RE i RP u biomedicinskom inženjerstvu

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7 Families of Additive Manufacturing

According to ASTM F2792 Standards

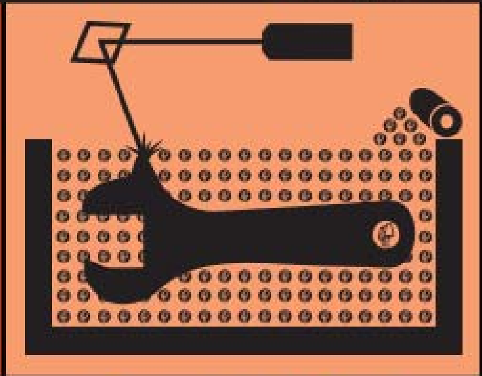
VAT PHOTOPOLYMERIZATION

Alternative Names:
SLA™- Stereolithography Apparatus
DLP™- Digital Light Processing
3SP™- Scan, Spin, and Selectively Photocure
CLIP™ – Continuous Liquid Interface Production

Description:
A vat of liquid photopolymer resin is cured through selective exposure to light (via a laser or projector) which then initiates polymerization and converts the exposed areas to a solid part.

Strengths:
- High level of accuracy and complexity
- Smooth surface finish
- Accommodates large build areas

Typical Materials
UV-curable Photopolymer Resins (with various fillers)



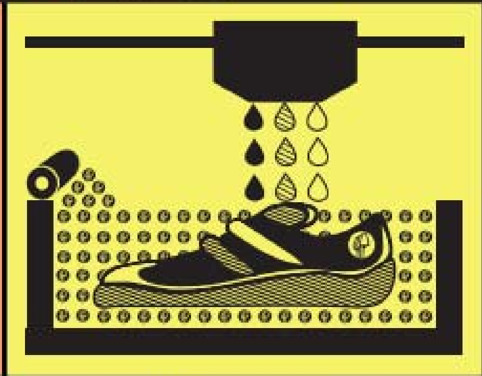
POWDER BED FUSION (PBF)

Alternative Names:
SLS™- Selective Laser Sintering; DMLS™- Direct Metal Laser Sintering; SLM™- Selective Laser Melting; EBM™- Electron Beam Melting; SHS™- Selective Heat Sintering; MJF™- Multi-Jet Fusion

Description:
Powdered materials is selectively consolidated by melting it together using a heat source such as a laser or electron beam. The unfused powder surrounding the consolidated part acts as a support material for overhanging features.

Strengths:
- High level of complexity
- Powder acts as support material
- Wide range of materials

Typical Materials
Plastics, Metal and Ceramic Powders, and Sand



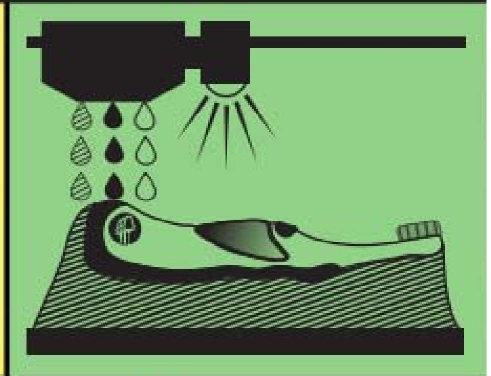
BINDER JETTING

Alternative Names:
3DP™- 3D Printing
ExOne
Voxeljet

Description:
Liquid bonding agents are selectively applied onto thin layers of powdered material to build up parts layer by layer. The binders include organic and inorganic materials. Metal or ceramic powdered parts are typically fired in a furnace after they are printed.

Strengths:
- Allows for full color printing
- High productivity
- Uses a wide range of materials

Typical Materials
Powdered Plastic, Metal, Ceramics, Glass, and Sand.



MATERIAL JETTING

Alternative Names:
Polyjet™
SCP™- Smooth Curvatures Printing
MJM - Multi-Jet Modeling
Projet™

Description:
Droplets of material are deposited layer by layer to make parts. Common varieties include jetting a photocurable resin and curing it with UV light, as well as jetting thermally molten materials that then solidify in ambient temperatures.

Strengths:
- High level of accuracy
- Allows for full color parts
- Enables multiple materials in a single part

Typical Materials
Photopolymers, Polymers, Waxes

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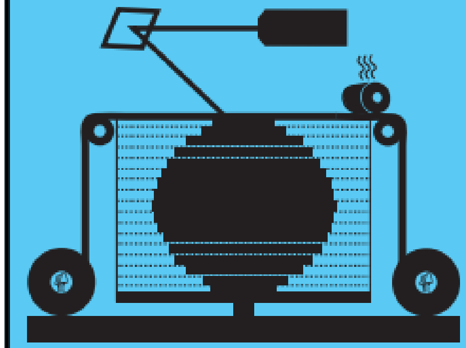


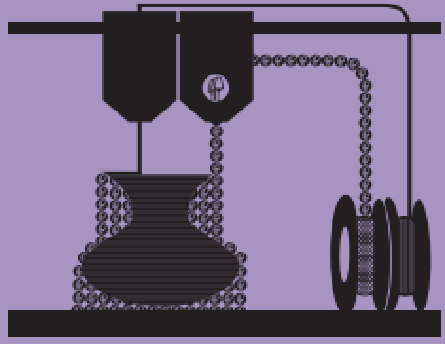
Sheet Lamination

Alternative Names:
LOM - Laminated Object Manufacture
SDL - Selective Deposition Lamination
UAM - Ultrasonic Additive Manufacturing

Description:
Sheets of material are stacked and laminated together to form an object. The lamination method can be adhesives or chemical (paper/plastics), ultrasonic welding, or brazing (metals). Unneeded regions are cut out layer by layer and removed after the object is built.

Strengths:
- High volumetric build rates
- Relatively low cost (non-metals)
- Allows for combinations of metal foils, including embedding components.

Typical Materials
Paper, Plastic Sheets, and Metal Foils/Tapes



Material Extrusion

Alternative Names:
FFF - Fused Filament Fabrication
FDM™ - Fused Deposition Modeling

Description:
Material is extruded through a nozzle or orifice in tracks or beads, which are then combined into multi-layer models. Common varieties include heated thermoplastic extrusion (similar to a hot glue gun) and syringe dispensing.

Strengths:
- Inexpensive and economical
- Allows for multiple colors
- Can be used in an office environment
- Parts have good structural properties

Typical Materials
Thermoplastic Filaments and Pellets (FFF); Liquids, and Slurries (Syringe Types)

Directed Energy Deposition (DED)

Alternative Names:
LMD - Laser Metal Deposition
LENS™ - Laser Engineered Net Shaping
DMD™ - Direct Metal Deposition

Description:
Powder or wire is fed into a melt pool which has been generated on the surface of the part where it adheres to the underlying part or layers by using an energy source such as a laser or electron beam. This is essentially a form of automated build-up welding.

Strengths:
- Not limited by direction or axis
- Effective for repairs and adding features
- Multiple materials in a single part
- Highest single-point deposition rates

Typical Materials
Metal Wire and Powder, with Ceramics

Hybrid

Alternative Names:
AMBIT™ - Created by Hybrid Manufacturing Technologies

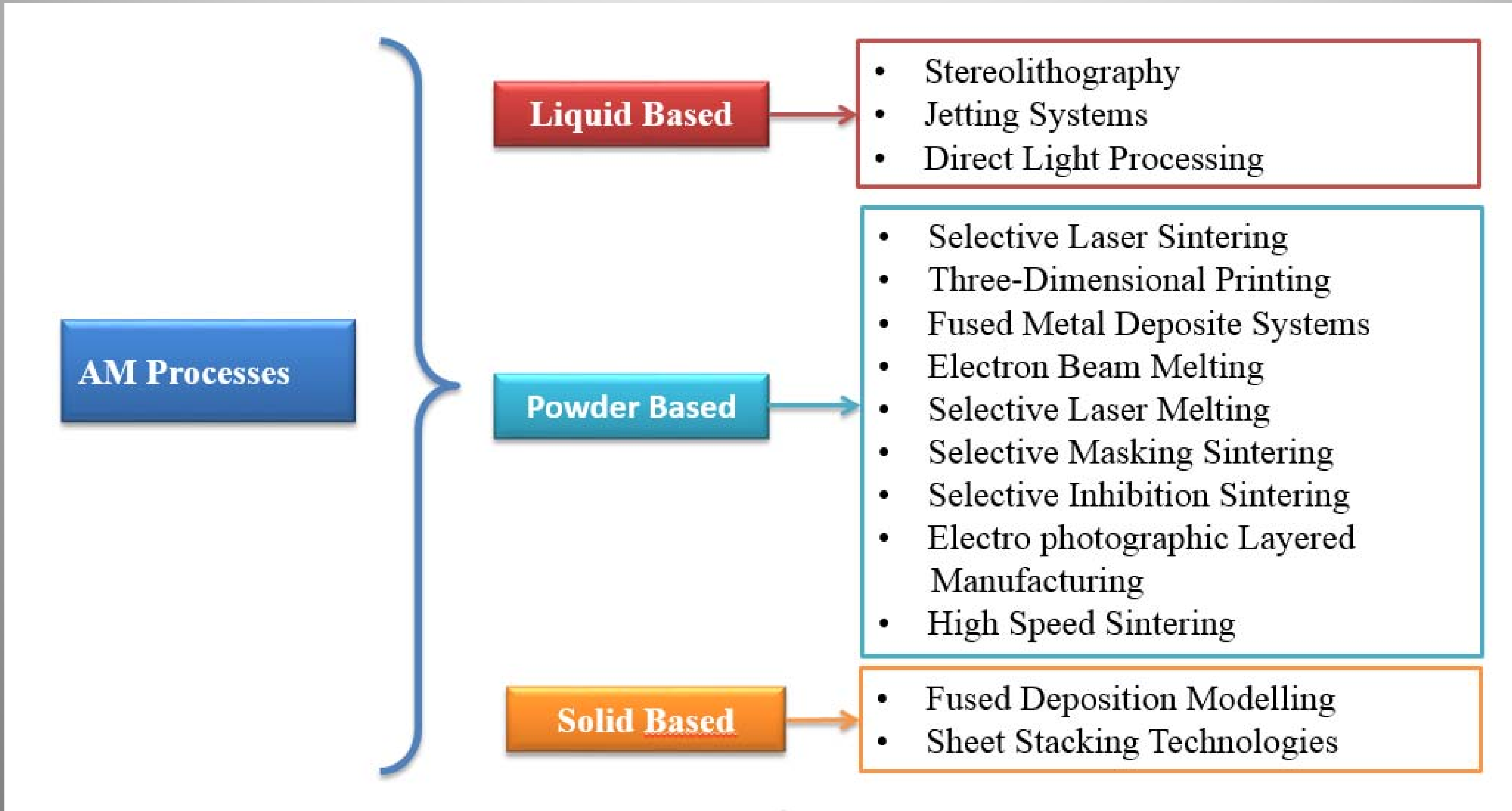
Description:
Laser metal deposition (a form of DED) is combined with CNC machining, which allows additive manufacturing and 'subtractive' machining to be performed in a single machine so that parts can utilize the strengths of both processes.

Strengths:
- Smooth surface finish AND High Productivity
- Geometrical and material freedoms of DED
- Automated in-process support removal, finishing, and inspection

Typical Materials
Metal Powder and Wire, with Ceramics

Podela AM postupaka prema početnom stanju materijala

A. Materijali u tečnom stanju
B. Materijali u praškastom stanju
C. Materijali u čvrstom stanju



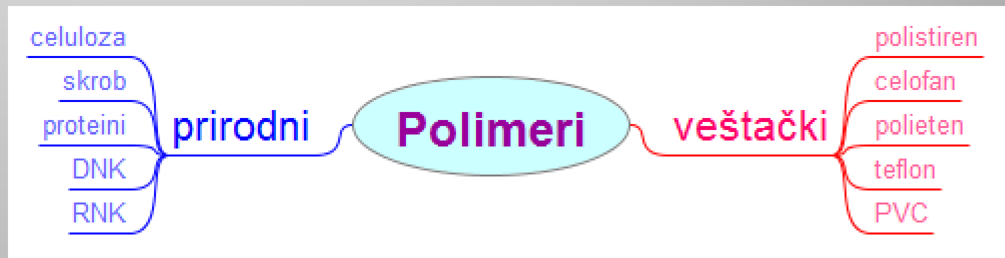
AM Postupci na bazi solidifikacije fluida

Fotopolimerizacija

Polimeri – su prirodne ili veštačke materije (jedinjenja) koje se sastoje od velikih molekula sačinjenih od velikog brojnih manjih osnovnih, ponavljajućih jedinica **monomera (mera)** koju su povezani hemijskim tj. kovalentnim vezama.

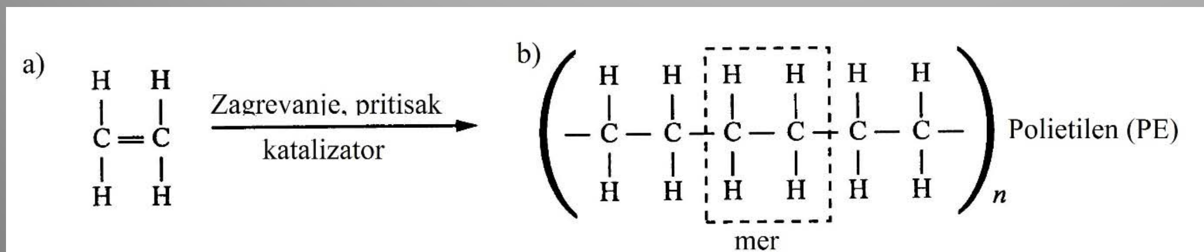
Fotopolimeri – polimeri koji očvršćavaju pod dejstvom spoljašnjeg elektromagnetnog zračenja (EM), iz različitih delova EM spektra:

- Gama zračenja
- Rengetskog zračenja
- Mlaza elektrona
- Ultraljubičastog zračenja
- Svetlosti iz vidljivog spektra

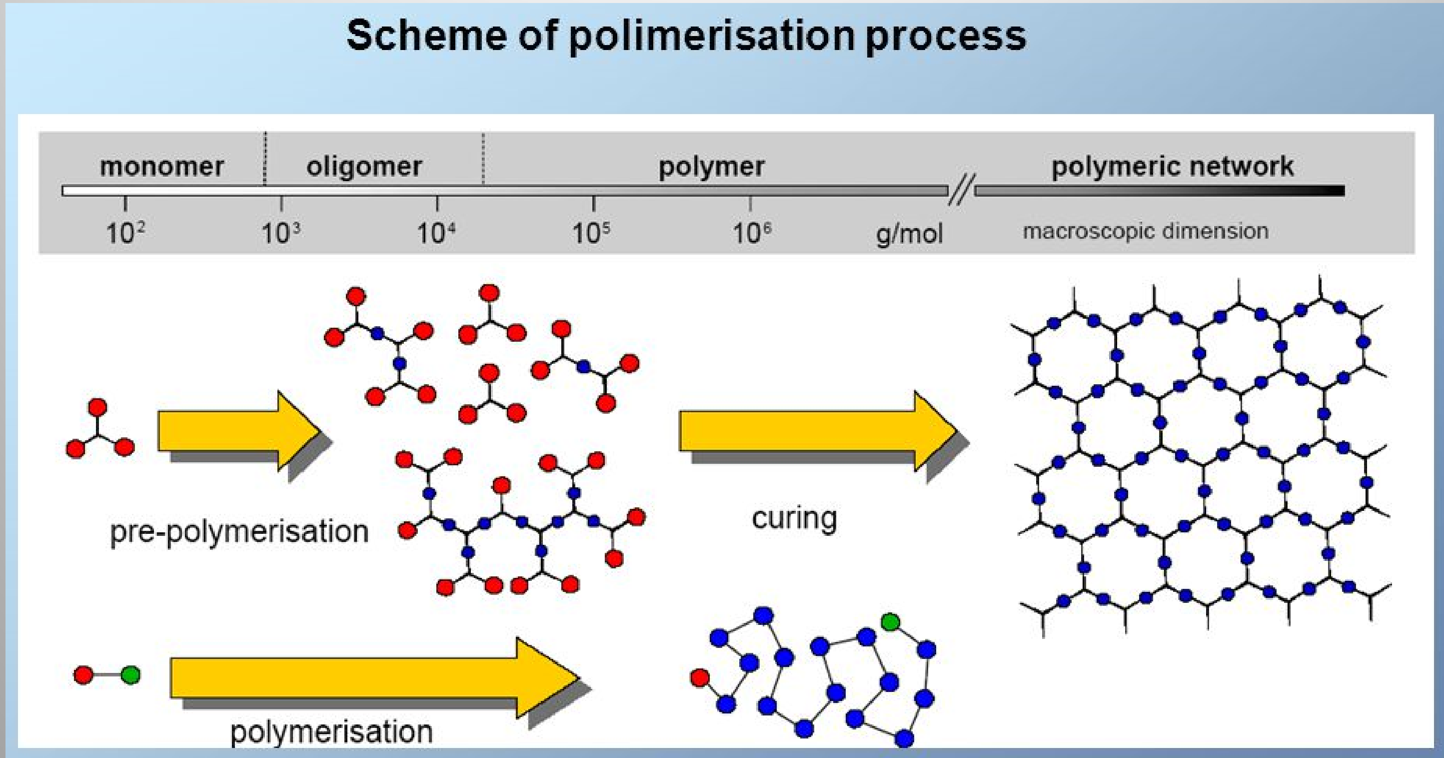


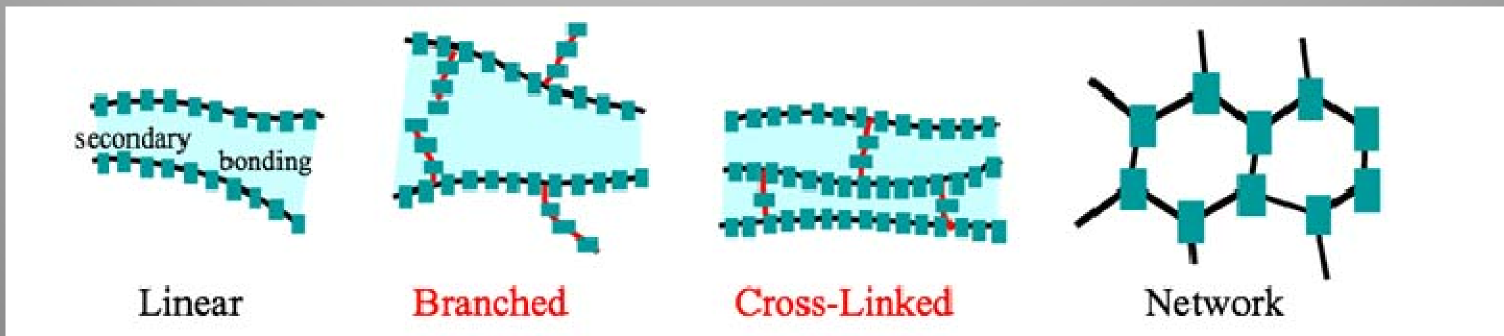
Polimerizacija – proces ulančavanja malih molekula-monomera, u veće molekule polimere.

Fotopolimerizacija – proces polimerizacije koji je iniciran fotohemijskim procesom, pri čemu je neophodno obezbediti energju iz nekog spoljašnjeg izvora zračenja (UV zračenja)



AM Postupci na bazi solidifikacije fluida





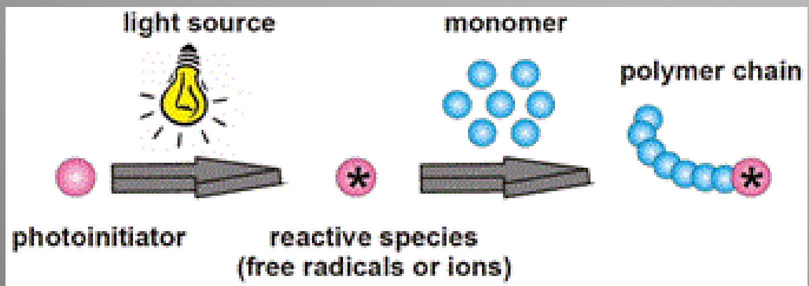
AM Postupci na bazi solidifikacije fluida

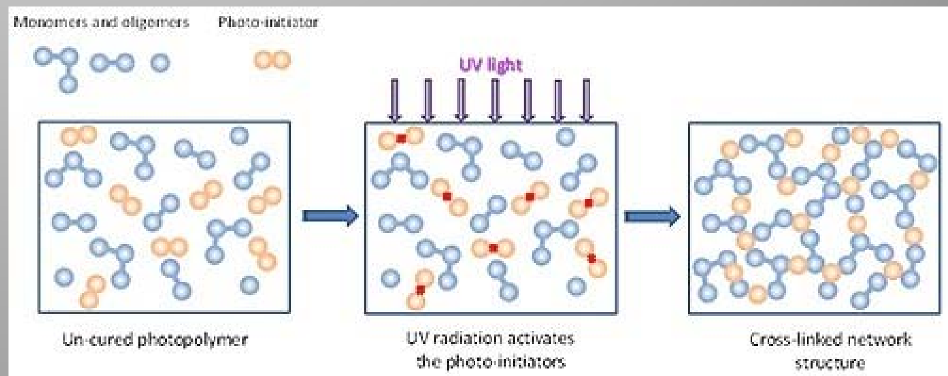
Fotopolimerizacija

- Za AM koriste se tečni fotopolimeri koji očvršćavaju pod dejstvom UV zračenja.
- Sastav/formulacija fotopolimera:
  1. Tečni monomeri i oligomeri – molekuli male molekularne mase koji su sposobni da stupaju u reakciju sa identičnim ili različitim molekulima radi formiranja polimera.
  2. Fotoinicijtori – molekuli koji usled apsorcije svetlosti emituju reaktivne čestice koje ubrzavaju proces polimerizacije. Generišu se toplotnim ili fotohemijskim procesom.

     Slobodni radikali – fotopolimerizacija starijih akrilnih monomer

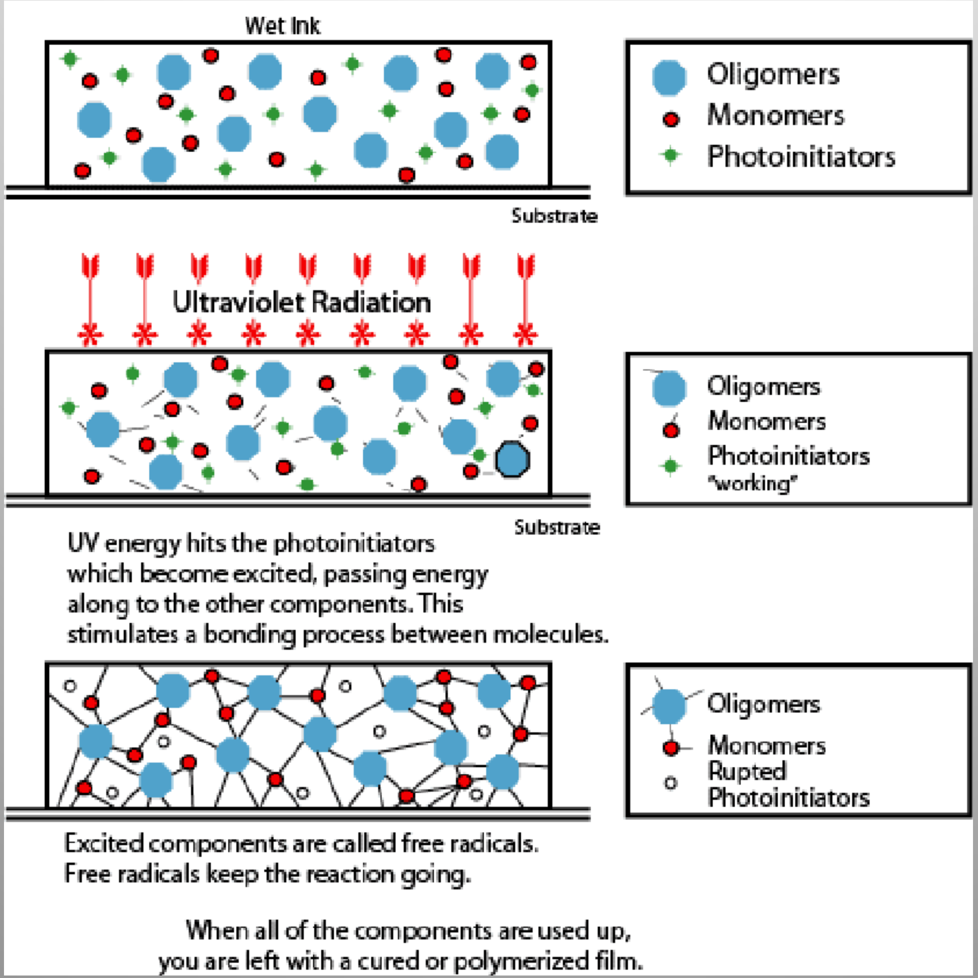
     Katjonski fotoinicijatori – fotopolimerizacija novijih epokisdnih monomera (smola) fotohemijskim procesom
  3. Aditivi (stabilizatori, pigmenti, bojila..)





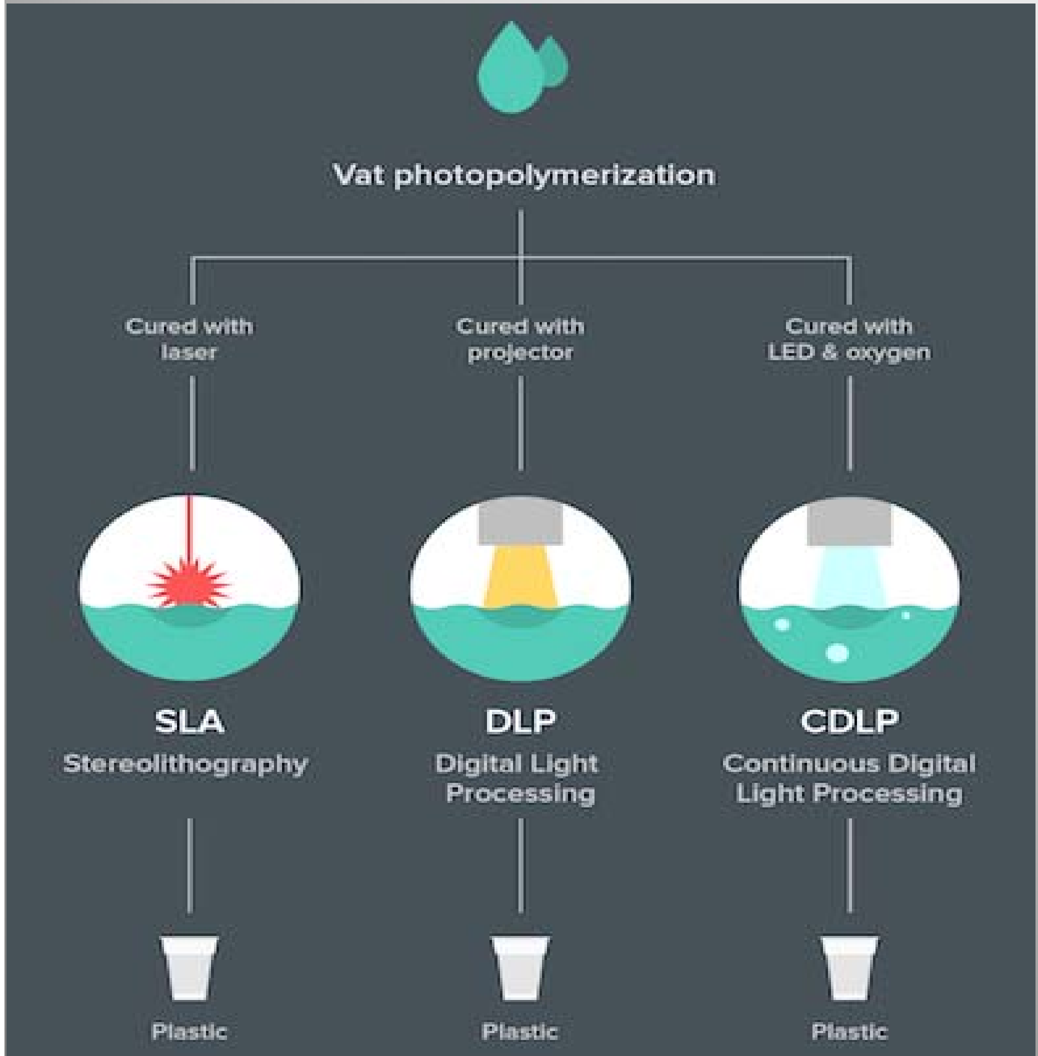
AM Postupci na bazi solidifikacije fluida

Fotopolimerizacija



AM Postupci na bazi solidifikacije fluida

Polimerizacija u kadi – Vat photopolymerization



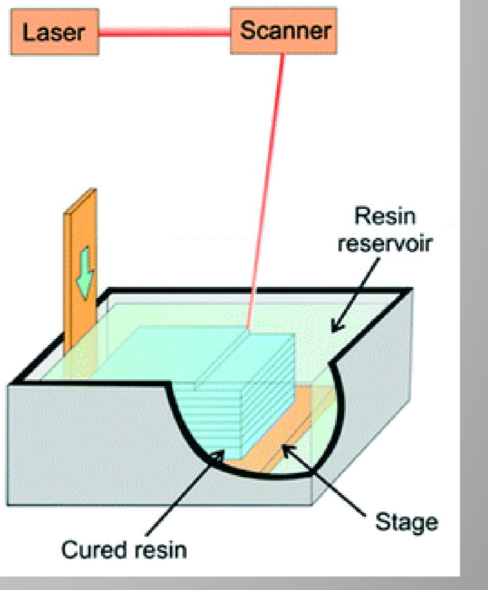
SLA - koristi platformu uronjenu u tečnu fotopolimernu smolu. Laserski zrak prati površinu poprečnog preseka (sloj) od tačke do tačke pri čemu smola očvršćava. Platforma se lagano podiže da bi se novi sloj smole doveo iinad objekta. Ovaj postupak se ponavlja sloj po sloj da bi se dobio izgradio čitav objekat/deo. Gotovi delovi se očvršćavaju UV-om radi poboljšanja mehaničkih svojstava.
DLP - slična je SLA, s tim što DLP koristi digitalni projektor svetlosti da odjednom generiše jednu sliku svakog sloja. DLP omogućava brže vreme štampe u poređenju sa SLA jer se svaki sloj izrađuje odjednom.
CDLP – delovi se dobijaju na isti način kao i kod DLP-a, s tim da platforma kontinualno pomera u pravcu Z - ose. Projektovanjem slike sloja kroz UV zaslon propusan za kiseonik omogućava neotvrdnutoj smoli da razdvoji predmet/objekat i prozor kontrolom toka kiseonika. Ovo omogućava brže vreme izrade, jer tokom štampanja ne prestaje dela od platforme nakon izrade svakog sloja.

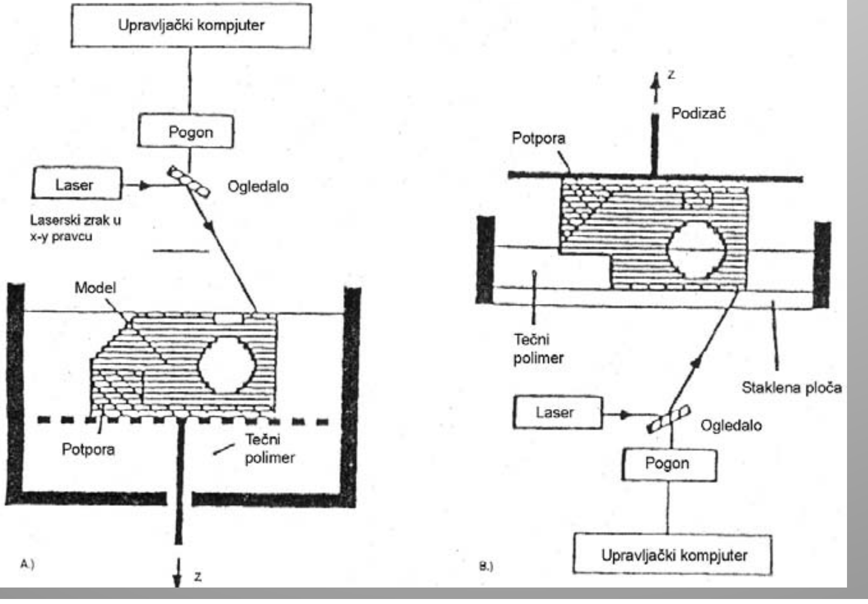
AM Postupci na bazi solidifikacije fluida

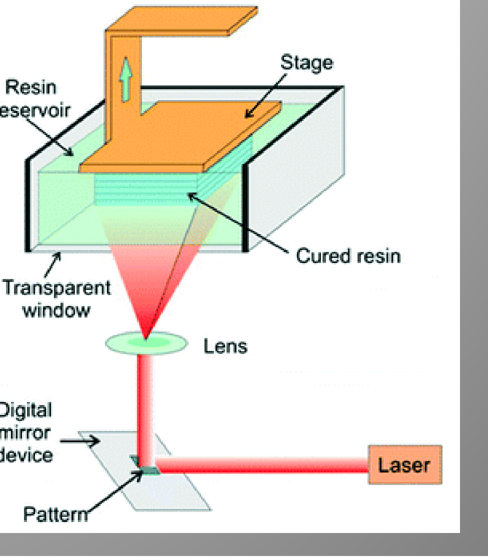
Očvršćavanje površine monomera može se odvijati putem dva modela:

A) Model slobodne površine: Očvršćavanje se javlja duž površi dodira tećnost/vazduh. Kod ovoga postupka mora se voditi računa da površina tečnosti bude što ravnija jer to direktno utiče na kvalitet i dimenzije finalnog dela.

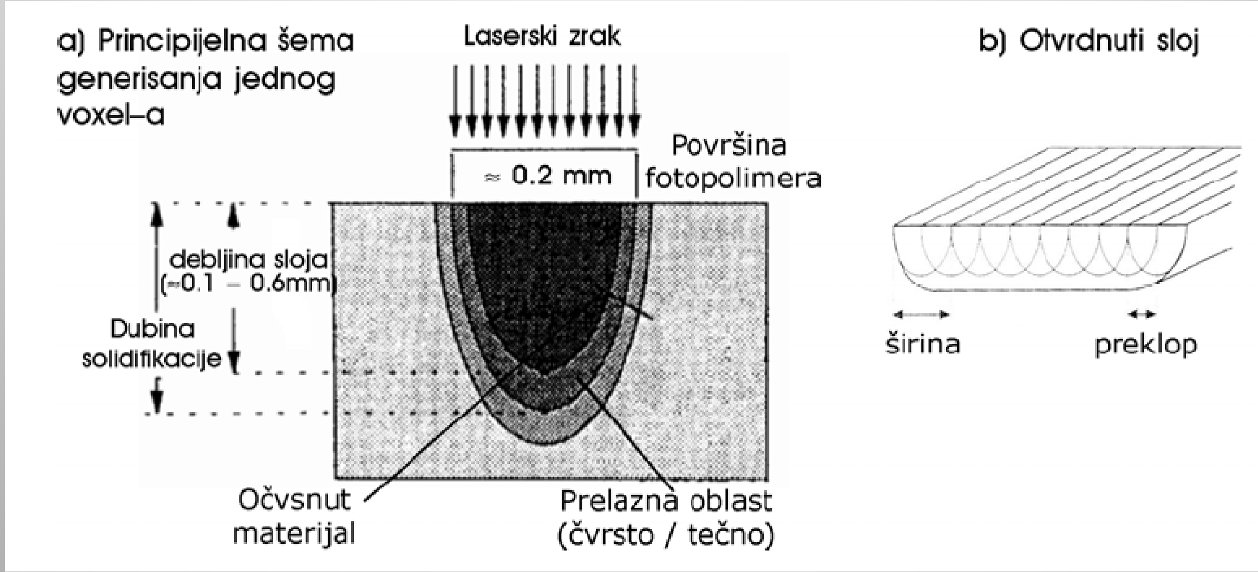
B) Model fiksne površine: Tečni polimer se nalazi u rezervoaru sa transparentnom površinom (prozorom) i očvršćavanje se odvija duž površine dodira prozor/tečnost.

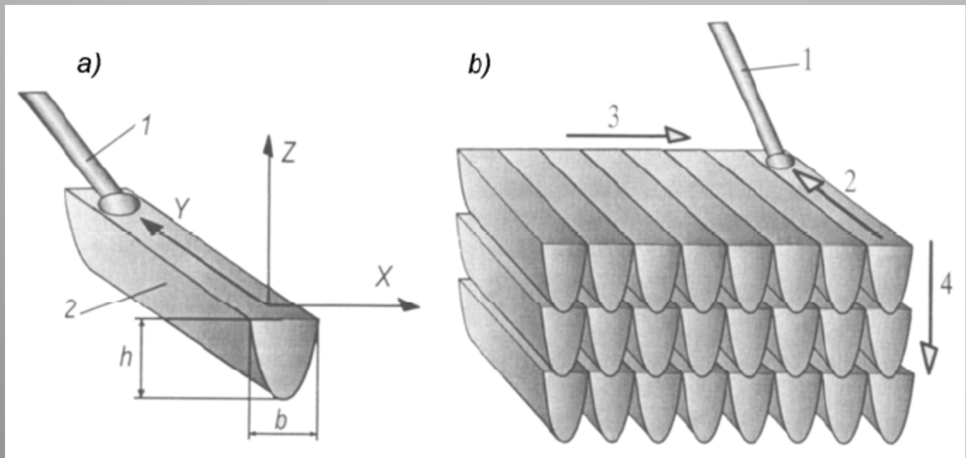






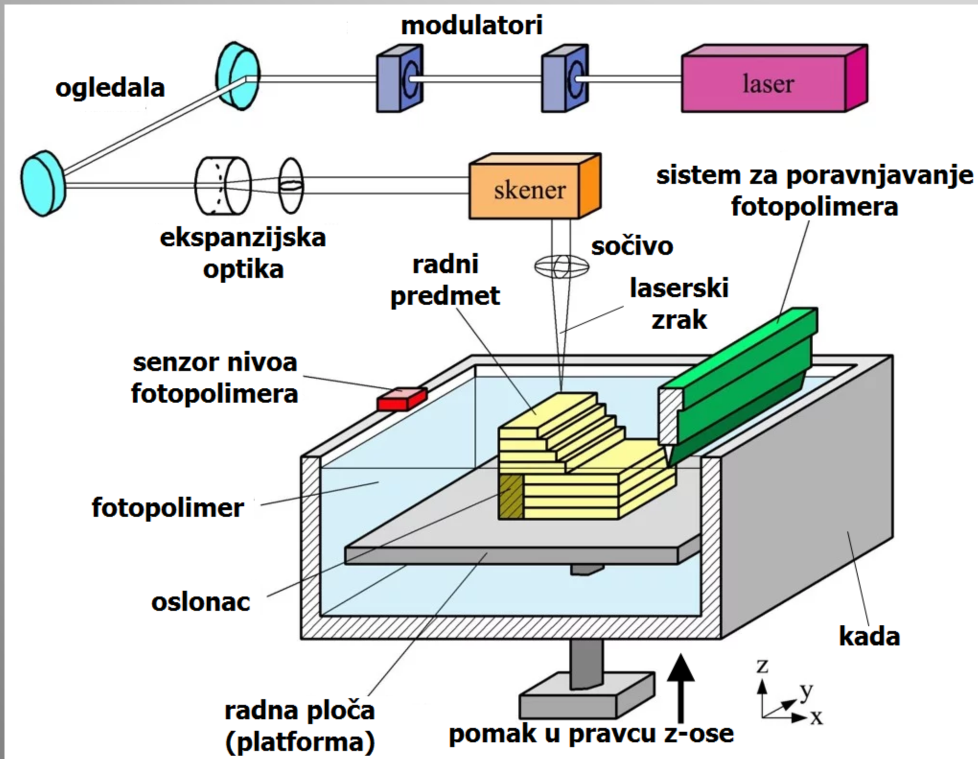
AM Postupci na bazi solidifikacije fluida

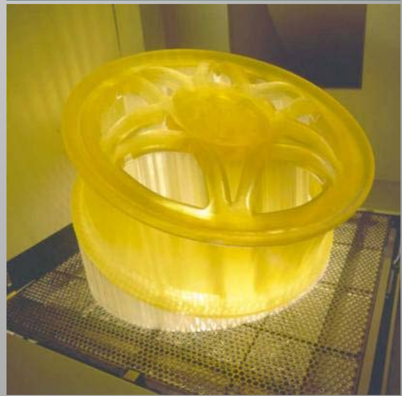




Stereolitografija –SLA
(Fotopolimerizacija u kadi)

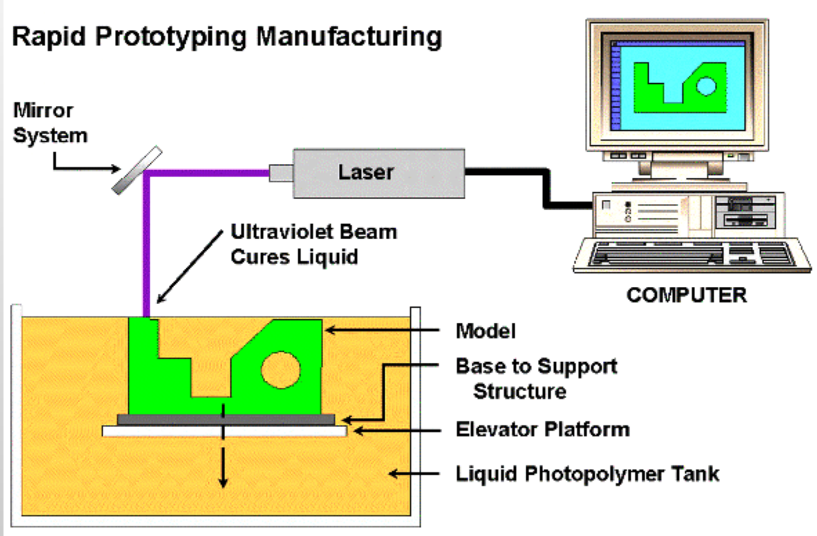
- Prva AM tehnologija
- Stereo (čvrsto telo), litho (kamen), and graphien (pisati).
- 1986 - Čarls Hal, 3D System, USA
- 1987-1988 - Prvi komrercijalni SLA uređaj





Stereolitografija

1. Potporna struktura je postavljena na pokretnu platformu i potopljena je u rezervoar (kadu) tečnog fotoosetljivog monomera, tako da samo tanak tečni film bude iznad.
2. UV laser lokalno unakrsno povezuje monomer u tankom tečnom filmu iznad potporne strukture
3. Pokretna platforma se spušta za mali, unapred definisani korak tako da novi (sveži) sloj tečnog monomera se pojavljuje iznad objekta (prethodno očvrslog sloja). Proces (korak 2) se ponavlja.
4. Na kraju procesa, kade je ceo deo očvrsnuo uklanja se sa platform i razdvaja od potporne strukture

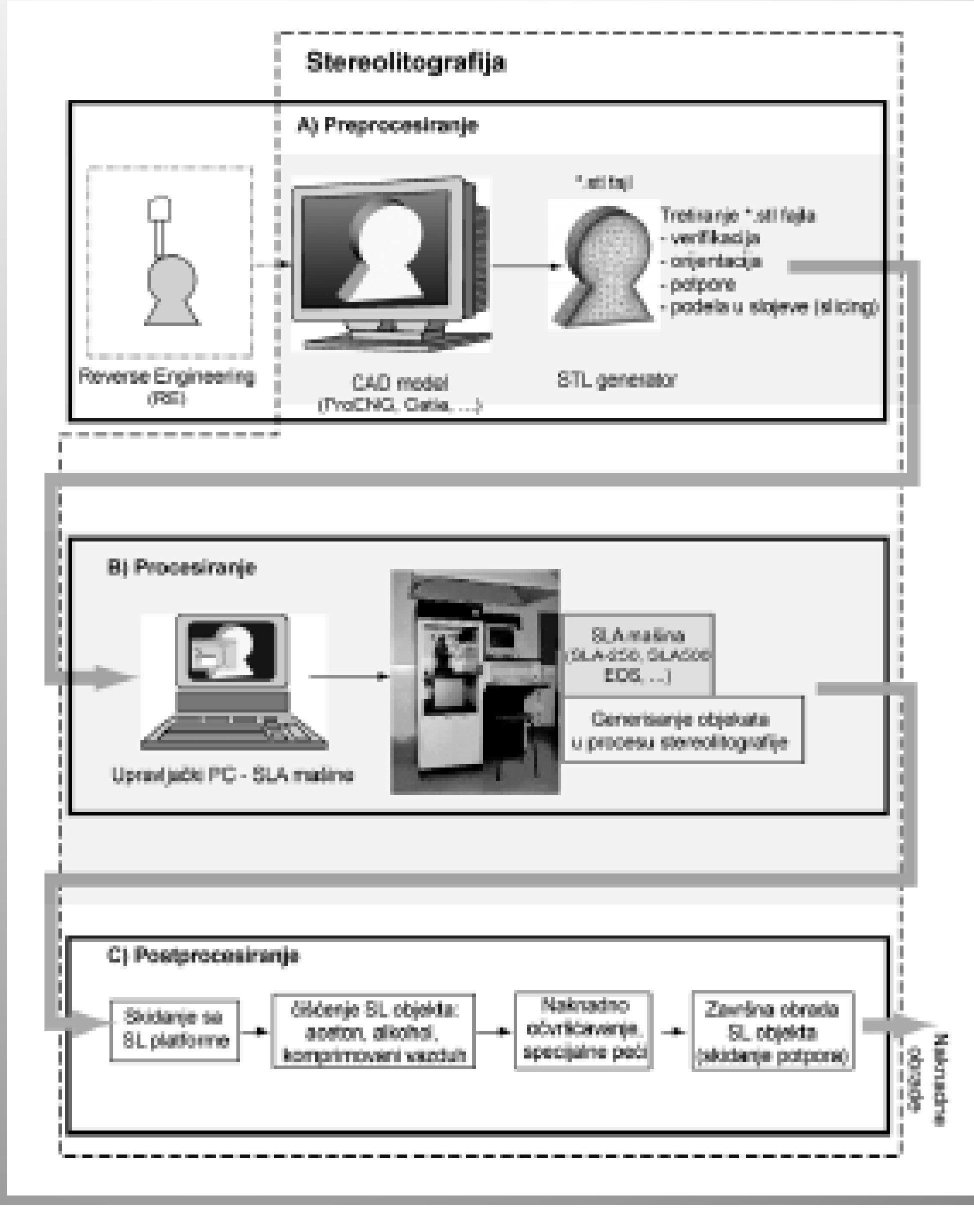


Odgovarajući foto-polimer mora biti veoma transparentan u odnosu na UV zračenje u neočvrslom (tečnom) obliku, dok u čvrstom stanju mora imati veliku moć upijanja, kako bi se izbeglo curenje očvsle strukture u slojevima ispod sloja koji se trenutno štampa.

Stereolitografija

Faze postupka

A – Preprocesiranje
B – Procesiranje
C – Postprocesiranje



Stereolitografija

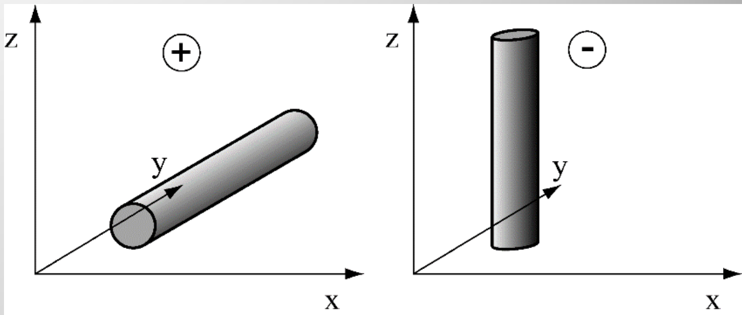
<u>Preprocesiranje – faze</u>

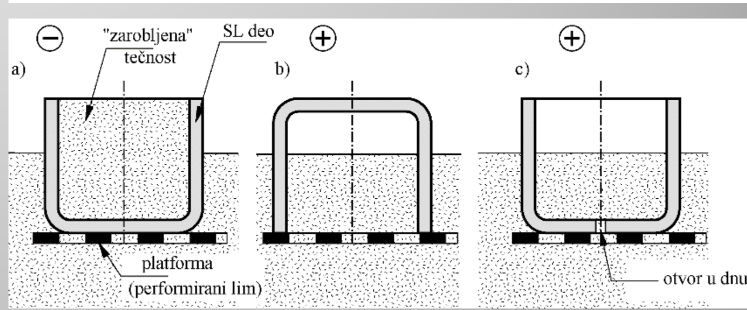
- Kreiranje CAD modela.
- Generisanje *.stl datoteke. (aproksimacija CAD modela u model čija je spoljna površina u obliku diskretne mreže trouglova. datoteke se naziva tesaliranje ili facetiranje. Tako generisana datoteka se zatim verifikuje.
- Obrada *.stl pomoću specijalnog softvera (na primer Lightyear). Tom prilikom definiše se orijentacija objekta, generišu se potpore, definišu se pojedinačni slojevi .

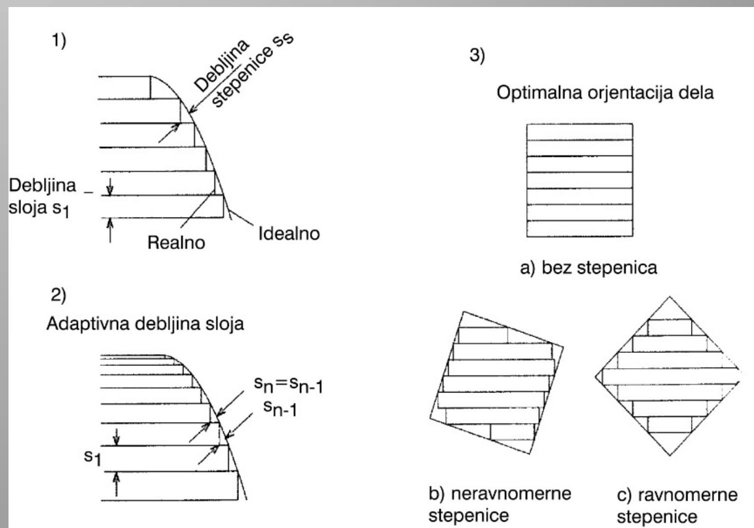
Stereolitografija

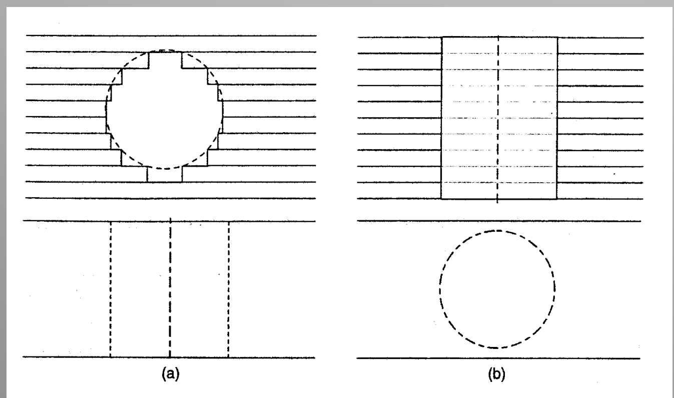
<u>Preprocesiranje – orijentacija objekta</u>

- Svaki objekat mora biti smešten u pozitivni x, y, z CAD prostor
- Rastojanje između objekta i CAD koordinatnog početka treba da je što manje
- Visinu objekta treba minimizirati
- Potrebno je obezbediti mogućnost brzog i efikasnog sušenja dela i to tako da se smanji udeo zona na objektu koje mogu zadržavati fotopolimer nakon procesa.
- Pogodnom orijentacijom minimizirati broj nagnutih površina kako bi se smanjio negativni “efekat stepenica“.
- Krivolinijske konture kreirati u horizontalnoj ravni jer se veća rezolucija može postići u horizontalnoj ravni nego u vertikalnoj.





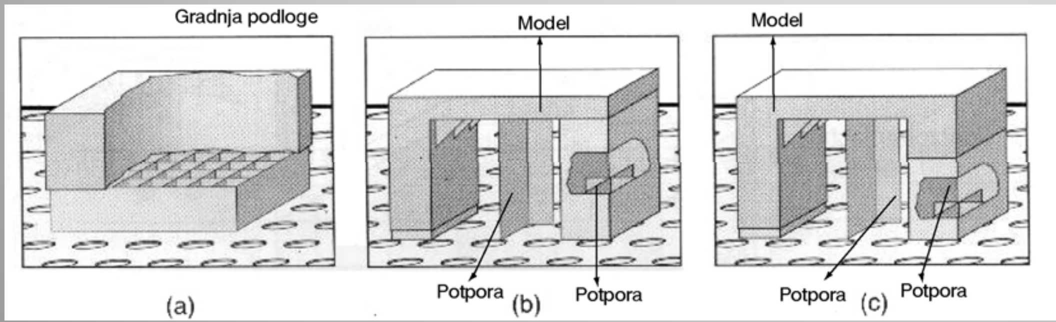


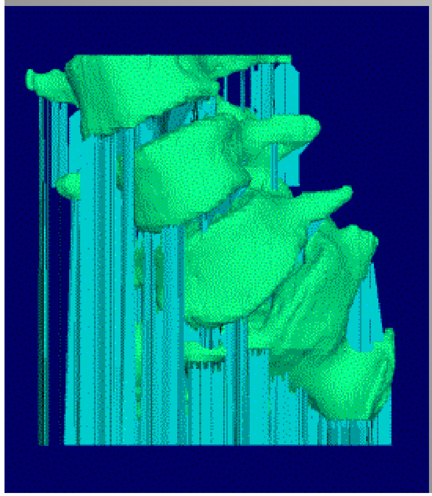


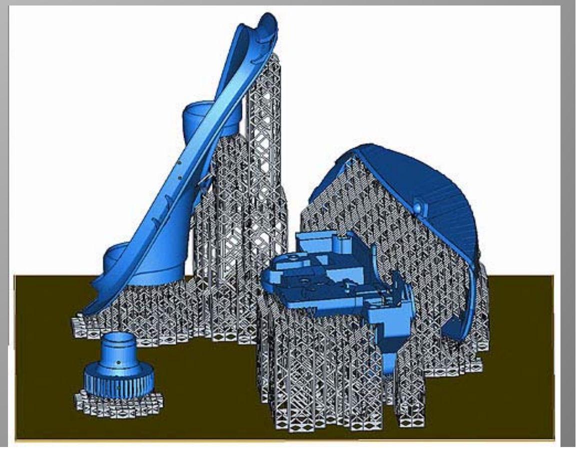
Stereolitografija

Preprocesiranje – oslonci (potpore)

- ❑ Odvajanje objekata od platforme radi lakšeg skidanja
- ❑ Da se obezbedi čvrsto “ukotvljavanje“ objekta za platformu
- ❑ Da se spreče neželjene deformacije objekta za vreme procesiranja.



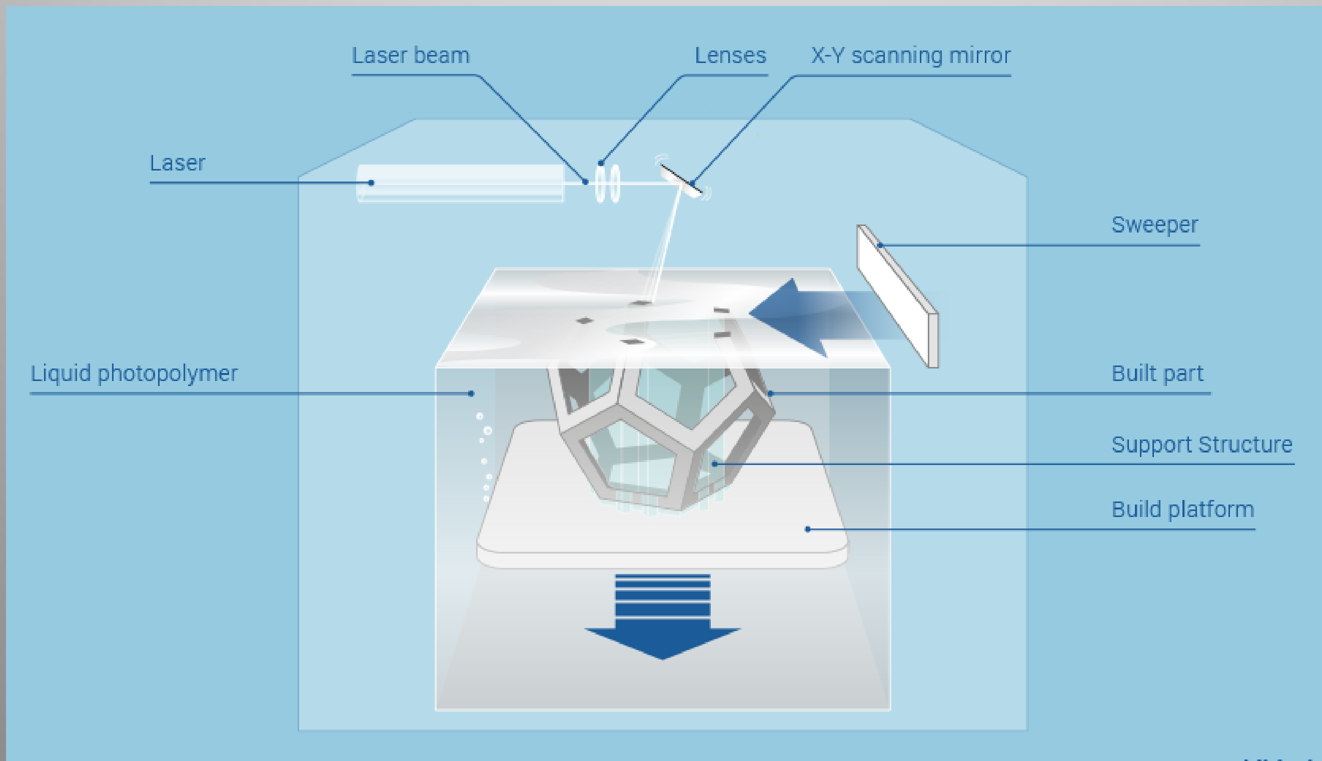




Stereolitografija

Procesiranje

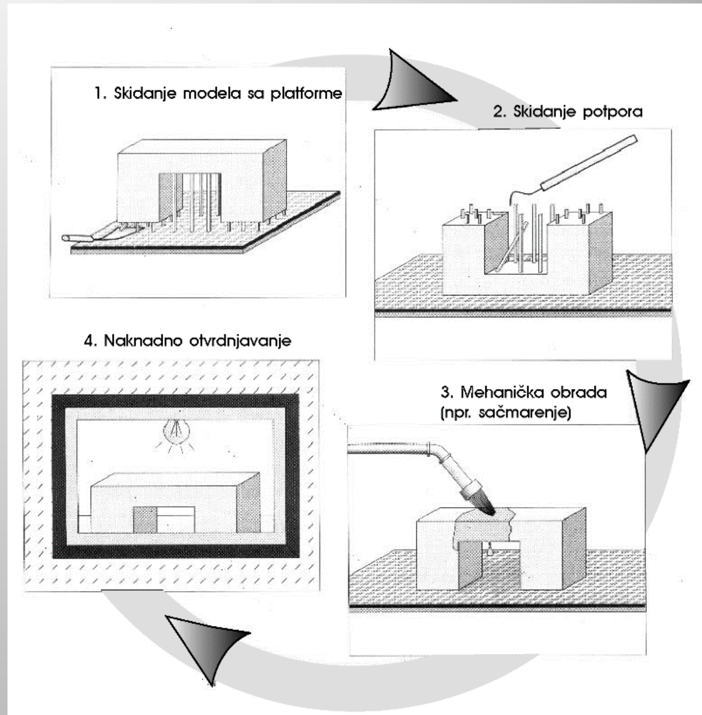
- ❖ Računar
- ❖ Kontrolne aktivnosti (aktiviranje lasera, provera nivoa fotopolimera itd.)
- ❖ Generisanje fizičkog modela

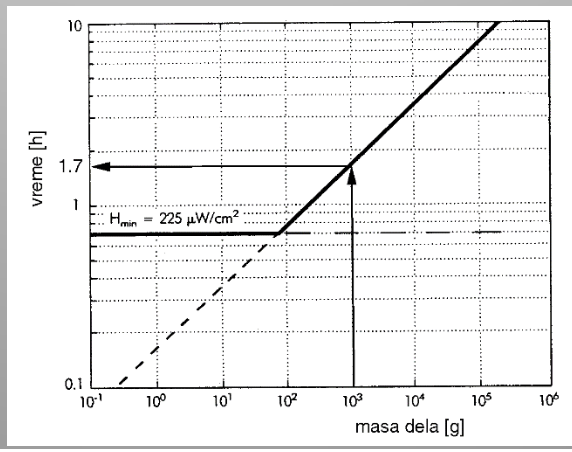


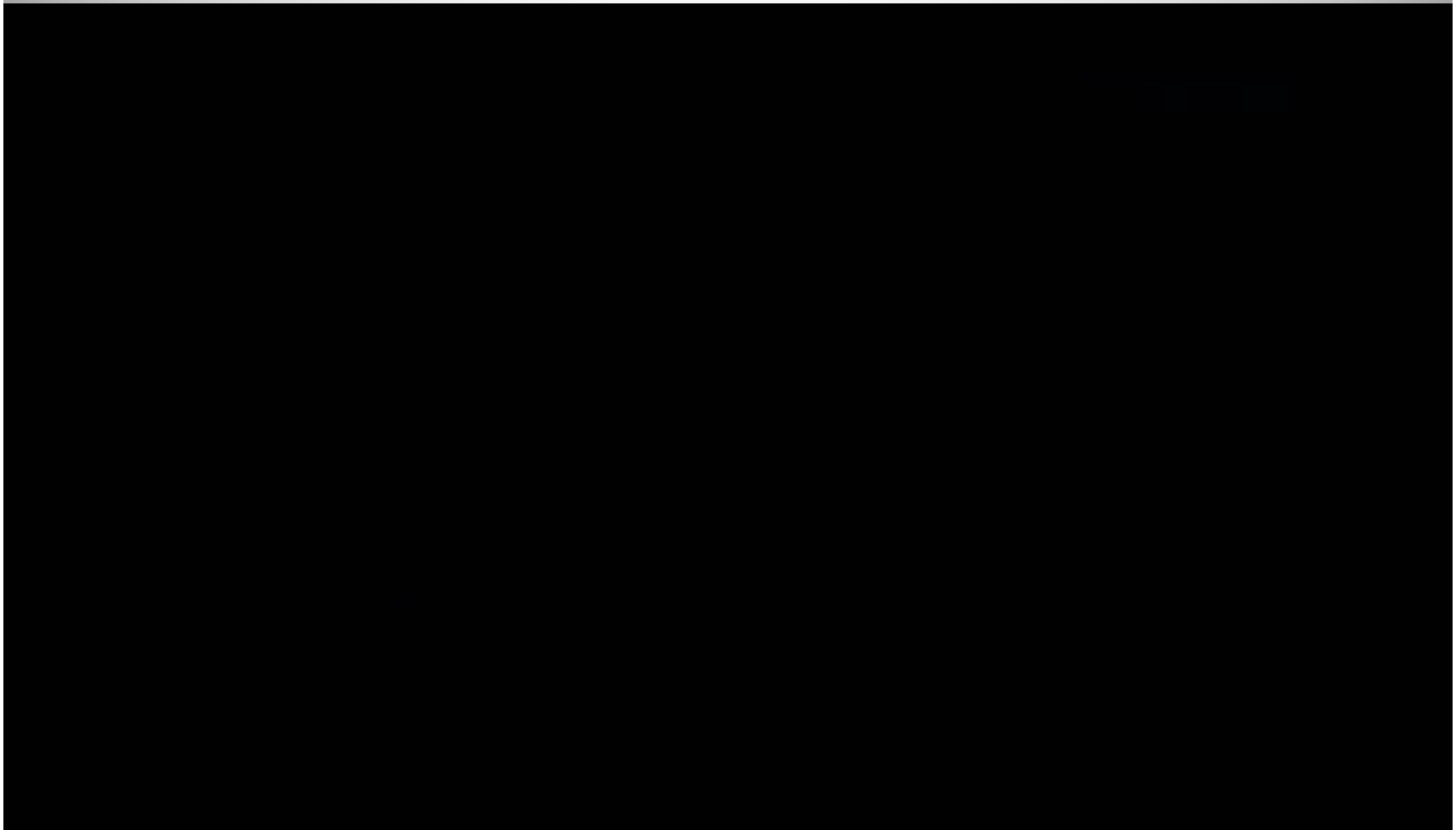
Stereolitografija

Postprocesiranje

- skidanje objekta sa platforme
- čišćenje objekta
- naknadno očvršćavanje objekta (post curing)
- završna obrada objekta sa skidanjem potpora







Stereolitografija

Glavne prednosti

- ✓ Mogućnost izrade delova/modela koje nije moguće proizvesti konvencionalnim postupcima.
- ✓ Tačnost izrade (oko 0,05 mm u x-y ravni)
- ✓ Mogućnost izrade delova različitih dimenzija
- ✓ Mogućnost kontinualnog odvijanja procesa (non-stop rad).
- ✓ Transparentnost materijala.
- ✓ Širok izbor materijala
- ✓ Kvalitet površine

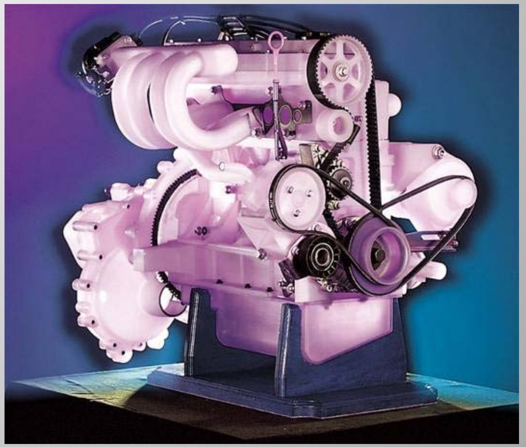
Nedostaci procesa

- Veoma sofisticirane sekvence procesa.
- Kvalitet lasera promenljiv, cena lasera visoka.
- Naknadno očvršćavanje
- Neophodnost potpora-oslonaca.
- Relativno skupo održavanje/čišćenje.
- Čvrstioća, elastičnost i osetljivost na visokim temperaturama ponekad ne zadovoljavaju potrebne zahteve.
- Toksičan materijal
- Postprocesiranje

Stereolitografija

Primena SLA

❖Modeliza konceptualizaciju, pakovanje i prezentaciju
❖Prototipovi za dizajn, analizu, verifikaciju i funkcionalna ispitivanja
❖Deloviza prototipove alata i alate za maloserijsku proizvodnju
❖Kalupi i mustre za precizno livenje i livenje u pesku
❖ Medicina – hiruški modeli za predoperativno planiranje
❖Zubne proteze



The Ultimate Guide to Stereolithography

How SLA Works

formlabs

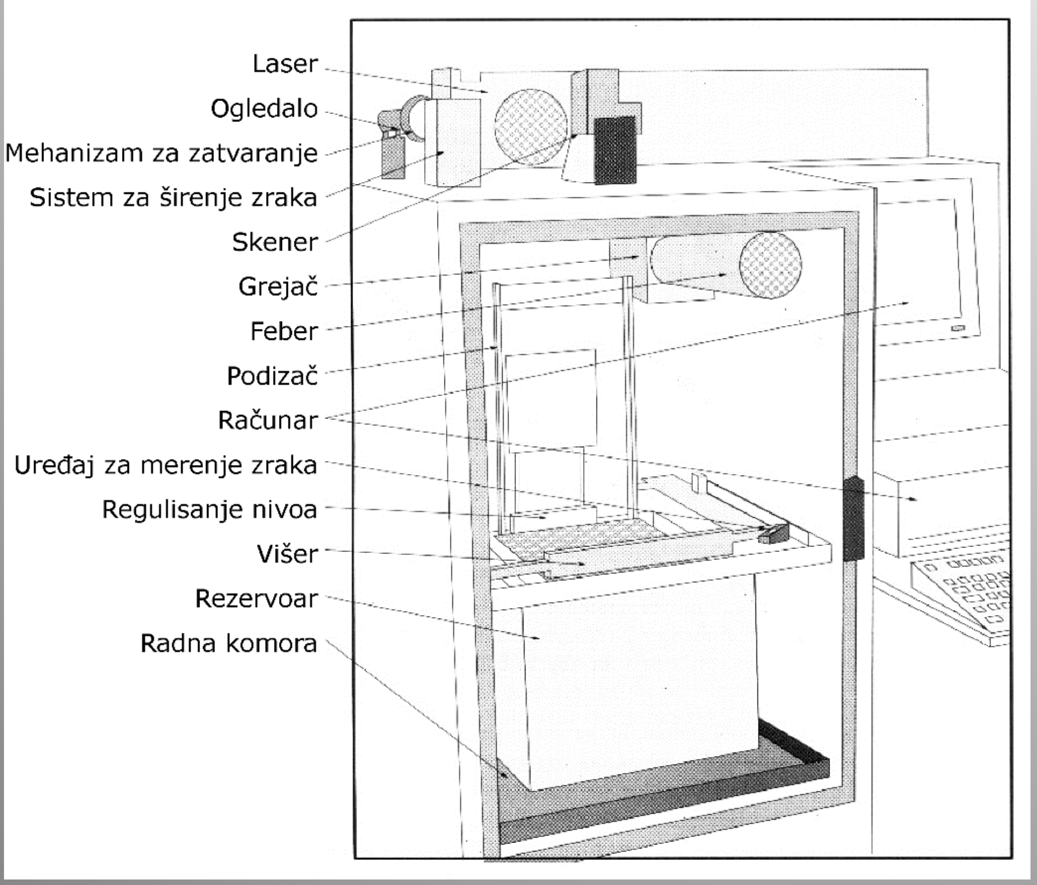
Stereolitografija

<u>Faktori koji utiču na kvalitet dela</u>:

- Fizičke i hemijske karakteristike fotopolimera
- Brzina i rezolucija optičkog sistema
- Snaga, talasna dužina i vrsta lasera
- Veličina/fokus laserskog zraka
- Nanošenje (premazivanje) slojeva fotopolimera
- Naknadno očvršćavanje/postprocesiranje

Stereolitografija

Stereolitografska mašina tipa SLA-250



Karakteristike SLA sistema kompanije 3D Systems

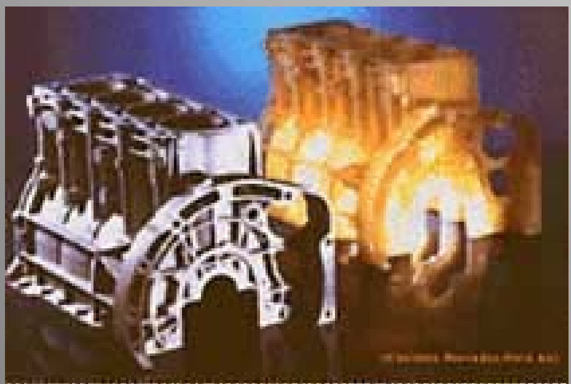
Model	SLA 5000	SLA 7000	Viper si^2
Namena	Sistem za izradu velikih delova	Sistem za izradu velikih delova, dva puta brži od SLA 5000, sa manjom debljinom slojeva za bolji kvalitet površine	Poseduje dve rezolucije, trajniji laser
Dimenzije radne zapremine	508x508x584 mm	508x508x600 mm	250x250x250 mm
Zapremina radne tečnosti	253,6 l	253,6 l	32,2 l
Tip lasera	$Nd{:}YVO_4$	$Nd{:}YVO_4$	$Nd{:}YVO_4$
Talasna dužina lasera	354,7 nm	354,7 nm	354,7 nm
Snaga lasera	216 mW	800 mW	100 mW
Trajanje lasera	5000 radnih sati	5000 radnih sati	7500 radnih sati
Dve tačke fokusa	Ne	Da	Da
Prečnik tačke fokusa u graničnom pojasu	0,25±0,025 mm	0,25±0,025 mm	0,25±0,025 mm 0,075±0,015 mm
Prečnik tačke fokusa u šrafuri	0,25±0,025 mm	0,7615±0,0765 mm	
Sistem za presvlačenje	Zephyr	Zephyr	Zephyr

SLA 7000

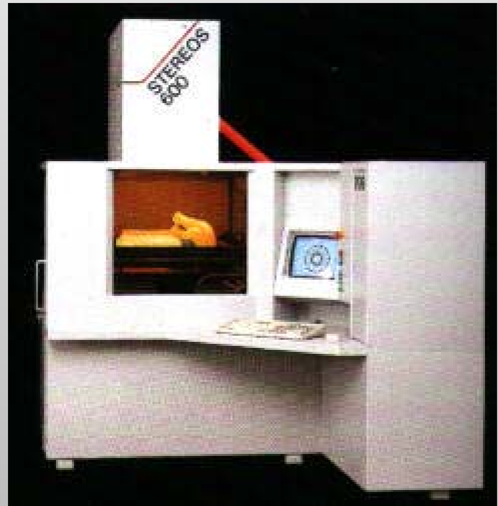
Viper si^2

Stereolitografija

Quick Cast (SL-500)

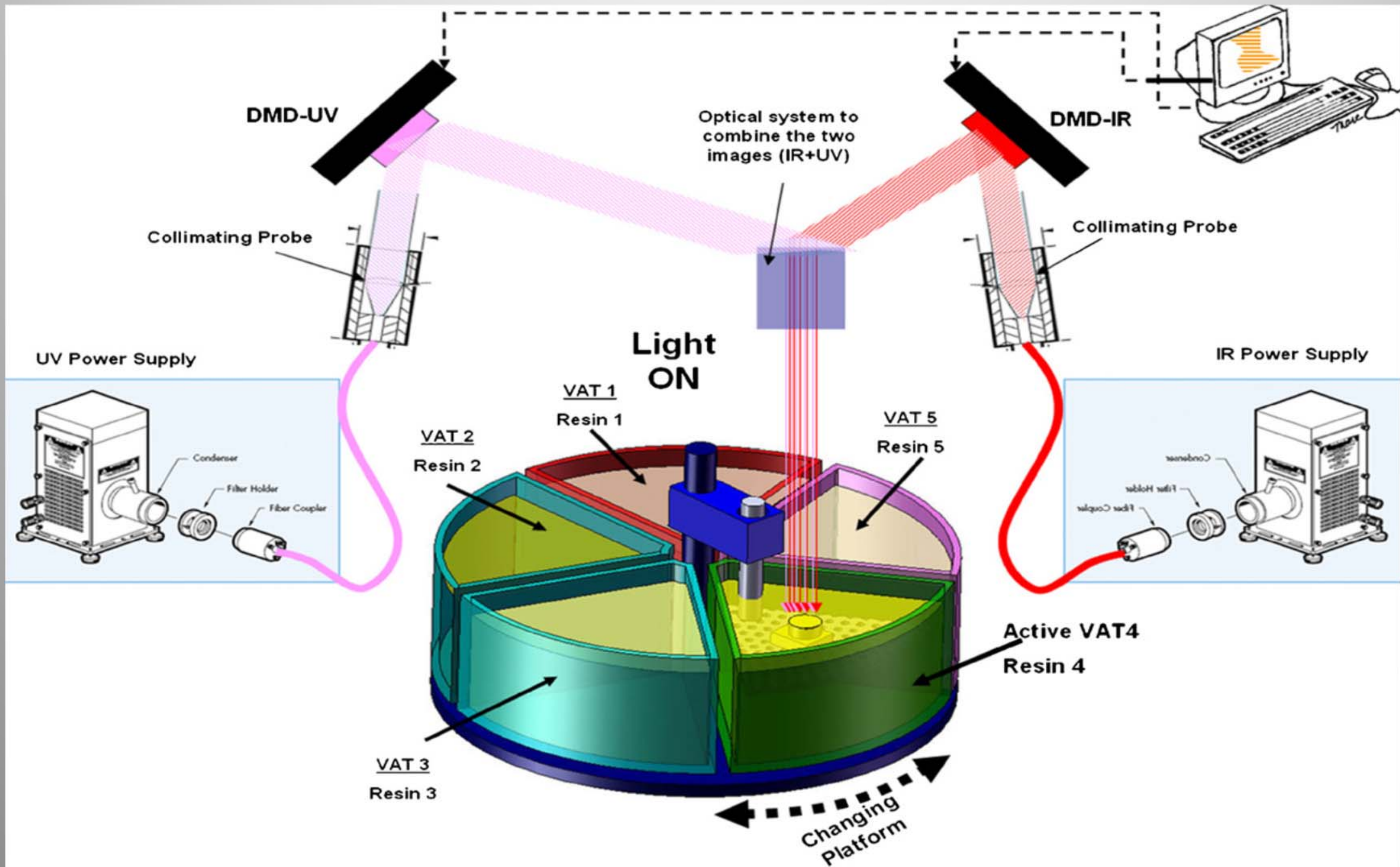


EOS



F&S GmbH

Multi - Stereolitografija



Mikro Stereolitografija -µSL

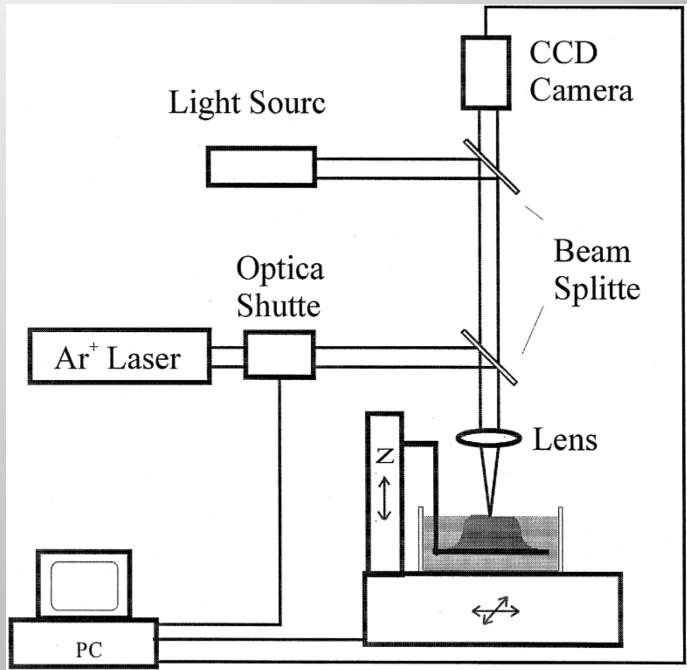
Prvi put opisan u literaturi - 1993

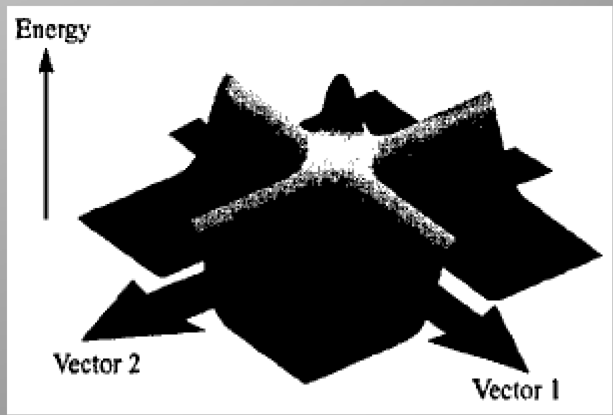
- Laser
- X-zraci
- Blue ray

Microstereolithography (MSL),
Integrated Hardened Stereolithography (IH)
Deep X-ray Lithography (DXRL)

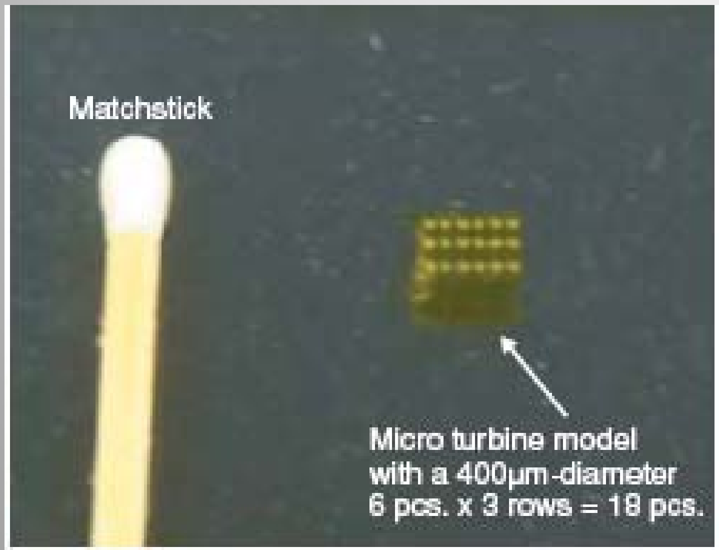
Dimenzije delova <1mm
UV laser sa fokusom <20 µm (1–2µm)
Debljina sloja: 1–10 µm
Tačnost:

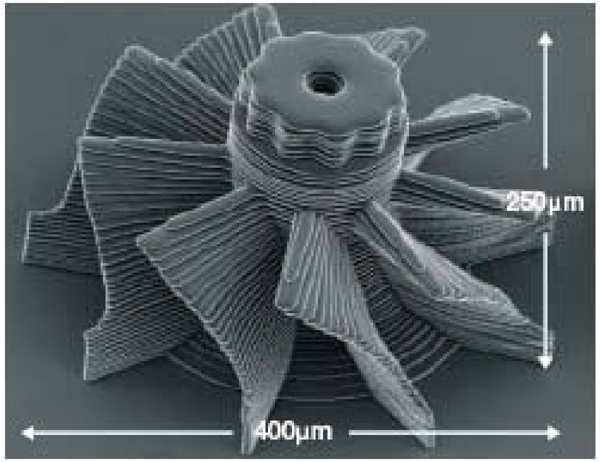
- **0.25 µm u x–y ravni**
- **1.0 µm u z-pravcu**



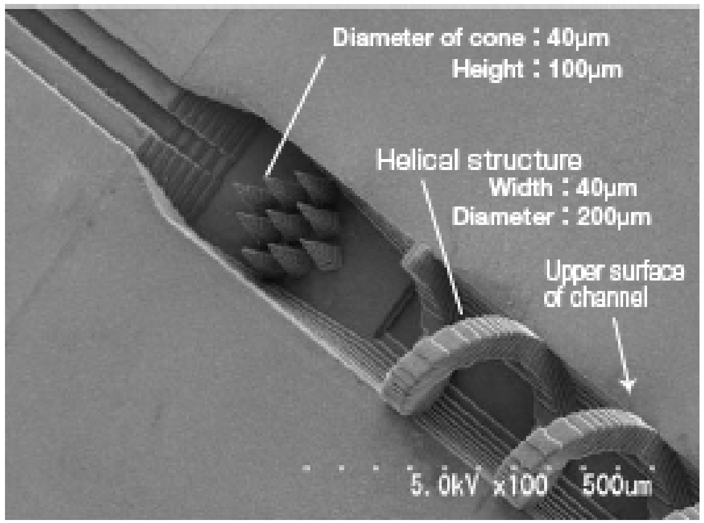


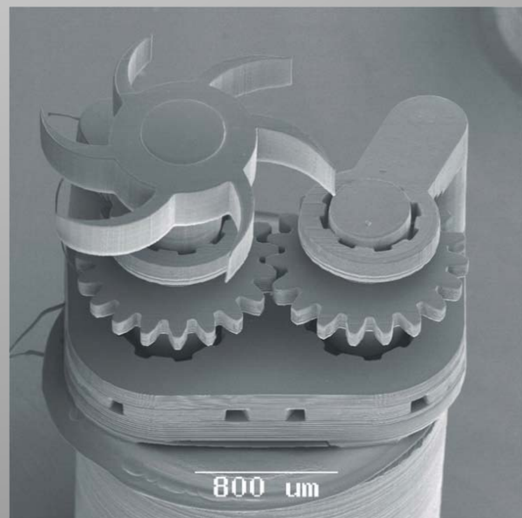
Mikro Stereolitografija -µSL



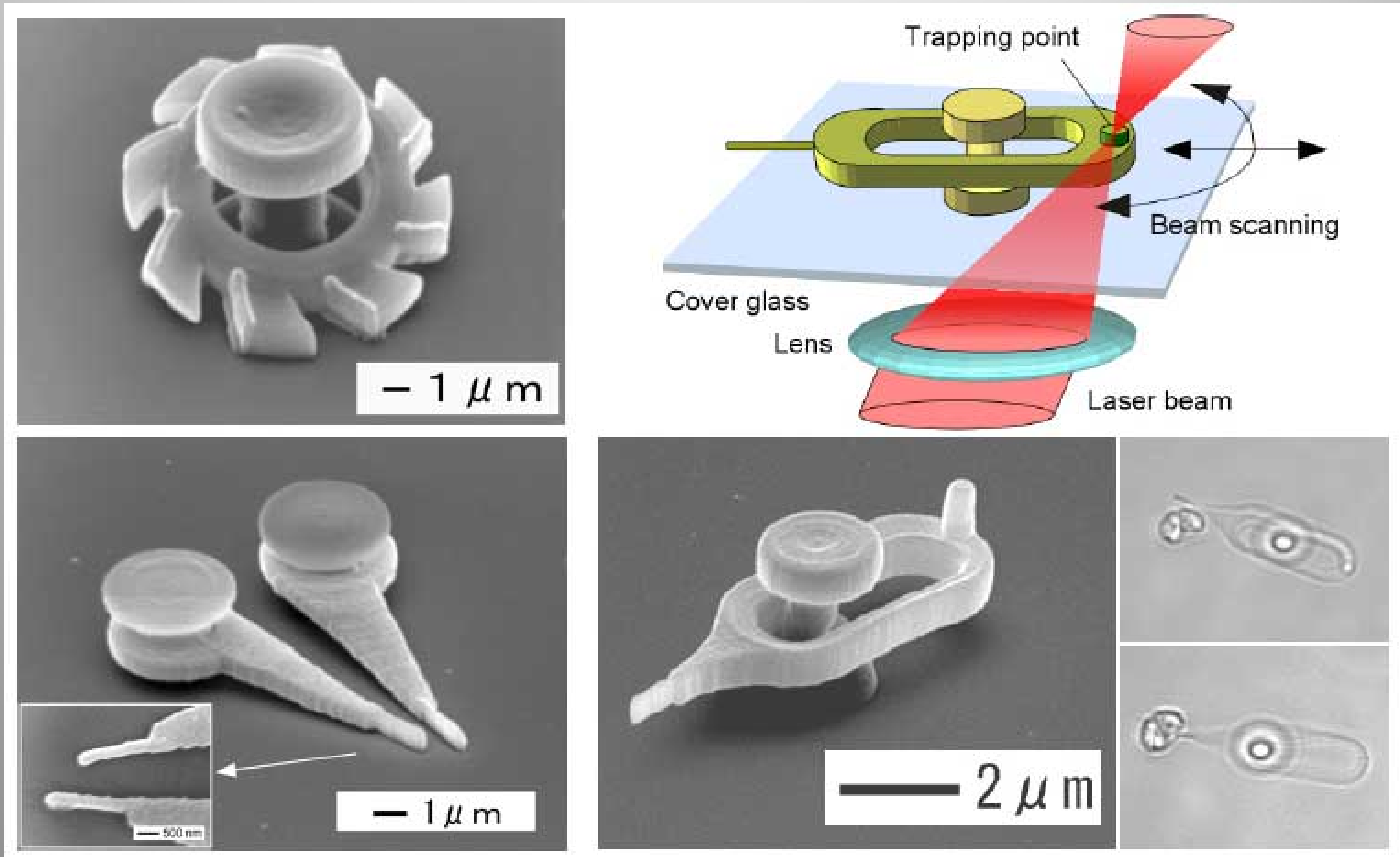


SEM photo of micro turbine
The time required for the production of 18 pcs.
was approximately 1 hour.

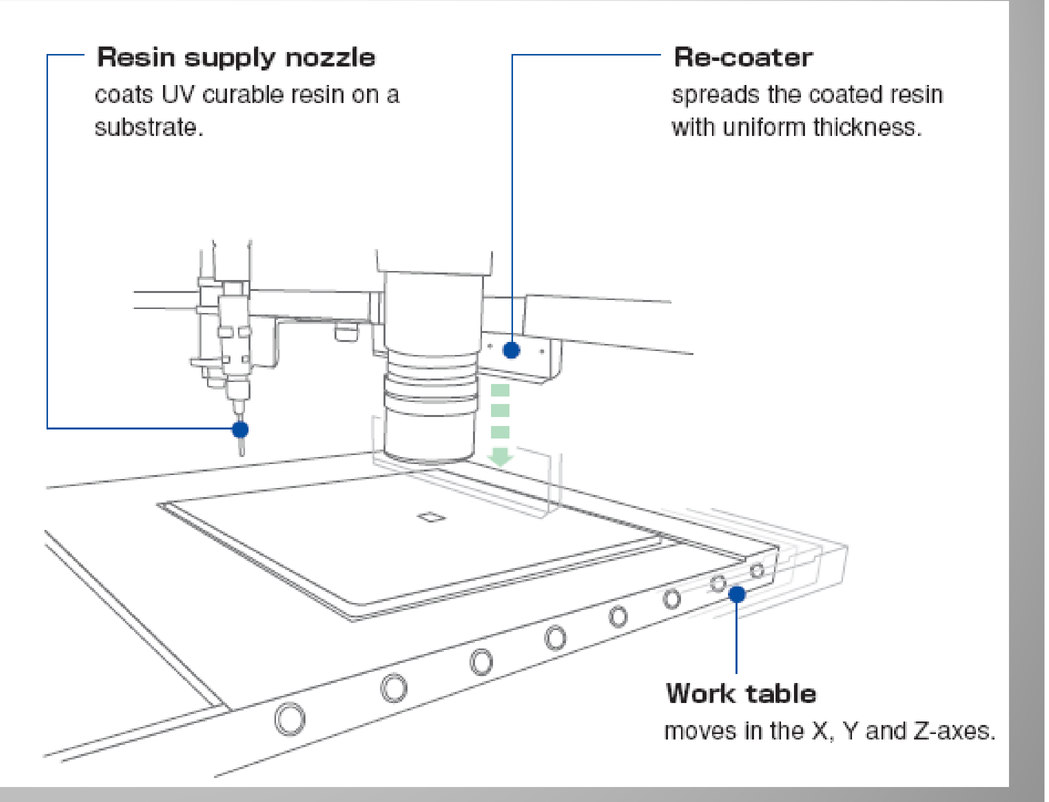




Mikro Stereolitografija -μSL



Mikro Stereolitografy system **ACCULAS**

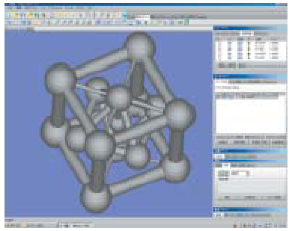


■System Specification

Light source	Selectable between LD (405nm) and LED (365nm)	Resin	Custom made high resolution resin
Image modulation	Spatial light modulator	Data interface	Dedicated interface software "Viola" (plug-in for Magics) (*3)
Exposure resolution	1μm (*1)	Power supply	100V AC, 2kVA
Modeling range	150 x 150 x 50mm	External dimensions	1,000 (W) x 1,000 (D) x 1,855 (H) mm (excluding control PC)
Maximum model pitch	50mm square (*2)		
Minimum layer thickness	5 - 10μm	Weight of the main unit	Approximately 600 kg

Mikro Stereolitografy system **ACCULAS**

CAD Data CG Drawings



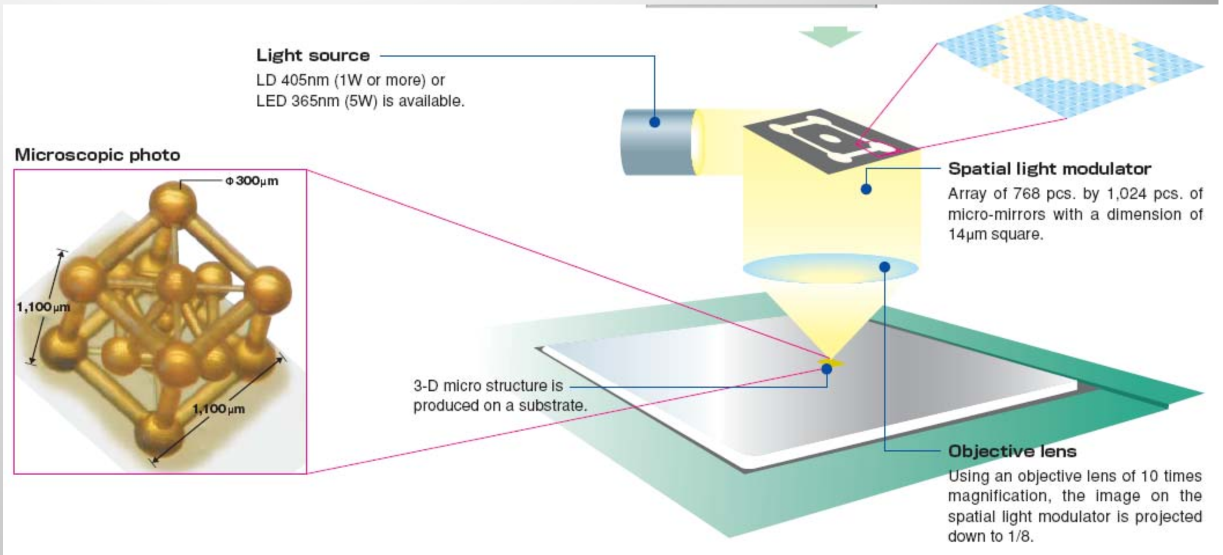
Data Processing

Layer Slicing

3-D data is sliced with a thickness of 5 to 10μm to yield cross-sectional data.

ACCULAS® Operation Screen

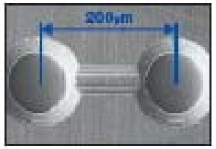
Based on the data transferred from a data processing PC, the micro-mirrors turn ON/OFF to create the images. The images are exposed on the coated UV curable resin sequentially to produce a 3-D micro-structure.

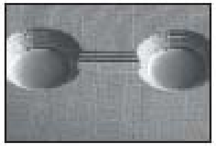


Mikro-elektro-mehanički sistemi (MEMS)

Biomedical Field

- Bio chips
- Healthcare chips
- MEMS for Medical use
  - Micro actuators
  - Micro catheters



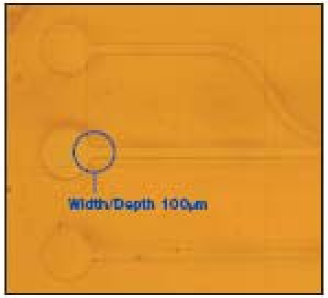


Optoelectronics Field

- Photonics crystals
- Opt-IC chips
- Micro lens arrays
- Light guide plates
- Photo masks
- Micro magnetic devices

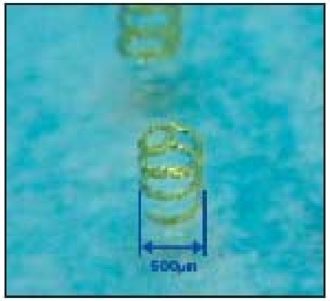
Chemical Field

- μTAS
  - Micro reactors
  - Chemical IC chips
  - Micro analysis chips
- Micro channel



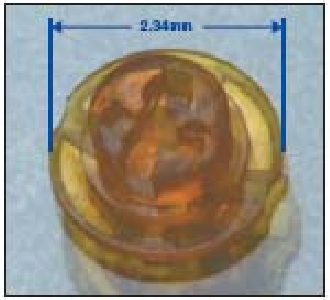
Micromachine Field (MEMS, Microsystems)

- Micro sensors
- Cantilevers
- Probes



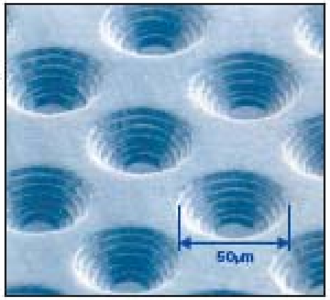
Micro Parts

- Micro gears
- Micro connectors
- Micro parts for Investment casting



Master for Electroplating and Silicon Rubber Mold

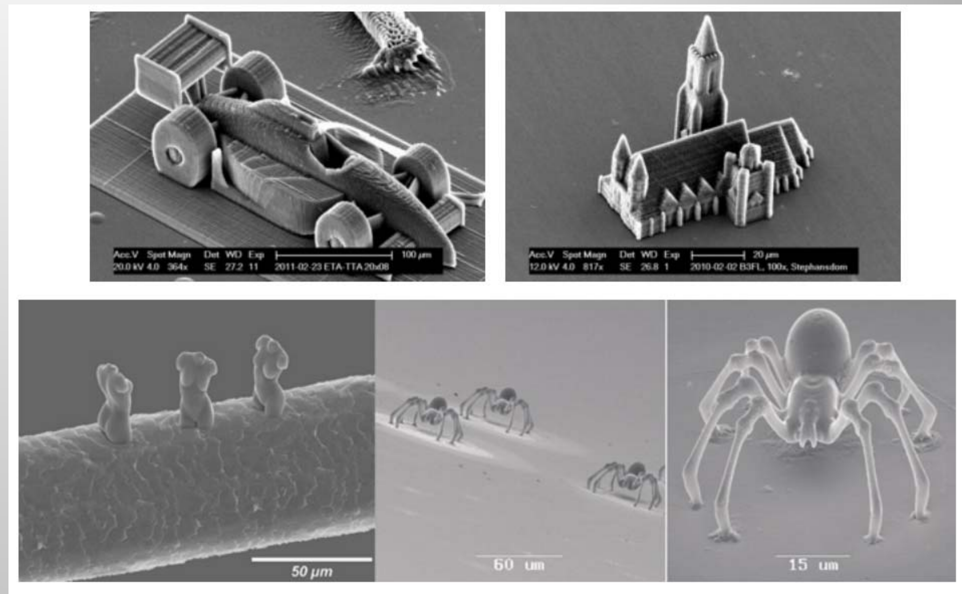
- Nano-imprinting process
- Embossing process
- Injection molding process

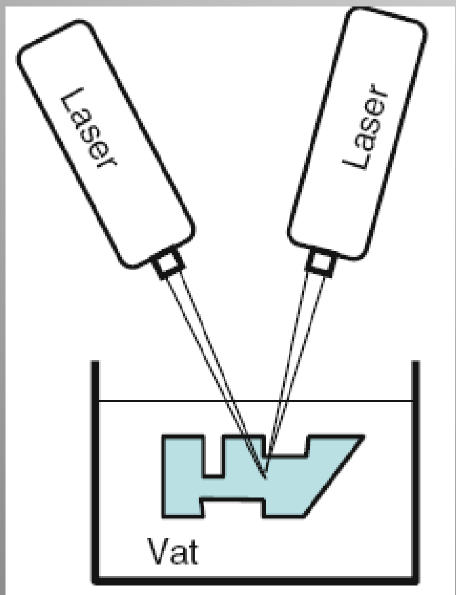


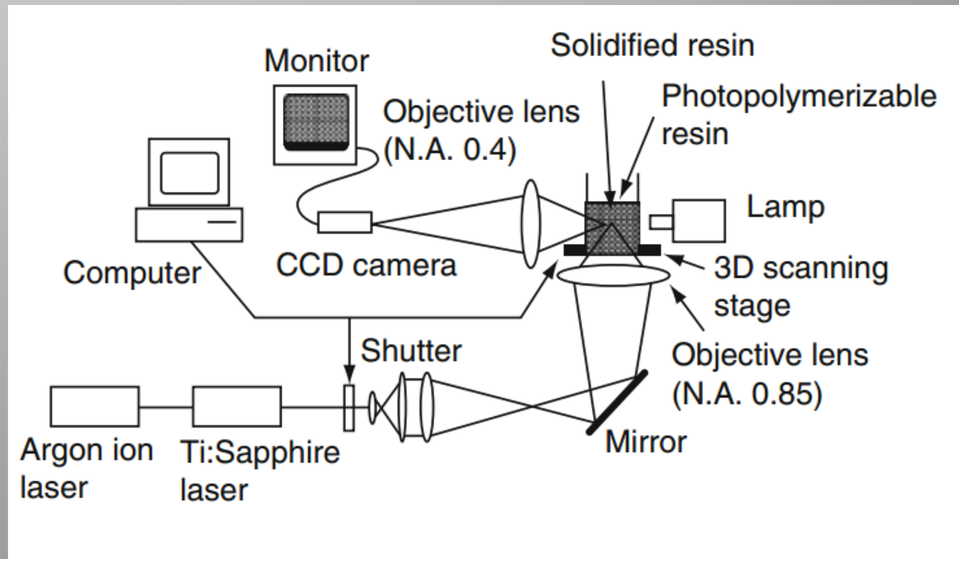
Two-Photon Stereolithography-TPSL

TPSL

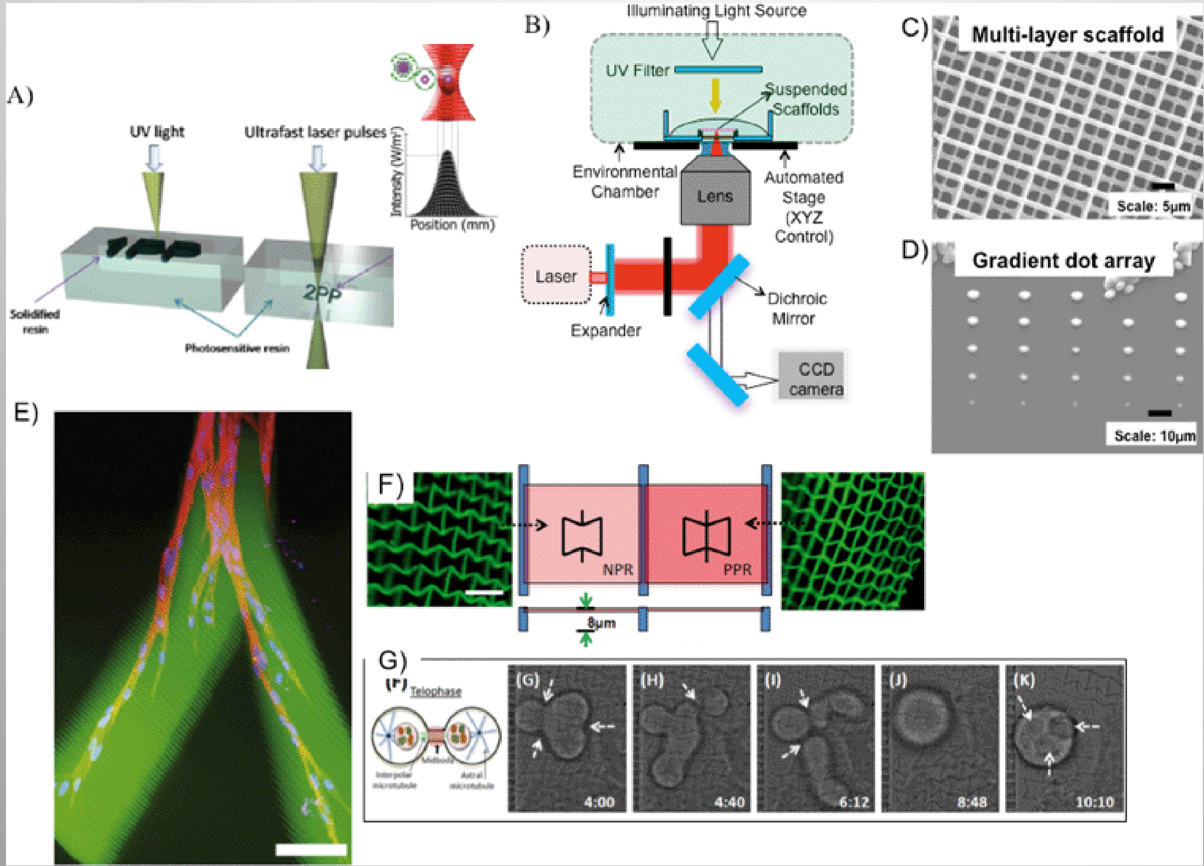
- ❑ Povećana rezolucija
- ❑ Izrada delova malih dimenzija (0,2µm)
- ❑ Solidifikacija: dno-vrh
- ❑ Moguća solidifikacija ne samo površinskog sloja, već i sloja unutar posude (rastopa).







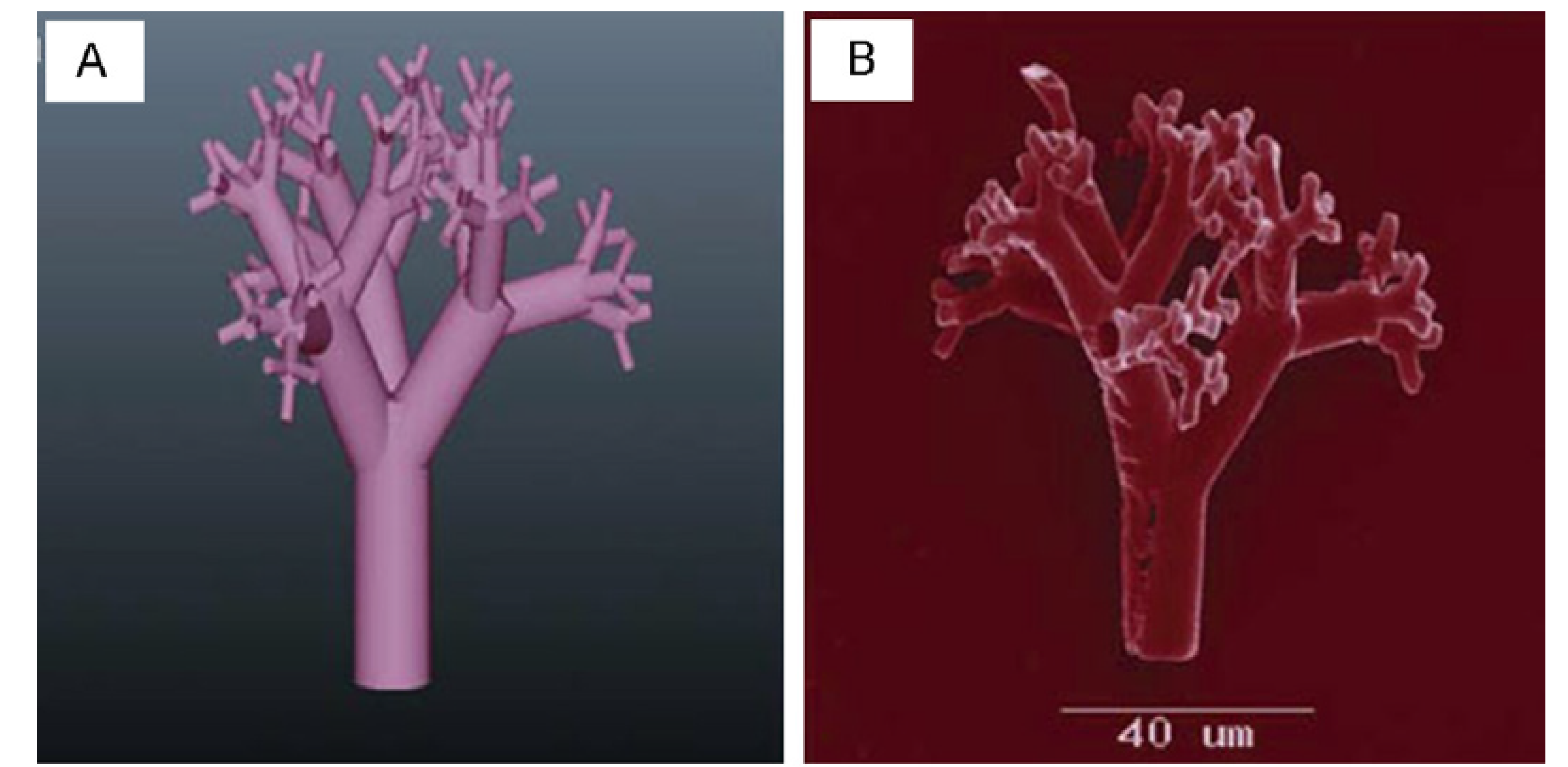
Two-Photon Stereolithography-TPSL



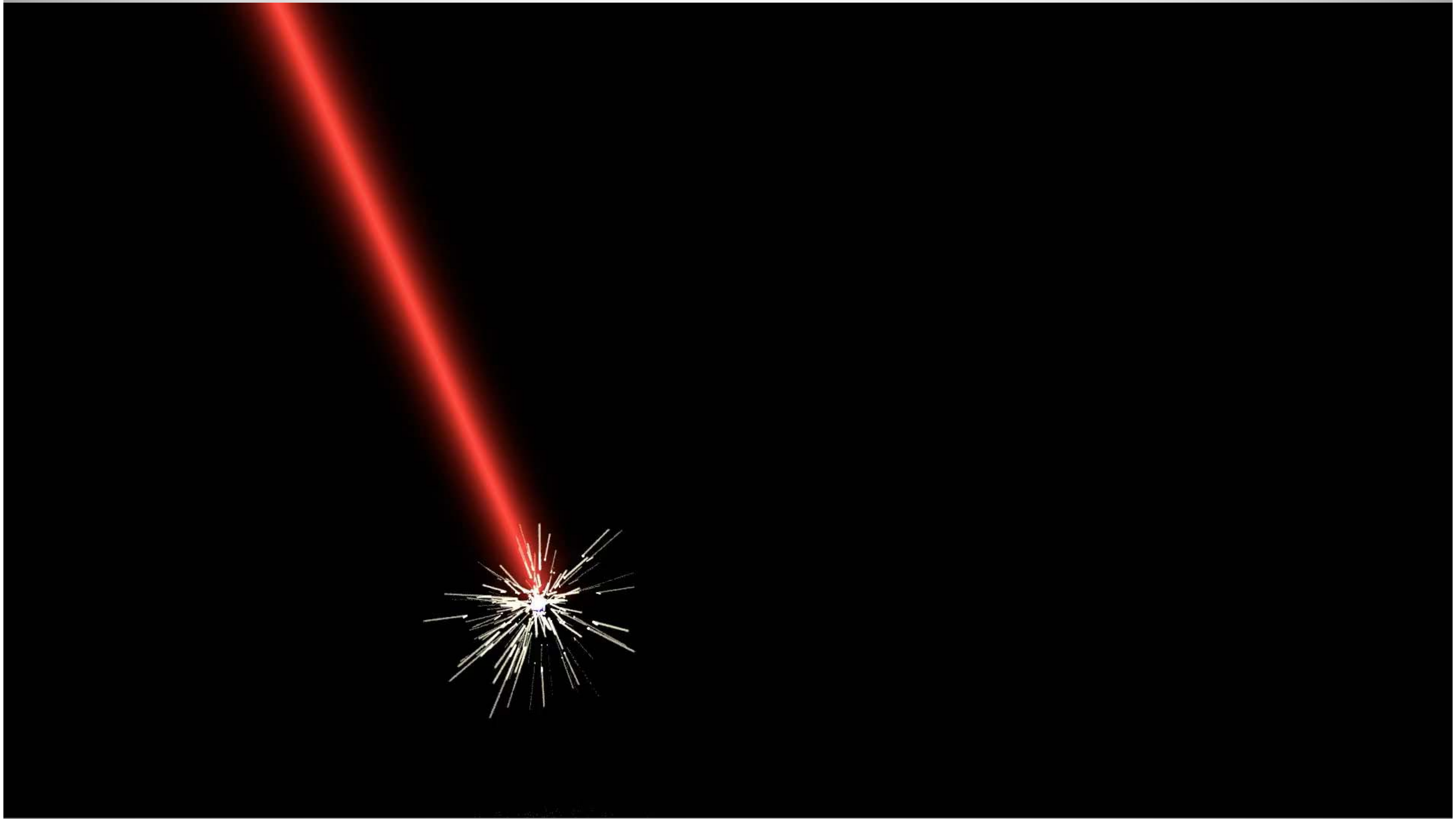
Scaffold – rešetkasta pomoćna struktura koja se koristi kao potpora u izgradi, održavanju i popravci drugih objekata

Scaffold (medicina) - su materijali i pomoćne strukture kreirane u svrhu pokretanja željnih ćelijskih interakcija radi stvaranja novih funkcionalnih tkiva u medicini. Ćelije se često „poseju" u ove strukture i sposobne su da podrže trodimenzionalno stvaranja tkiva.

Two-Photon Stereolithography-TPSL

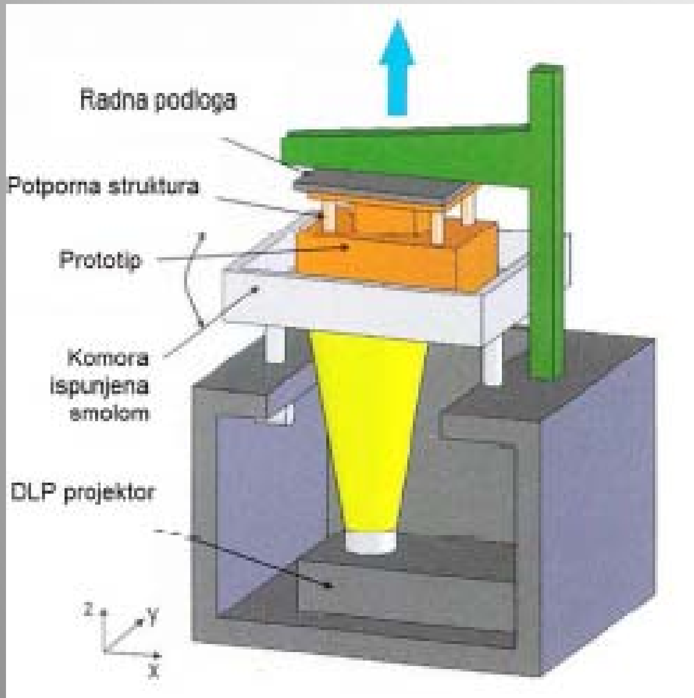


Plućna alveola

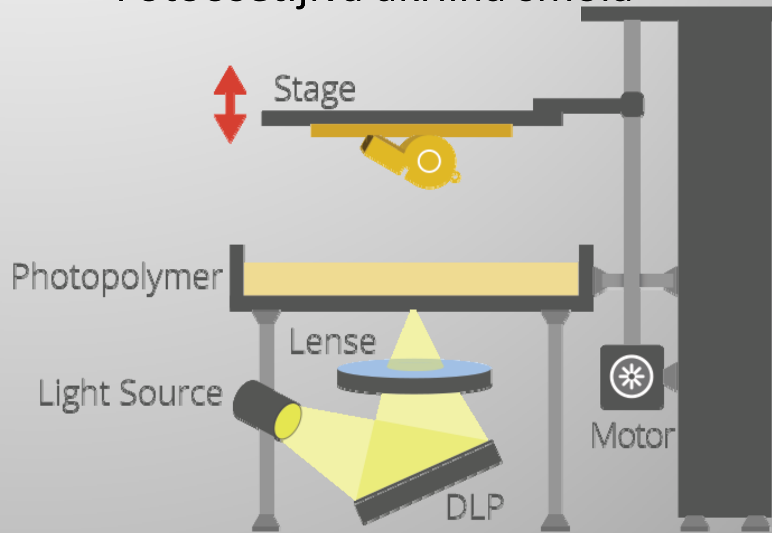


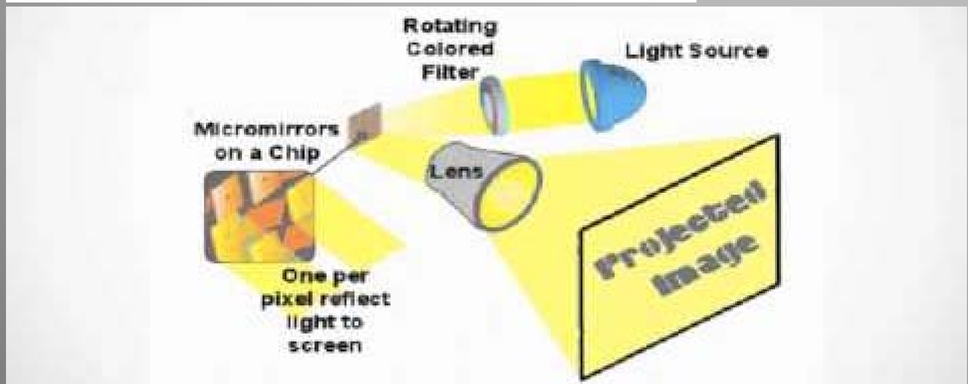
Digital Light Processing- DLP

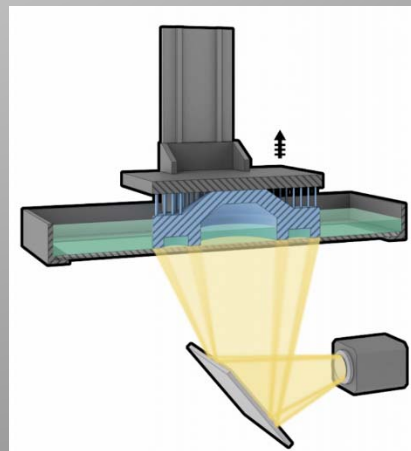
Očvršćavanje digitalno obrađenim svetlosnim signalom

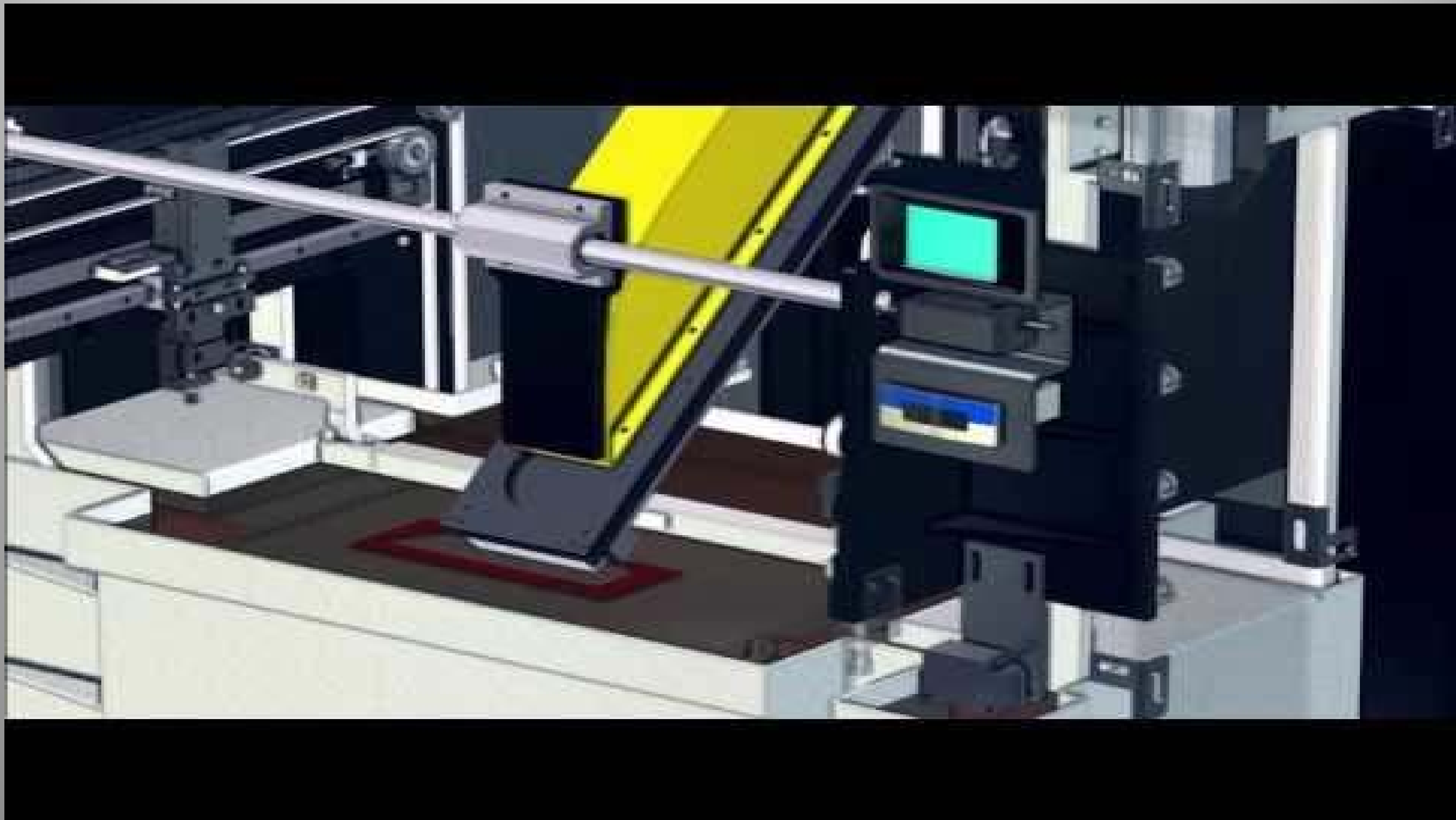


Fotoosetljiva akrilna smola





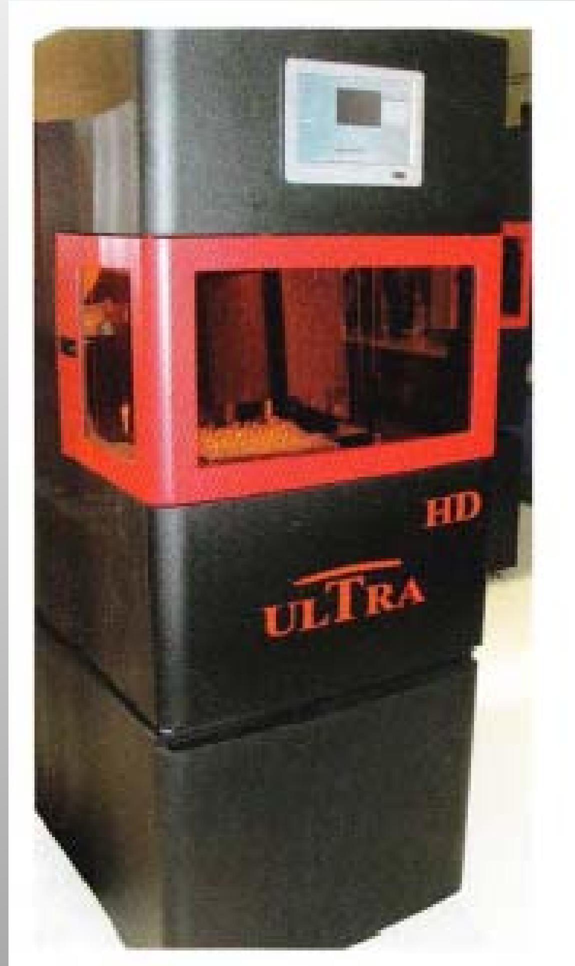




Digital Light Processing- DLP

Prednosti postupka su:
- brza i jednostavna izmena materijala,
- mogućnost primene velike količine fotoosetljivih materijala,
- primena biokompatibilnih materijala.

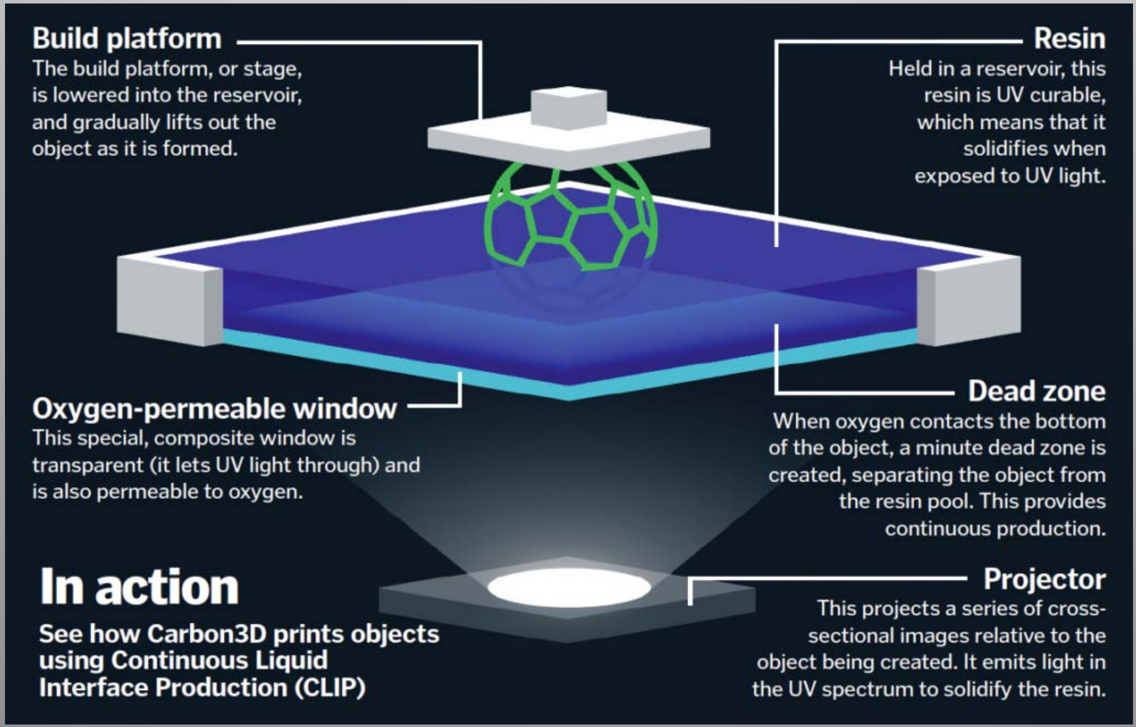
Nedostaci postupka su:
- ograničenost dimenzija,
- potrebna je potporna struktura



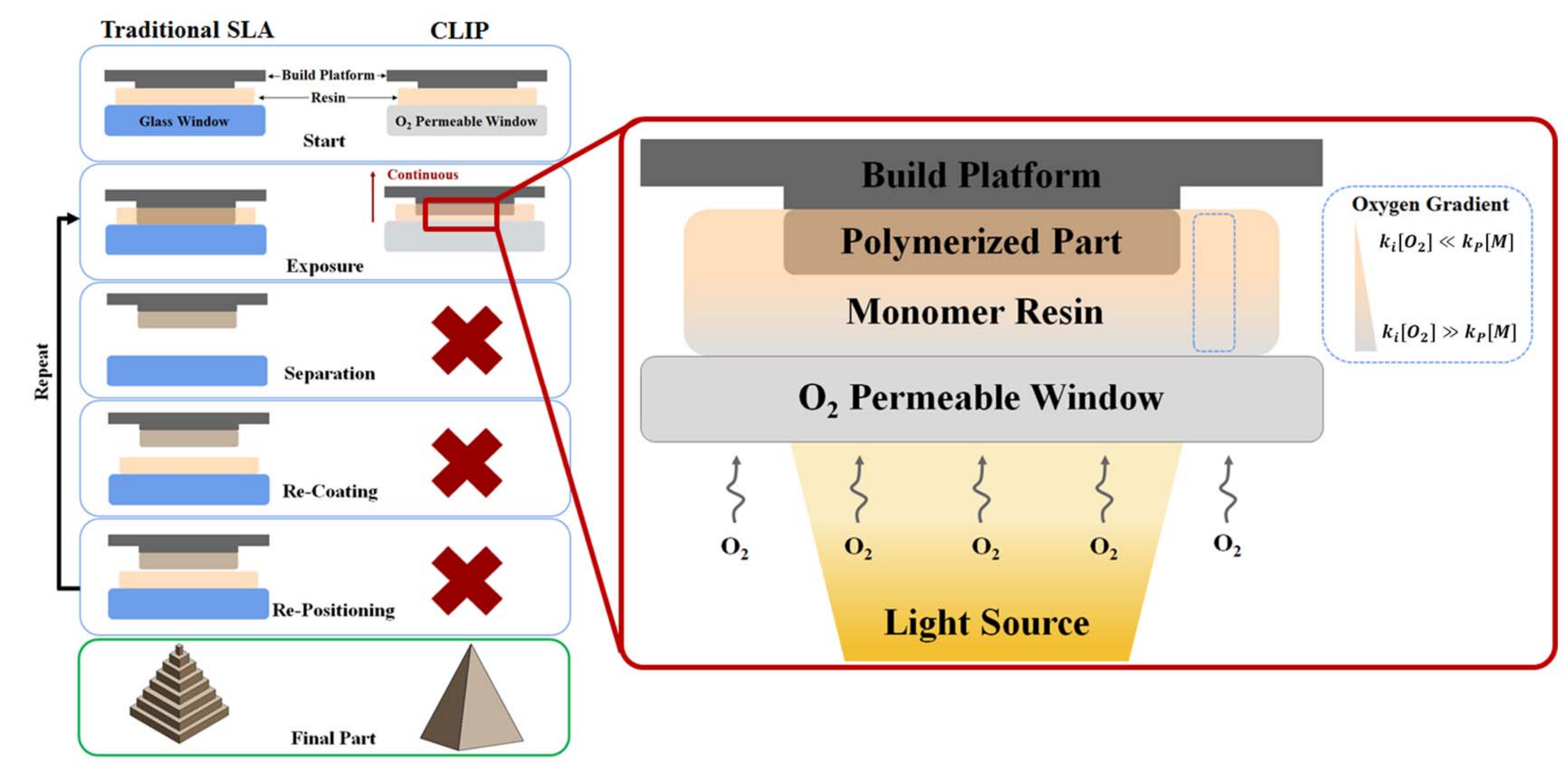
Continous Digital Light Processing- cDLP

(Continuous liquid interface production – CLIP)
(3D Carbon)

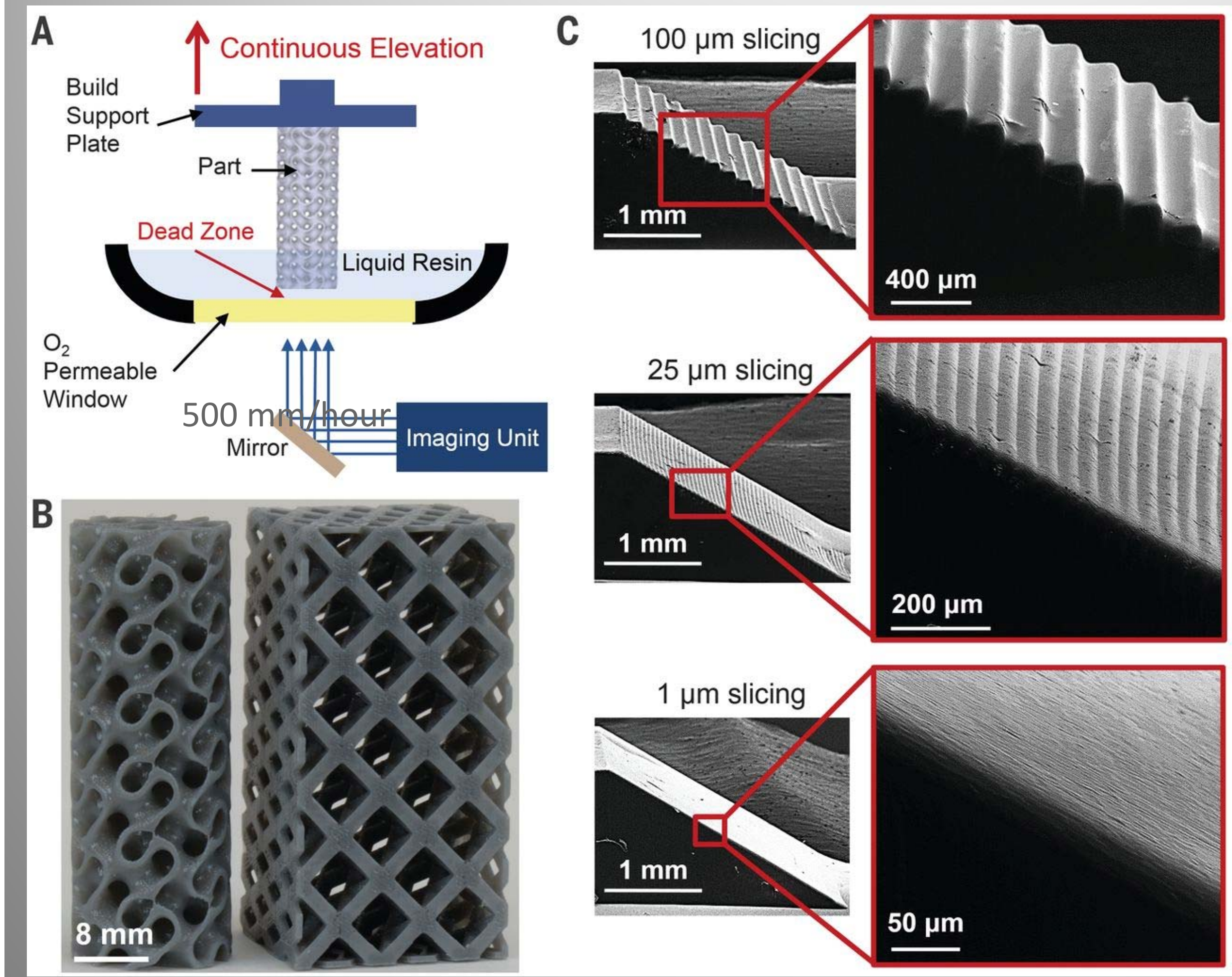
- Elastomeri, silikoni, najlon, keramika i biorazgradivi materijali
- Rezolucija štampe < 100 µm
- 25-100 brži proces u odnosu na klasičnu SLA
- U srcu CLIP procesa je poseban prozor koji je transparentan za svetlost i propustan za kiseonik, slično kao kod kontaktnih sočiva. Kontrolišući protok kiseonika kroz prozor, CLIP stvara „mrtvu zonu“ u bazenu smole debljine tek nekoliko desetina mikrona gde fotopolimerizacija ne može da se odvija

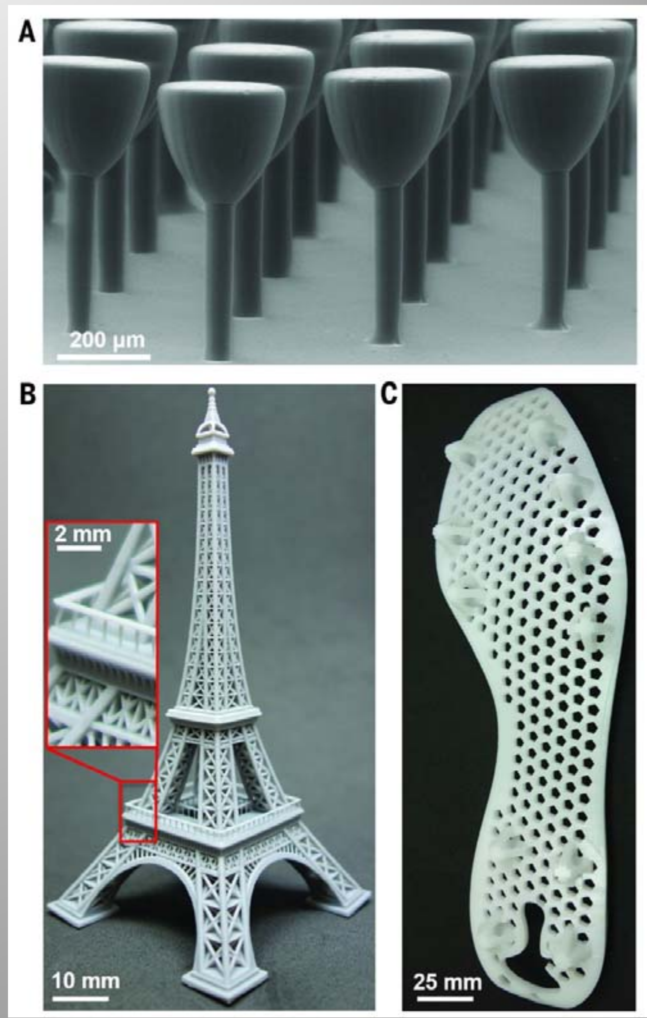


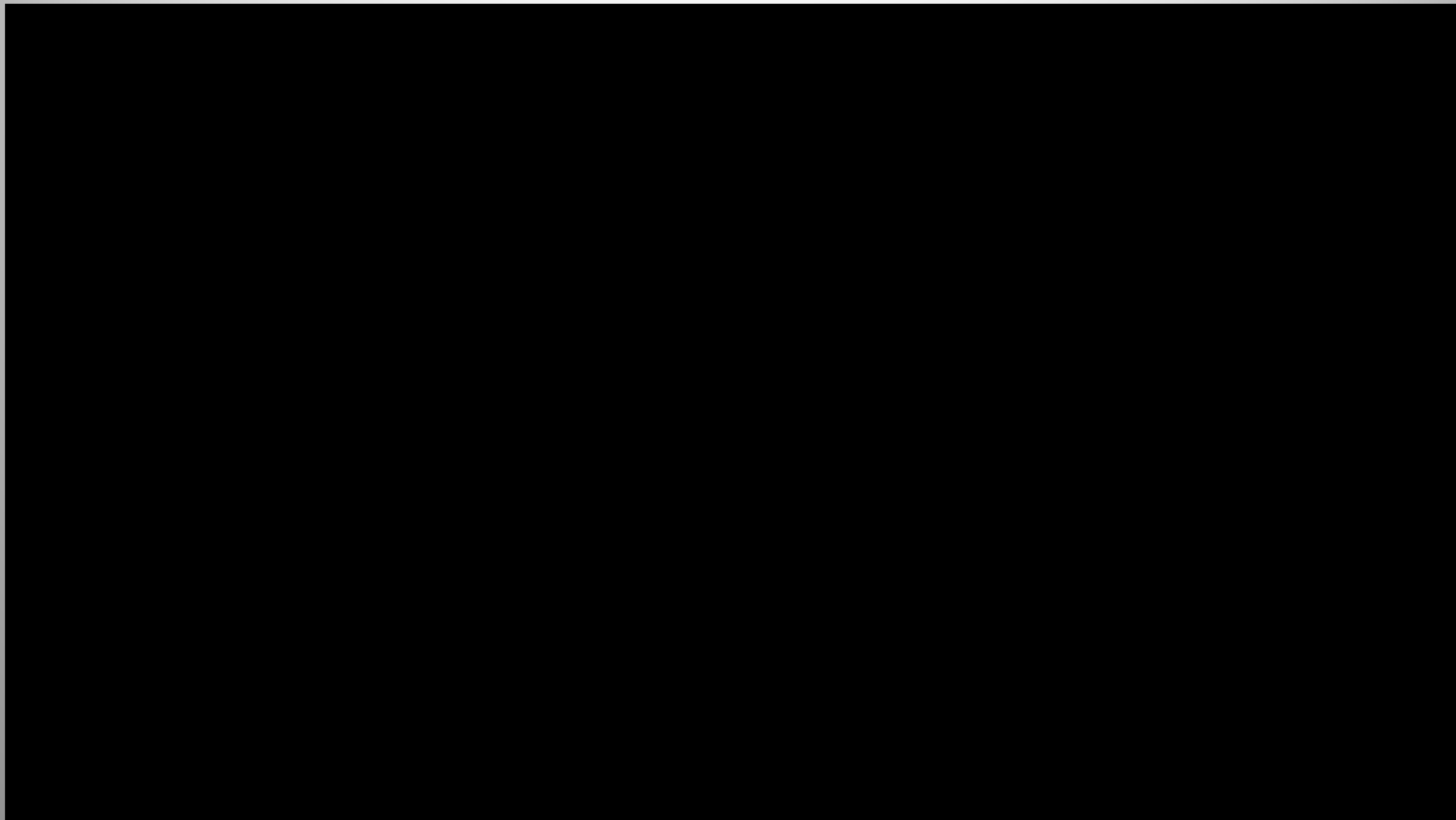
Continuous liquid interface production (CLIP)



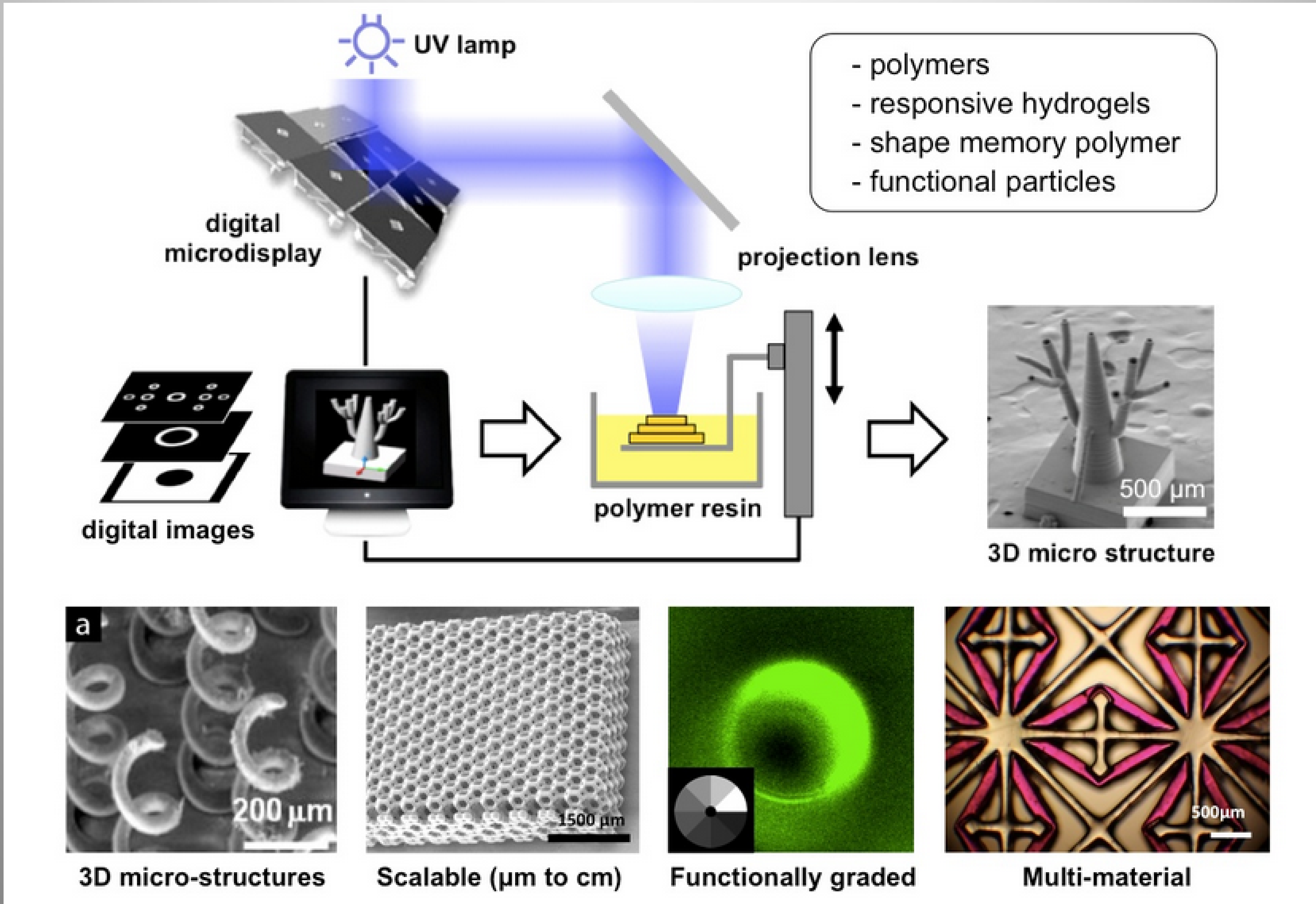
Continuous liquid interface production

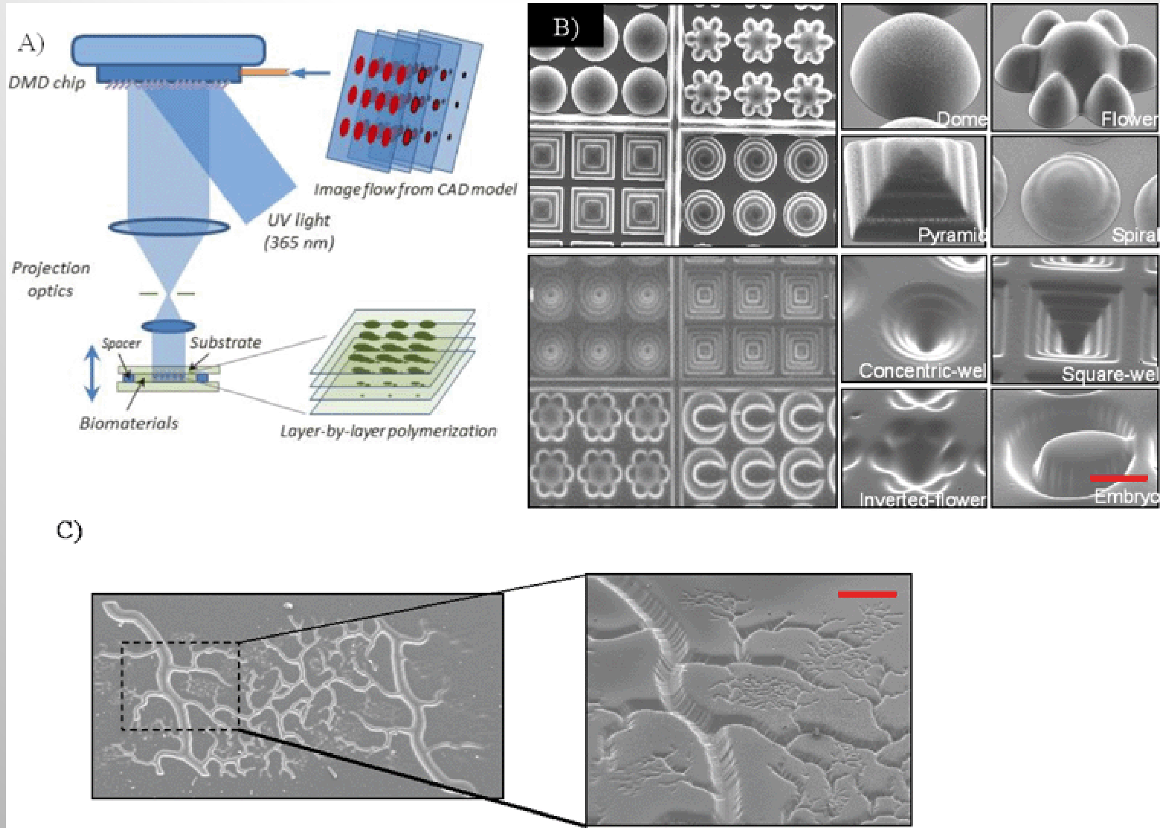


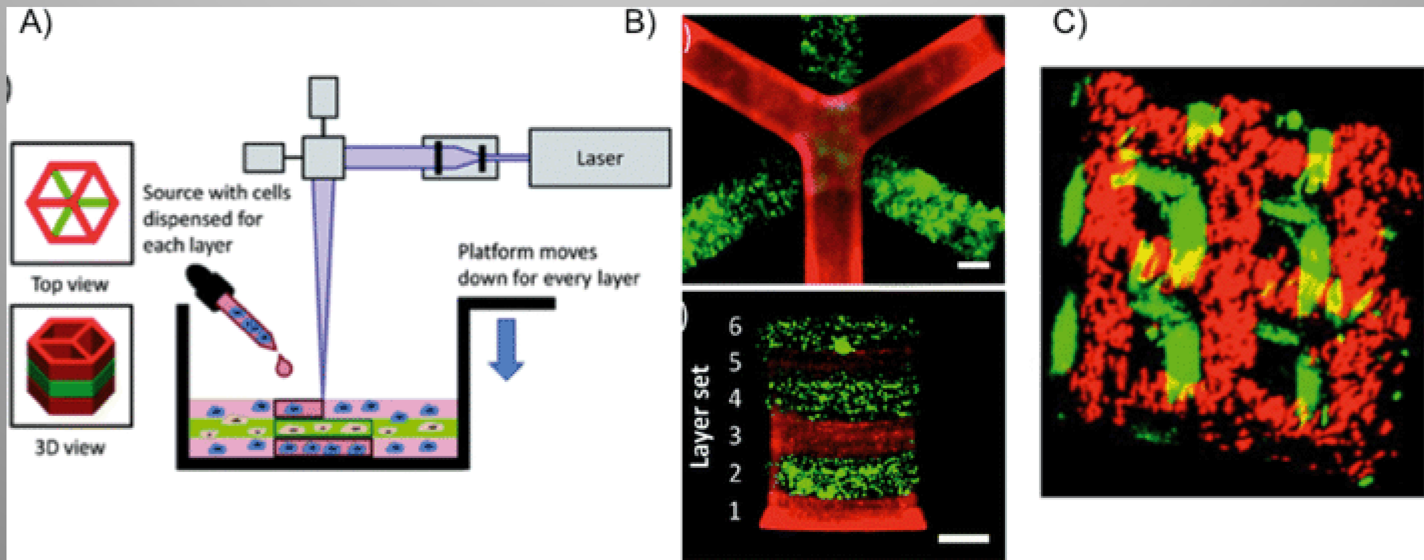


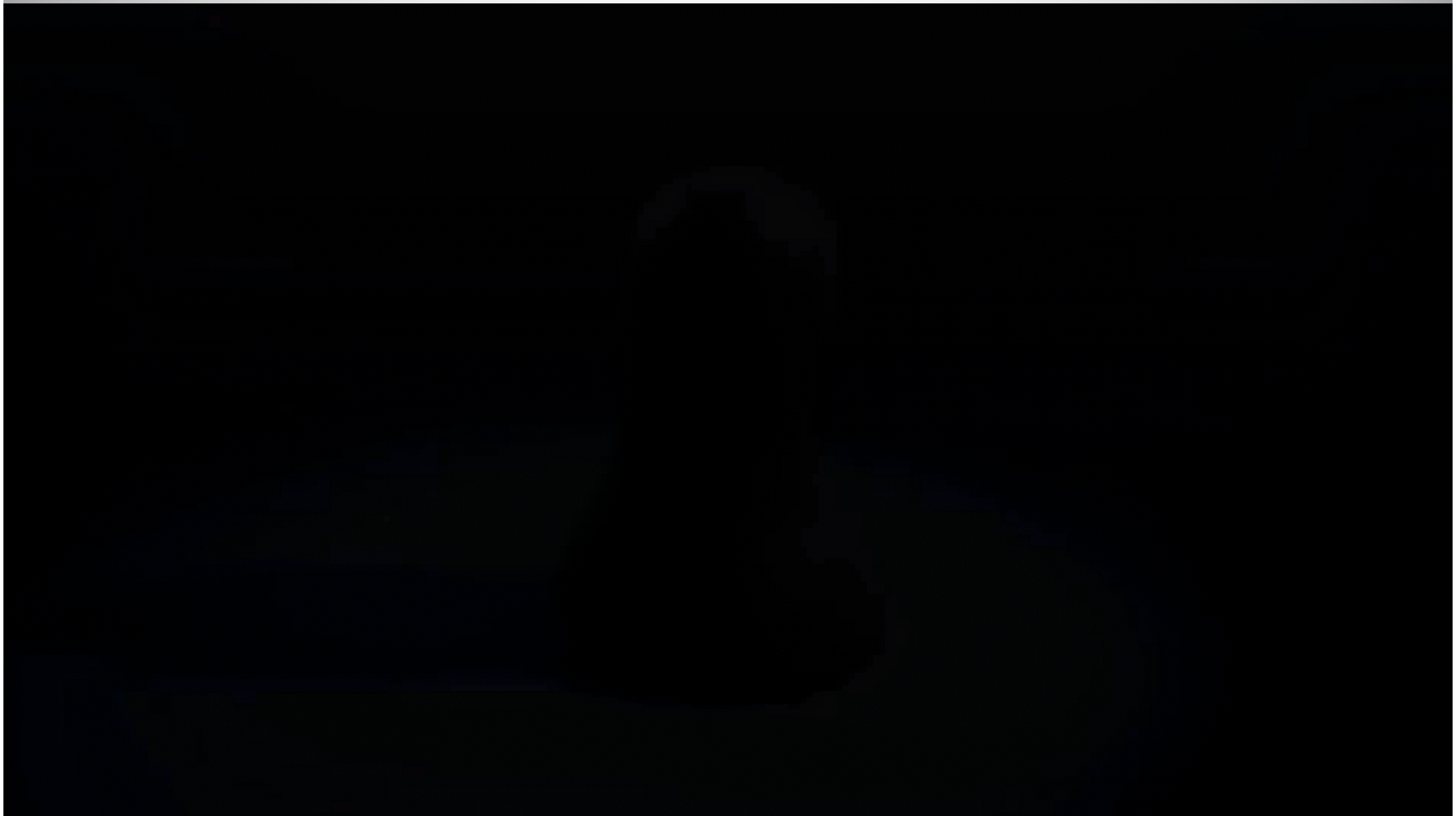


Projection Micro-Stereolithography - PμSL

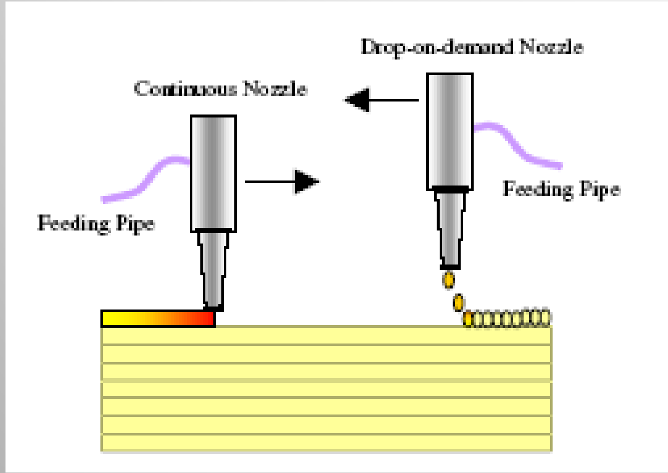


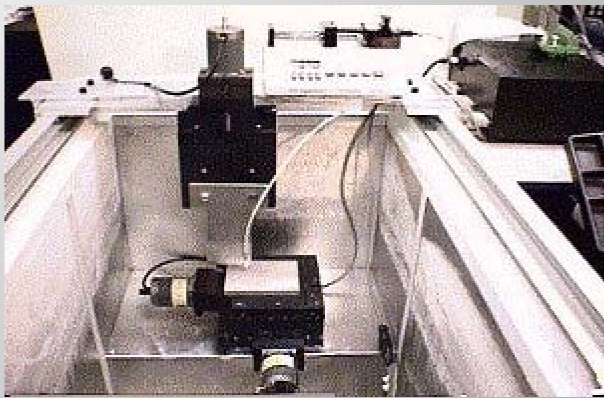

A)
DMD chip
Image flow from CAD model
UV light
(365 nm)
Projection optics
Spacer
Substrate
Biomaterials
Layer-by-layer polymerization
B)
Dome
Flower
Spiral
Inverted-flower
C)

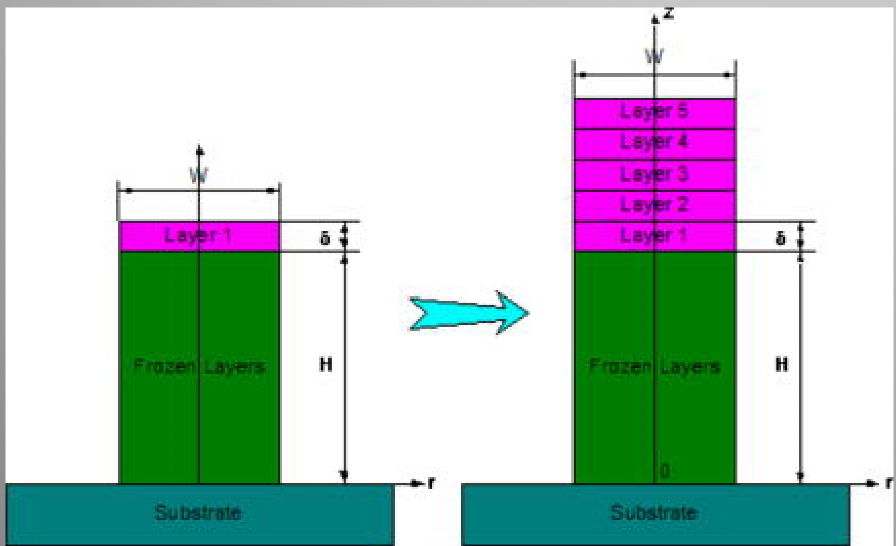

A)
Top view
3D view
Source with cells dispensed for each layer
Laser
Platform moves down for every layer
B)
Layer set
6
5
4
3
2
1
C)

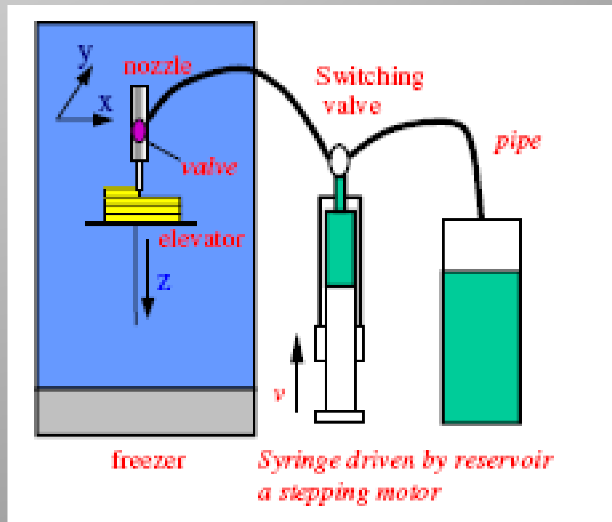


Rapid Freeze Prototyping - RFP









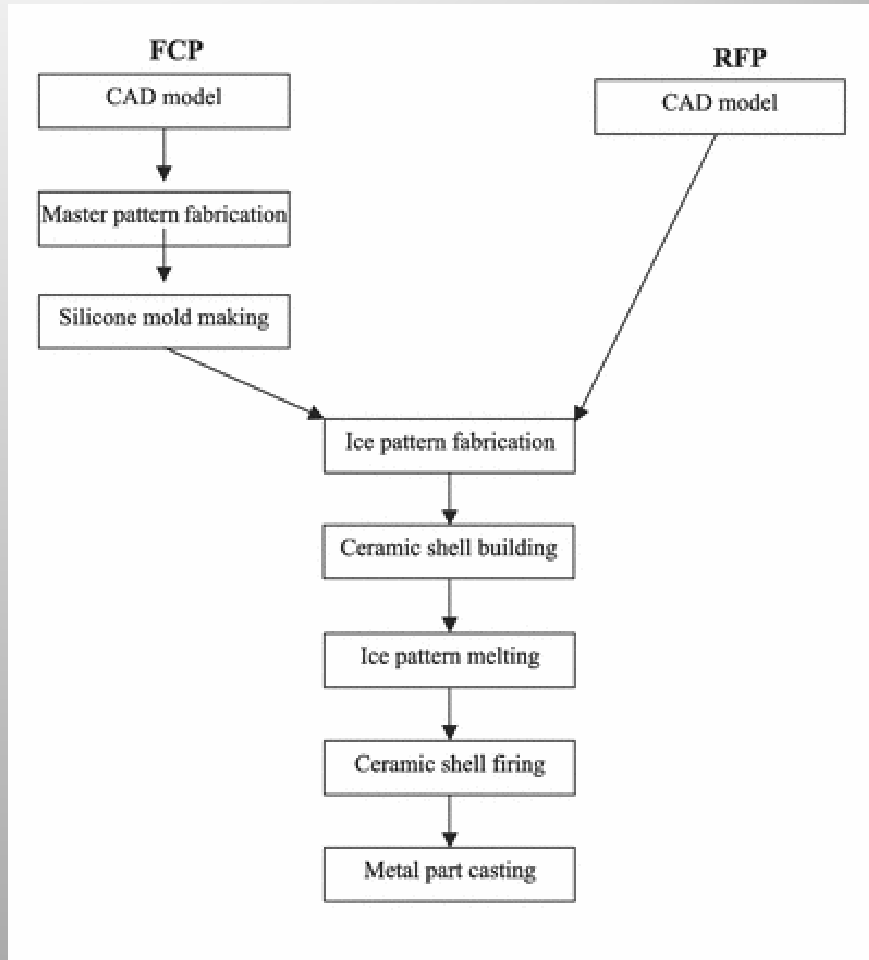
Rapid Freeze Prototyping - RFP

Glavne prednosti

- ✓ Niska cena
- ✓ Mala potrošnja energije
- ✓ Dobra tačnost.
- ✓ Brzina izrade.
- ✓ Eko-frendli postupak

Nedostatci procesa

- o Hladno okruženje.
- o Dopunsko procesiranje
- o Ponovljivost geometrije



Rapid Freeze Prototyping - RFP

Primena

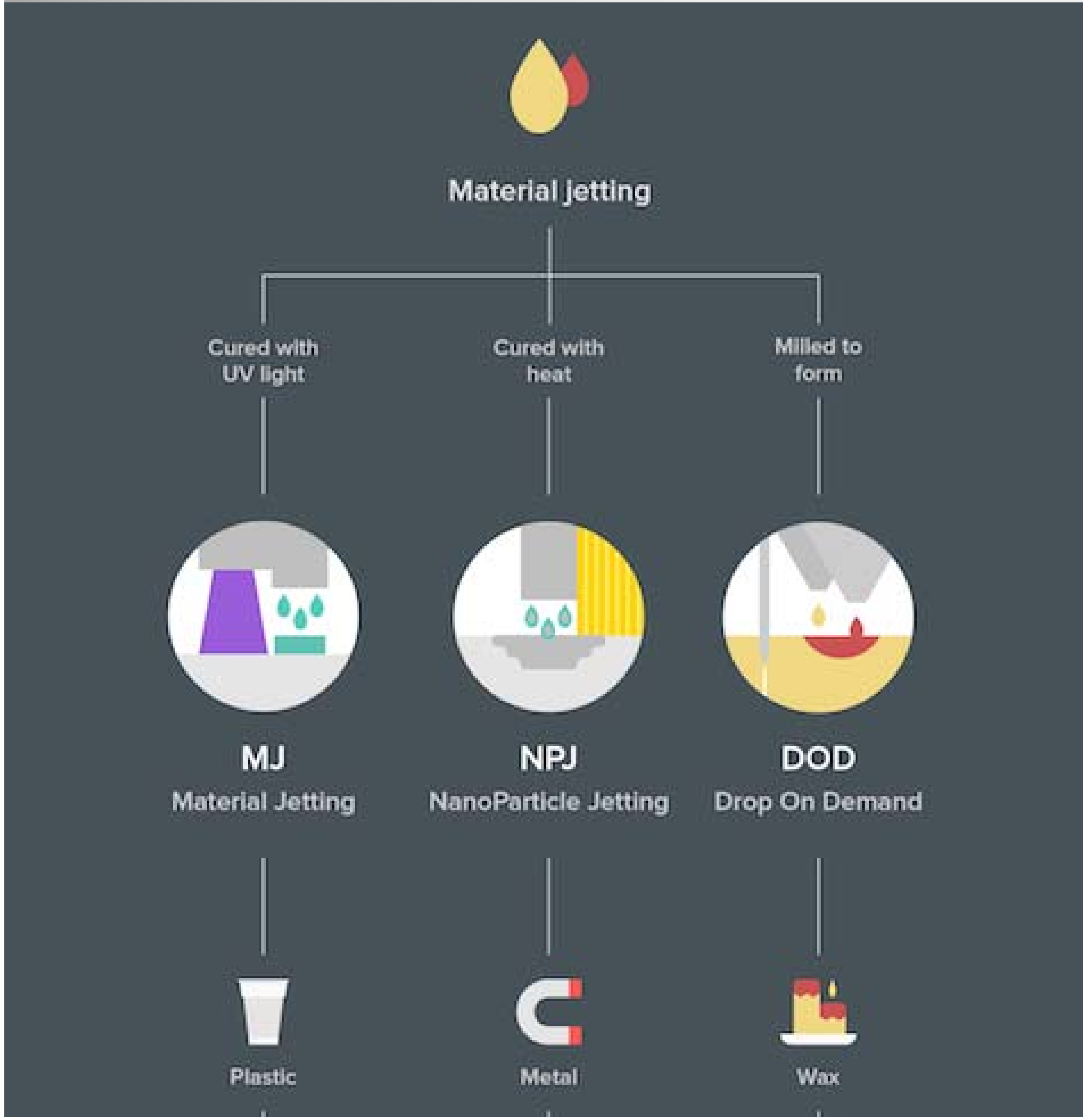
- Vizuelizacija proizvoda
- Izrada ledenih skulptura
- Izrada modela za livenje silikona
- Izrada modela za precizno livenje

These icy models of machine rods were produced by a water-based rapid prototyping system.

Source: University of Missouri-Rolla

AM Postupci na bazi solidifikacije fluida

Direktna 3D štampa



MJ - fotopolimer se linijski raspršuje iz velikog broja sićušnih mlaznica smeštenih u glavu štampača. Kada se kapljice deponuju na pokretnu platformu, one očvršćavaju pod dejstvom UV svetlosti. MJ procesi zahtevaju potporne strukture koje se generišu tokom izrade dela (istovremeno) i sastoje se od rastvorljivog materijala koji se uklanja tokom naknadne obrade.

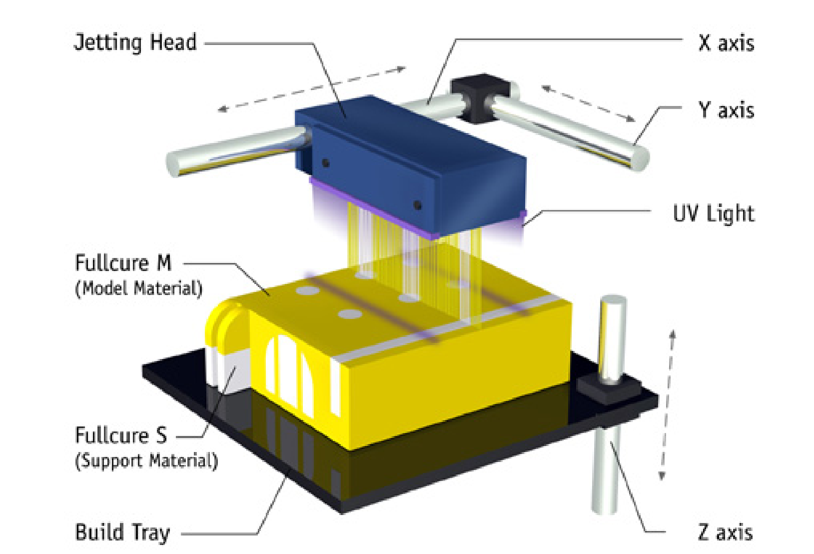
NPJ - koristi se tečnost koja sadrži metalne nanočestice ili nanočestice sa potporom, koje se ubacuje se u kertridž štampača i raspršuju na platformu u izuzetno tankim slojevima. Visoke temperature unutar komore čine da tečnost isparava ostavljajući za sobom metalne delove.

DOD - ovi štampači koriste dve različite mlaznice za štampu: jedna je za deponovanje osnovnog materijala (obično materijal sličan vosku) i drugi za rastvarajući potporni materijal. Glava štampača prati postavljenu putanju/konturu za štampanje sloja poprečnog preseka i deponuje materijal tačku po tačku. Ovi štampaći takođe koriste pokretni nož (fly-cutter) koji obrađuje/poravnava radni predmet nakon što se svaki sloj proizvede kako bi se obezbedila savršeno ravna površina pre štampanja sledećeg sloja.

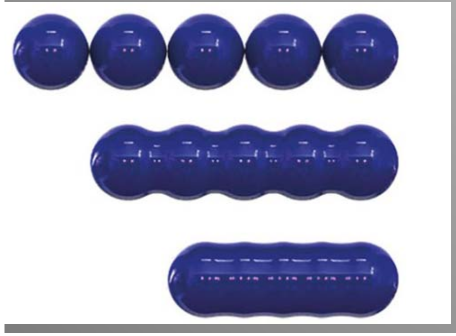
PolyJet Technology (PJT)

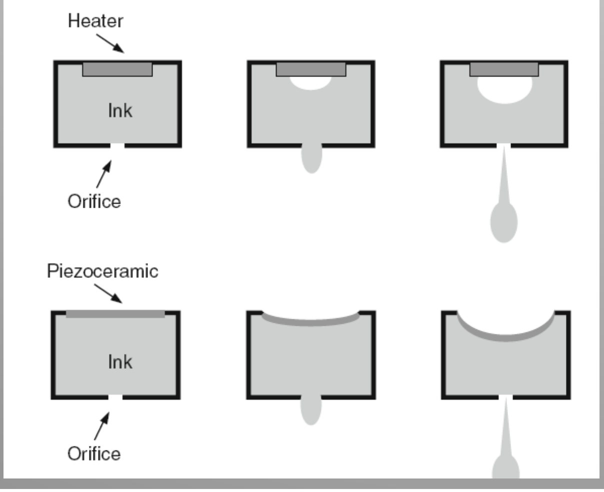
MultyJet, Material Jetting, TermoJet

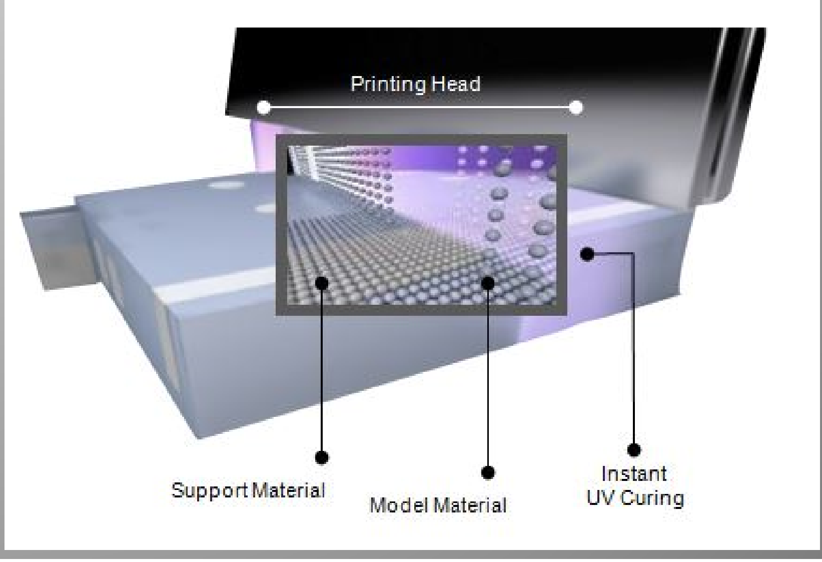
- Postupak sličan Ink-Jet štampi
- Kontinualni proces deponovanja tečnog polimera
- Polazani materijal (disperzija)
  - Osnovni materijal - UV polimer (tečna smola)
  - Materijali za oslonce rastvoren u osnonoj smoli
- Fotopolimerizacija
- Osnovni materiajal - termoset (akrilni)
- Digitalni materijali (mešavina više materijala)
- Termo glava sa velikim brojem mlazica (352)
- Materijal za oslonce na bazi gela
- Ultra tanki slojevi (14-16μm)



The Objet PolyJet Process







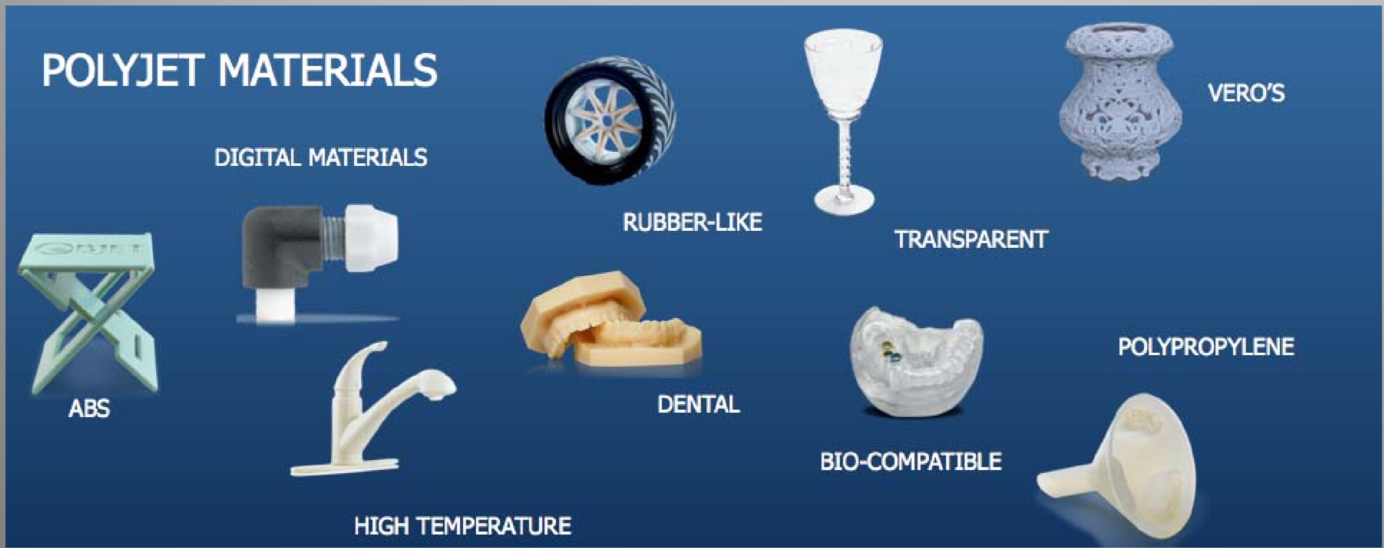
PolyJet Technology (PJT)

Glavne prednosti

- ✓ Efikasnost i jednostavost primene
- ✓ Niska cena štampe
- ✓ Tačnost (zid debljine manji od 0,6mm)
- ✓ Kvalitet (rezolucija 16µm)
- ✓ Brzina štampe
- ✓ Office-friendly postupak
- ✓ Veliki dijapazon različitih materijala

Nedostaci procesa

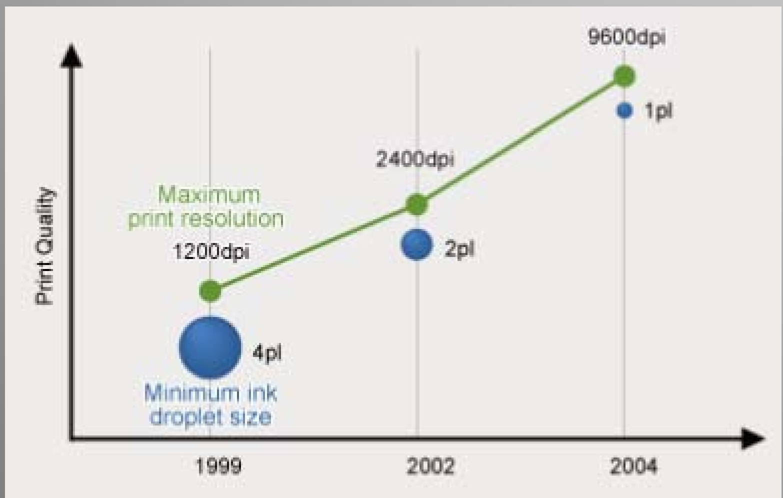
- o Relativno male dimenzije delova
- o Skupljanje



PolyJet Technology (PJT)

<u>Oblasti primene</u>

- ❑ Medicina
- ❑ Oblast elektronike
- ❑ Automobilska industrija
- ❑ Proizvodnja robe široke potrošnje
- ❑ Arhiktetura
- ❑ Obrazovanje
- ❑ Zabava
- ❑ Itd...

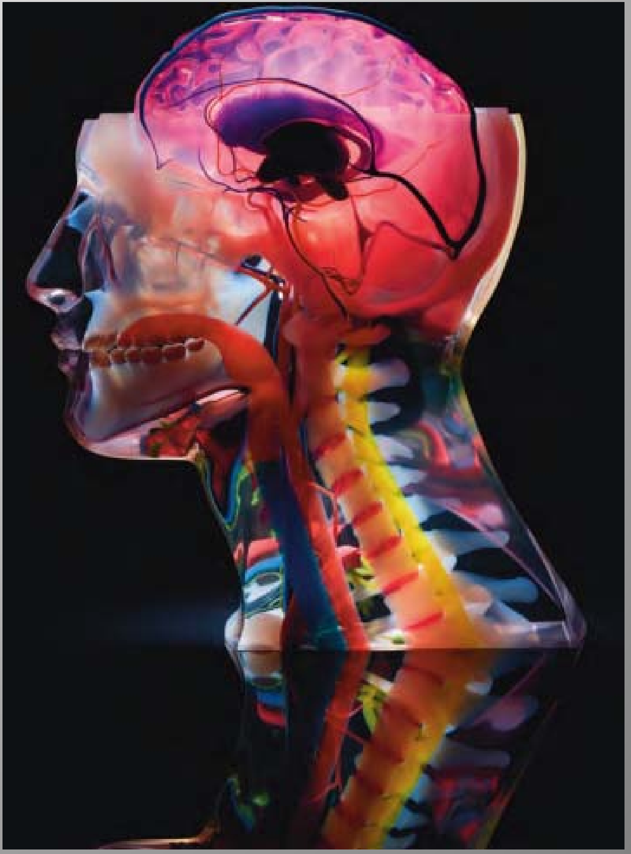


PolyJet Technology (PJT)

Medicina

- ❑ Anatomski modeli
- ❑ Funkcionalne proteze

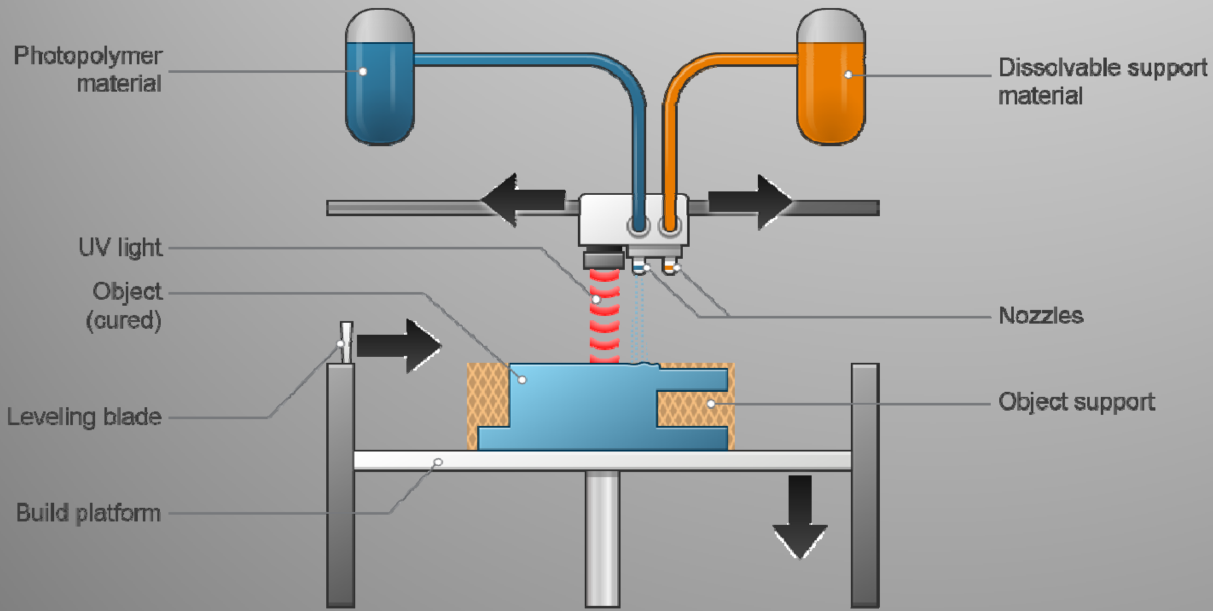




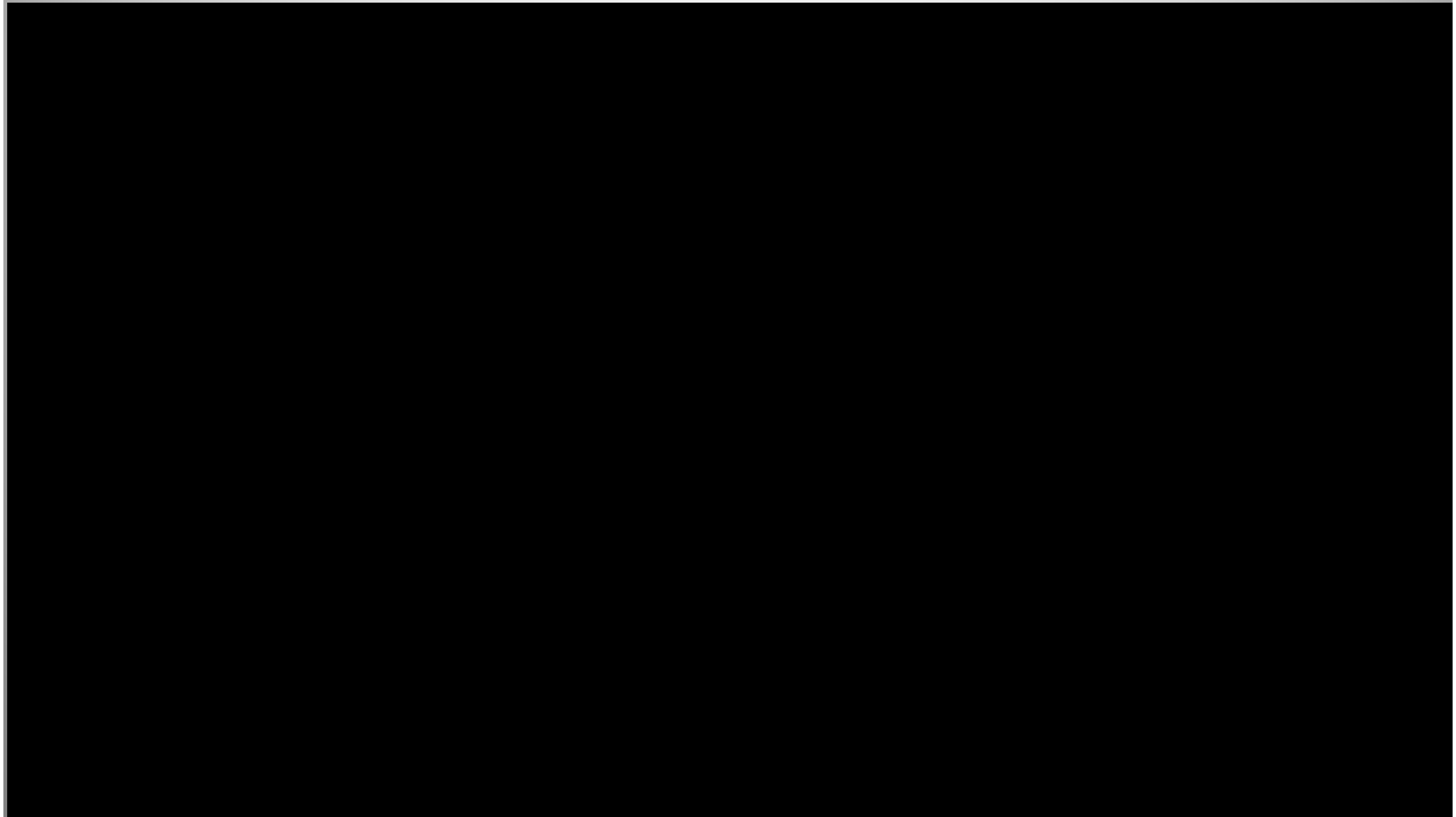
Drop on Demand (DOD)

Deponovanje kapi na zahtev

- Podvarijanta PolyJet postupka
- Diskontinualni proces deponovanja tečnog polimera
- Osnovni matrijal na bazi voska (prah se zagreva i topi u kertridžu)
- Dve glave (osnovni i dodatni matrijal)
- Rezolucija deponovanja - 5000 × 5000 kapi po inču
- Rezolucija štampe 22 µm u X-Y ravni i 25 µm za Z-osu
- Izrada voštanih modela za precizno livenje

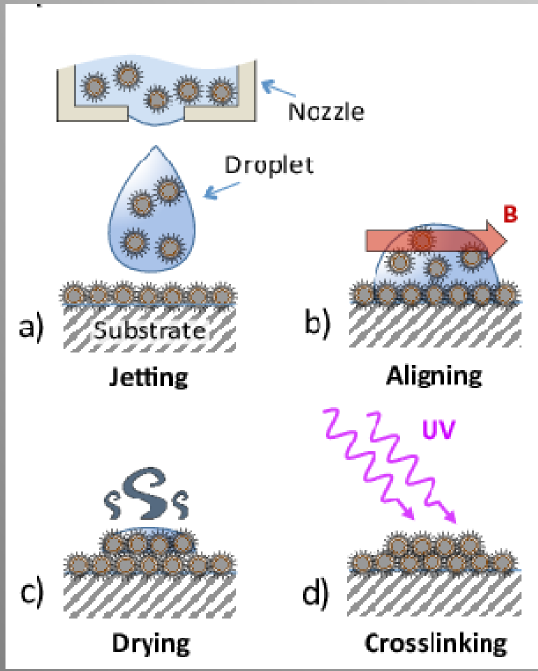


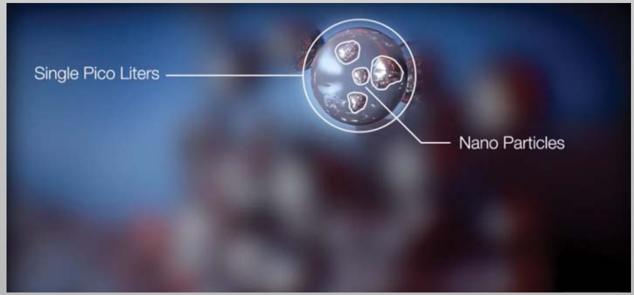
Drop on Demand (DOD)



Nano Particle Jetting (NPJ)

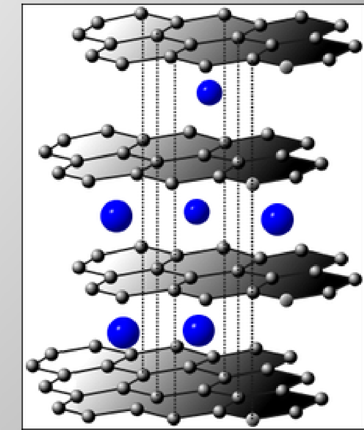
- Izraelska kompanija XJet
- Tečni rastvor - sadrži metalne/keramičke nanočestice ili nanočestice sa potporom,
- Iz kertridža štampača disperzija se raspršuje na platformu u izuzetno tankim slojevima (8-10 µm) .
- Visoka temperature komore (250°C) - tečnost isparava ostavljajući za sobom metalni/keramički skelet





Nano Particle Jetting (NPJ)

Nano Particle Jetting (NPJ)



PRIMENA:

- **Grafen i grafen-oksid nano-membrane**

(Grafen je dvodimenziona ugljenična struktura debljine jednog atoma.)

- **Hiruški instrumenti**
- **Keramički/metalni implanti**