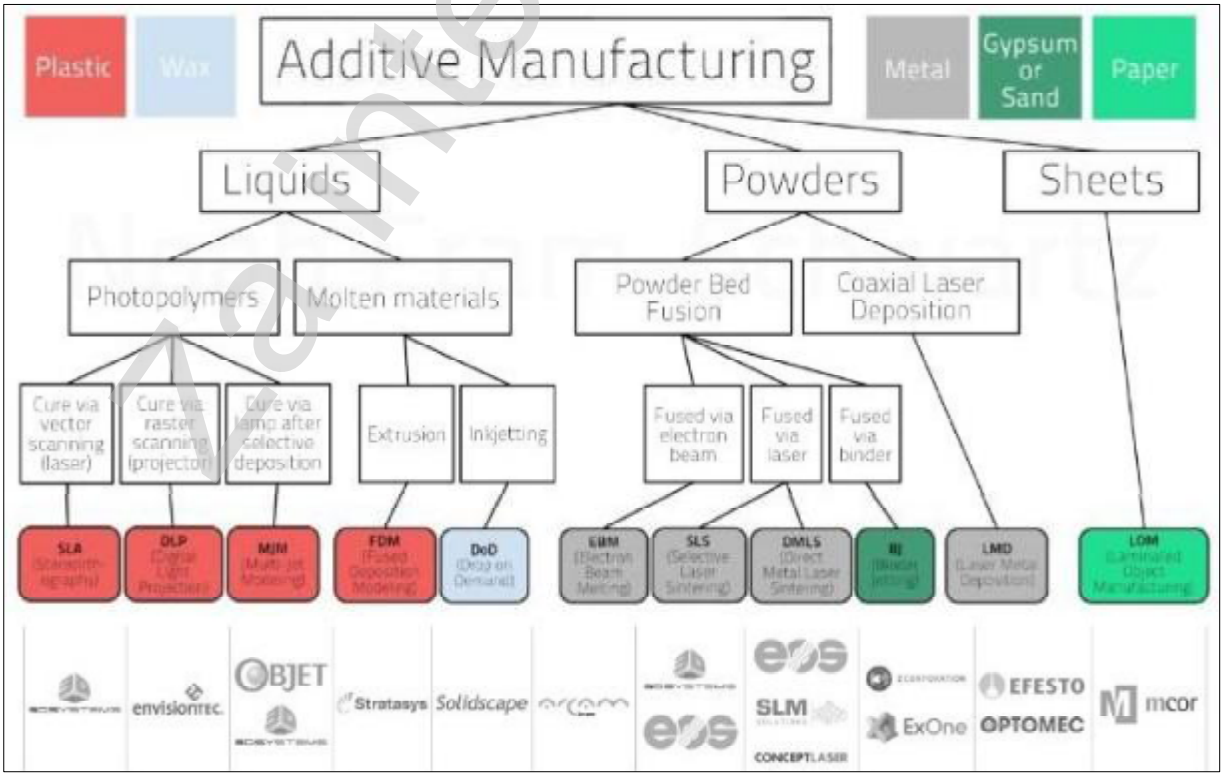
Gartner Hype Cycle (EC)



Razvrstitev AM procesov [ASTM]

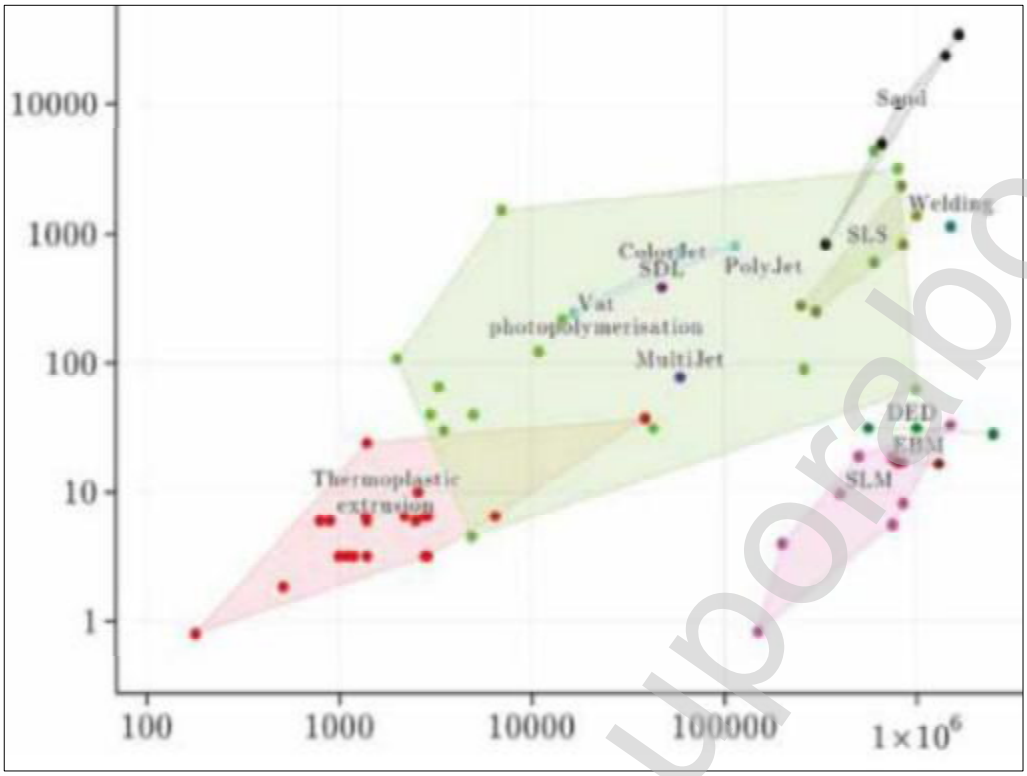
Process Type	Technique Definition	Example Technology	Material
Vat Photo polymerisation	Liquid photopolymer in a vat is selectively cured by light-activated polymerisation.	Stereo lithography (SLA), digital light processing (DLP)	Polymers and ceramics
Material Jetting	Droplets of build material are selectively deposited.	3D inkjet printing	Polymers and composites
Binder Jetting	Liquid bonding agent is selectively deposited to join powder materials.	3D inkjet printing	Metals, polymers, and ceramics
Material Extrusion	Material is selectively dispensed through a nozzle or orifice.	Fused deposition modelling (FDM)	Polymers
Powder Bed Fusion	Thermal energy selectively fuses regions of a powder bed.	Selective laser sintering (SLS), Selective laser melting (SLM), electron beam melting (EBM)	Metal, polymer, composites and ceramics
Sheet Lamination	A process in which sheets of material are bonded to form an object.	Ultrasonic Consolidation (UC)	Hybrids, metals and ceramics
Directed Energy Deposition	A process that focused thermal energy and fuses materials by melting as the material is being deposited.	Laser metal deposition (LMD)	Metals and hybrid metals

Razvrstitev AM procesov (Schwartz 2012)



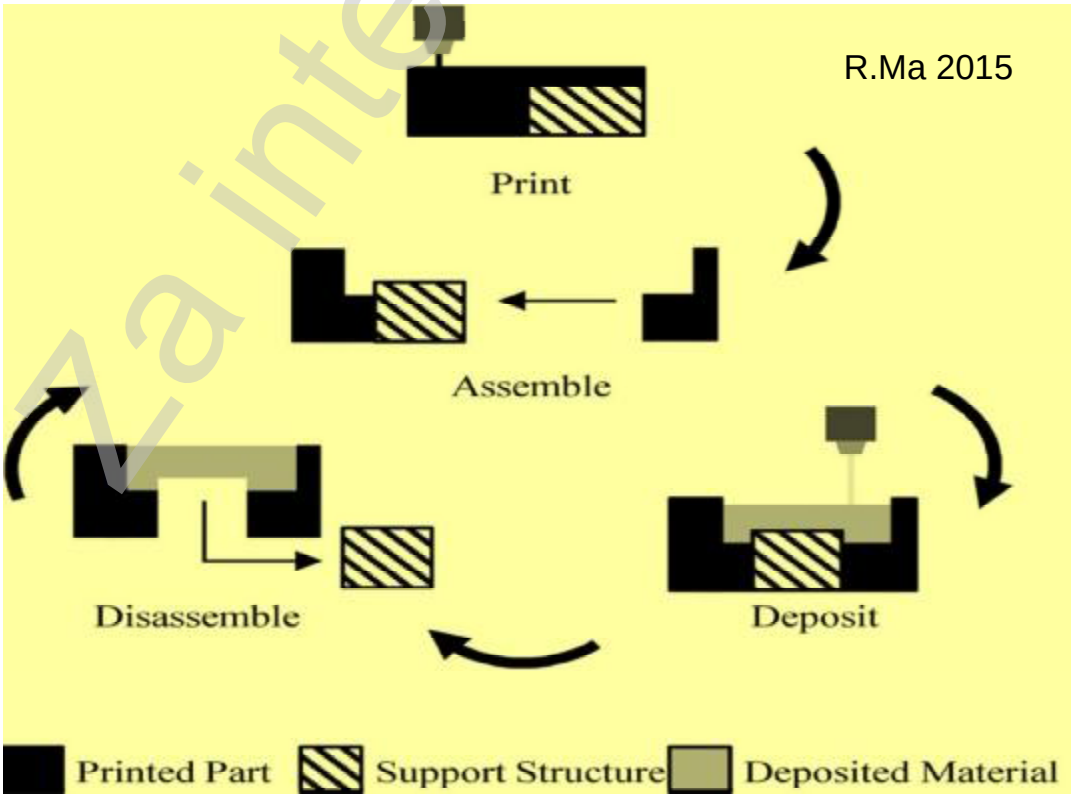
Cena opreme

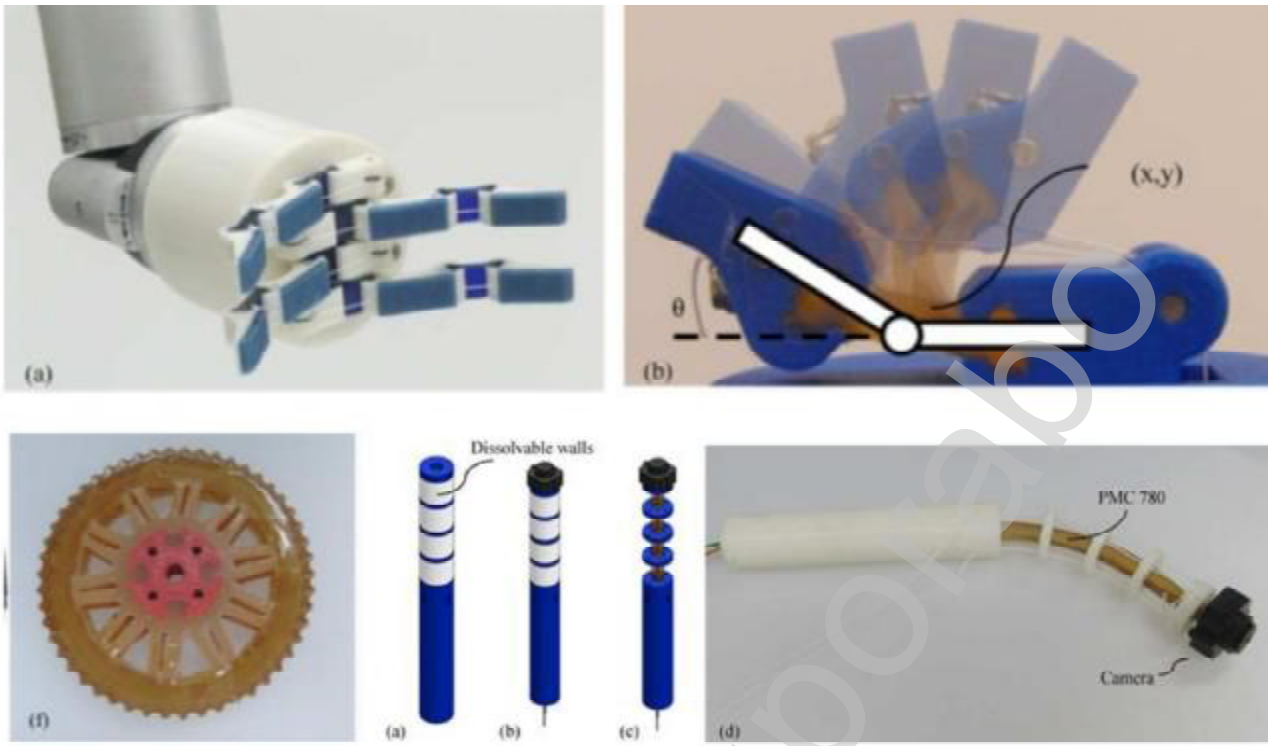
Speed (mm^3/s)



Price US$,
(Harrop 2014)

Hibridni 3D tisk z vlivanjem smole - HDM





Roka: tiskani prsti in lita fleksibilna vez;
Kolo: tiskane špice in lita guma
Kamera na fleksibilni sondi

Materiali za AM (Bhandary 14)

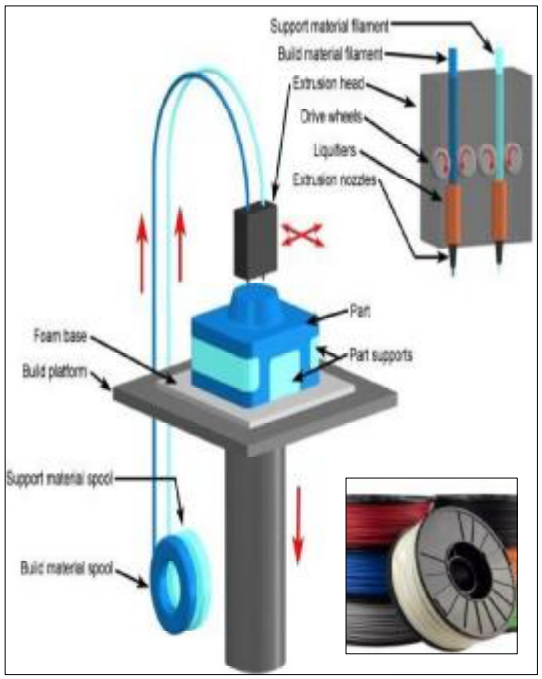
Industrija

- Plastika, guma in kovine.
- Les, steklo, glina, keramika, beton, **hiša**. (Uni S.California)
- Čokolada, slaščice, meso, ribe, sir, čips, **pice**. (byFlow)
- Prevodni epoksid 3% CNF, 200 Ω cm (Leigh 2012).
- Elektronika, proge 40 μ z Ag 30 nm, prevodnost **23%** Ag.

R&R

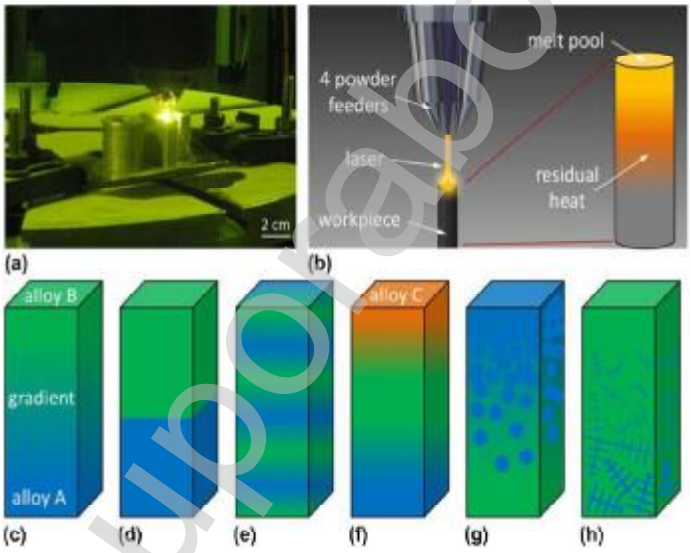
- Koža, ušesa, ledvice, kosti, žile, **srce**? (Uni Louisville)
- Živ les (NASA) in **meso** (Modern Meadow).
- Basalt - misija Mars (Kading 2015)
- Aerogel (Garcia 2016)
- Fleksibilne polnilne cink baterije (Hewitt 2013)
- Aktuatorji (Imaizumi 2013)

FDM, Hibridi, LD gradientni materiali

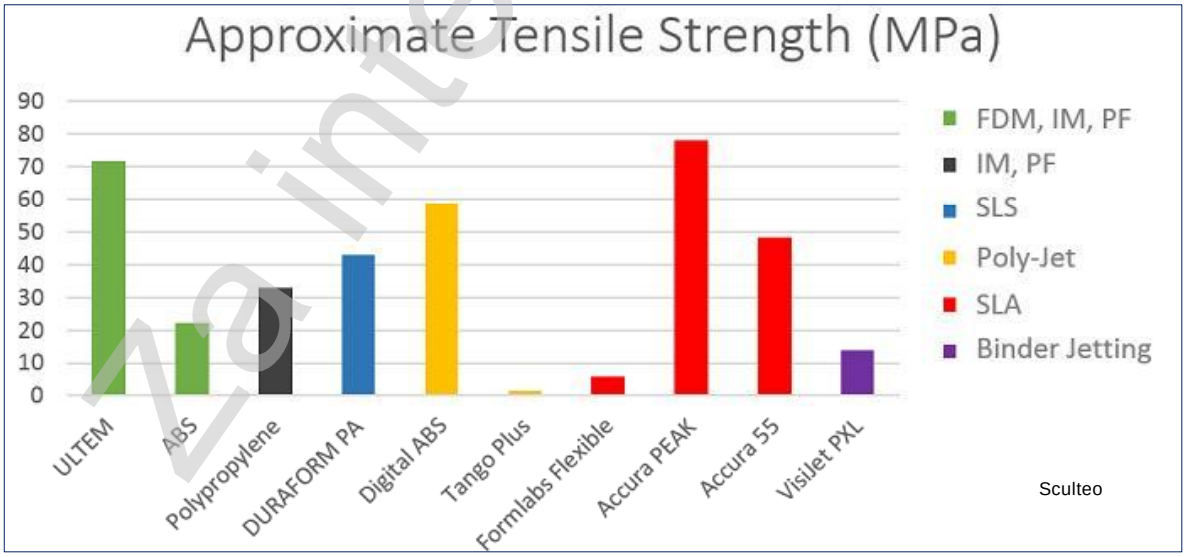


Gradientne zlitine (Hofmann 2014)

Multimaterialna testna čelada; Gradientni zobnik



Trdnost 3D polimerov



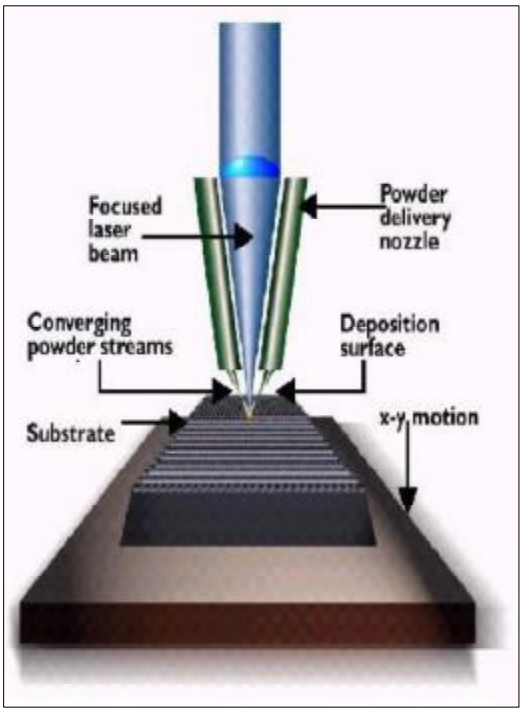
SLA, DLP in MJM so Na osnovi UV utrjevanih smol, z manjšo žilavostjo.

MJM, FDM in LMD omogočajo gradnjo funkcionalnih **gradientnih** materialov

SLA, DLP, DMLS, EBM, SLS in BJ zajemajo prah ali smolo iz kontejnerja

SLA, DLP, EBM jn DMLS zahtevajo podporni material, ki ga odstranimo

Metal (LENS Optomec)

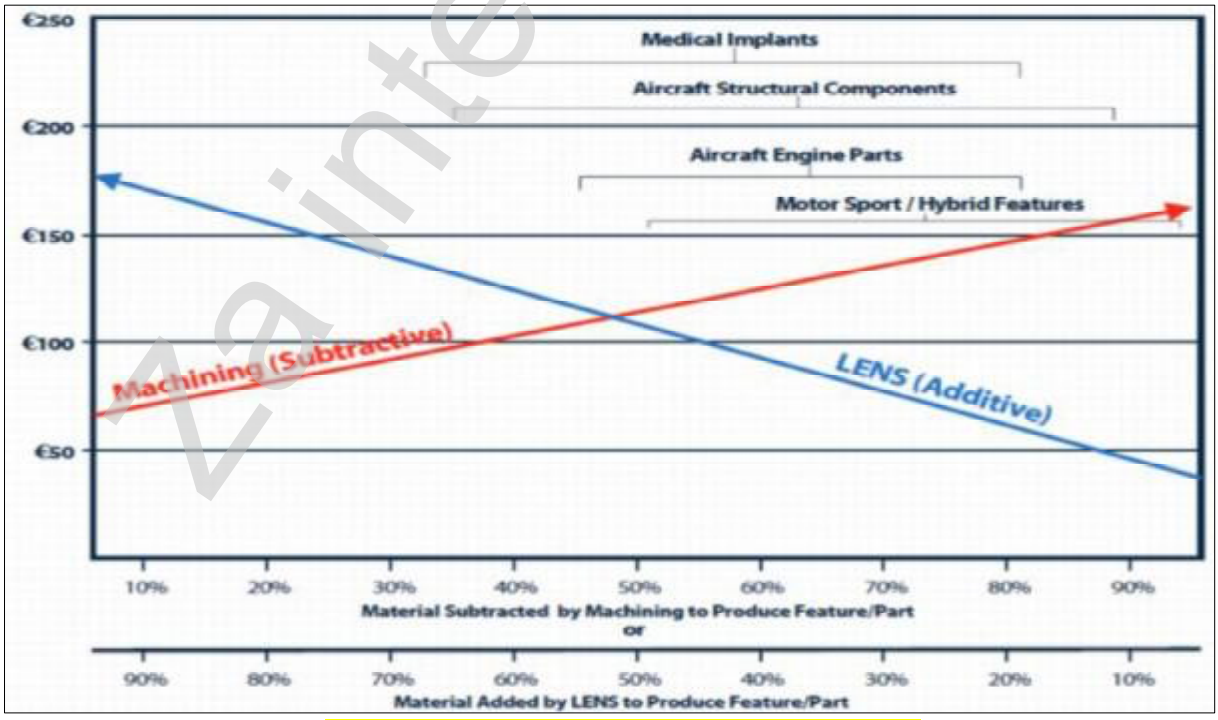


Jekla, Ti, Ni, Co, Al, Cu
W, V, Mo, Ta, Re, Nb, Mo-Si,_B, Nb-Si,
C103, Norem, NanoSteel.

Material	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	El. (%)
LENS Ti 6-4	848	955	15
Wrought Ti 6-4 Typical	883	952	14
LENS 316 Stainless Steel	276	661	67
Wrought 316 Stainless Steel	289	578	50
LENS Ni Alloy 625	579	930	38
Wrought Ni Alloy 625	400	834	30

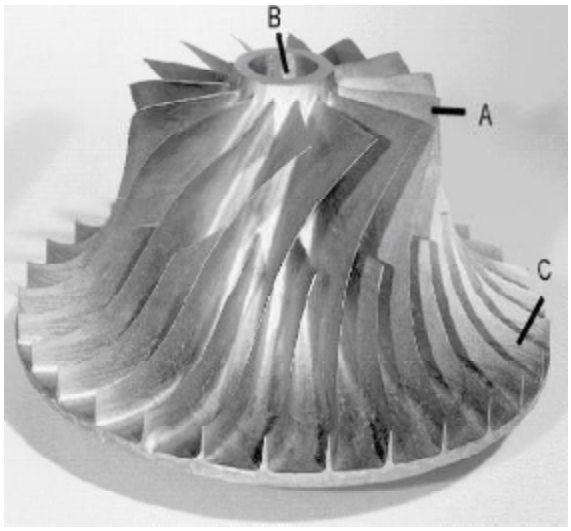
Dvosrenska šoba; Ohišje **satelita**

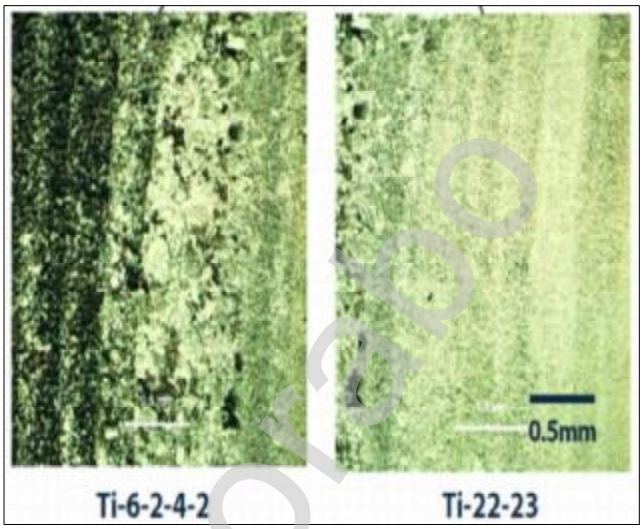
Metal (LENS Optomec)



Manufacturing **costs – additive vs. subtractive**

Funkcionalni **gradientni** materiali





A) Impact:Conventional Ti alloy (Ti 6-2-4-2)
B) LC Fatique Orthorhomic Ti alloy (Ti 22-23)
C) Creep Gamma Ti-Aluminide (Ti 48-2-2)

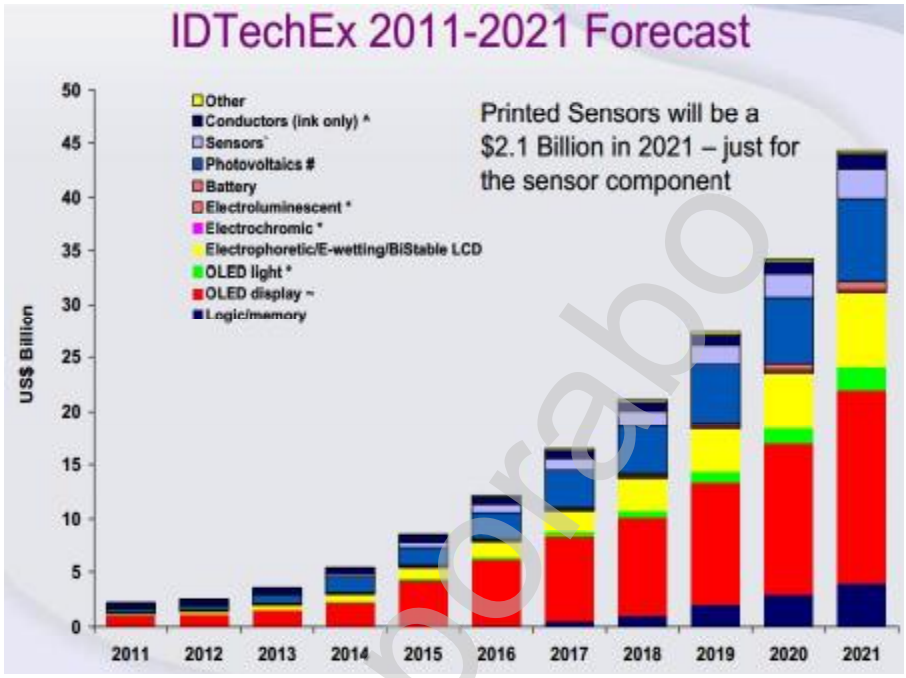
PLASTTECHNICS CLUSTER SLOVENIA
Kovine

Funkcionalni materiali

Karoserija Cobra in hladilnik FDM; zobne proteze SLM,

Beton FDM- prostorska mreža in livarska peščena jedra – FDM; Avionski deli 6m Ti; Printer WinSun Chi , 40 x 10 x 6.7 m.

Napredni EE materiali

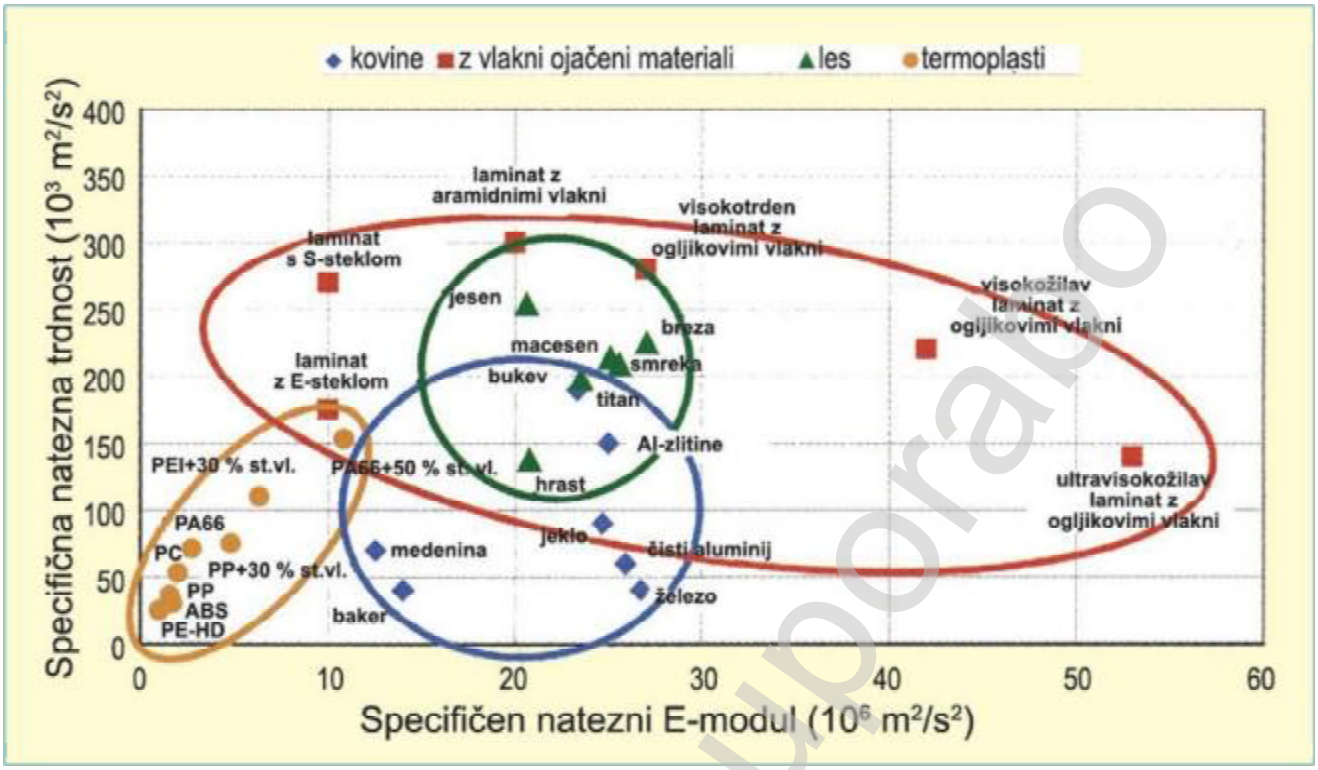


3D tisk elektronike bo od *5 md$ l. 2012* narasel na 35 md$ l. 2020 in **300 md$** l. 2030, največ zaradi OLED displejev

3D TISK HRANE

	Hot-melt extrusion	Sintering technology	Inkjet powder printing	Inkjet printing
Materials	Food polymers such as chocolate	Low melting powder such as sugar, NesQuik or fat	Powder such as sugars, starch, cornflour, flavours, and liquid binder	Low viscosity material such as paste or puree
Platform	x Motorized stage x Heating unit x Extrusion device	x Motorized stage x Sintering source (laser or hot air) x Powder bed	x Motorized stage x Powder bed x Inkjet print head for binder printing	x Motorized stage x Inkjet printhead x Thermal control unit
Fabricated products	Customized chocolates	Food-grade art objects, Toffee shapes	Sugar cube in full-color	Customized cookies, Bench-top food paste shaping
Machine	Choc Creator	Food Jetting Printer	Chefjet	Foodjet
Company	Chocedge	TNO	3D systems	De Grood Innovations

Les je najcenejši material za visoko togost in trdnost



Rast z inovacijami

“Dobil sem nagrado za inovacijo, zdaj bomo delali drugače.“