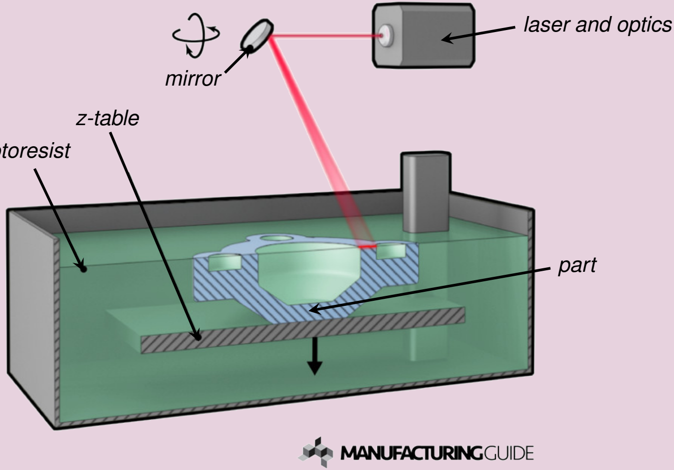
# Summary of the last lesson: Additive processes with liquid raw material

October 14, 2024

# ***Stereolithography***

# 1.1.0 Stereolithography, the machine

## Details of the machine



# 1.1.0 Stereolithography, new design (top-down)

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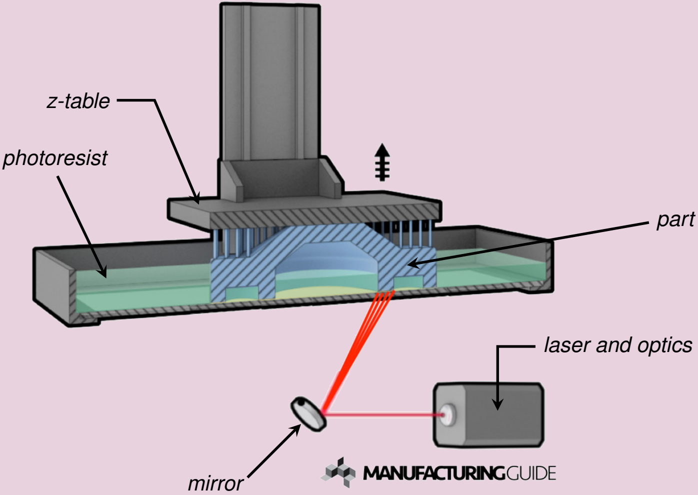

# 1.1.0 Stereolithography, technical data

## Mechanical properties of part (order of magnitude)

| ***Material*** | *E, GPa* | $R_m$, *MPa* | $\varepsilon_{rup}$, % |
|---|---|---|---|
| *VisiJet Flex* | *1.6* | *38* | *16* |
| *VisiJet HiTemp* | *3.4* | *66* | *6* |

## Equipment (type, dimensions)

| ***Laser*** | $\lambda$, $\mu m$ | *P, W* | ***Build volume***, *mm*$^3$ |
|---|---|---|---|
| *Helium-Cadmium (HeCd)* | *0.325* | *0.025* | $250 \times 250 \times 500$ |

## Performances

| ***x-y resol.***, $\mu m$ | ***layer thick.***, $\mu m$ | ***build speed***, *mm*$^3$*/s* | ***layering time***, *s* |
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Resolution issues

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▸ Computation of fabrication time

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## Advantages and applications

- *Relatively precise (even better then 25 $\mu$m),*
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▸ Small to medium series of parts

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Support structures

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# *APPENDICES*

# Resolution of an additive process

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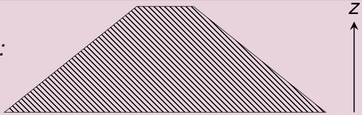
- *The resolution is limited by a stair effect.*
  *It is proportional to the layer thickness e:*



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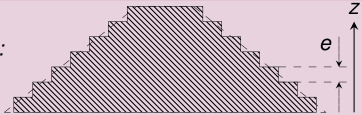

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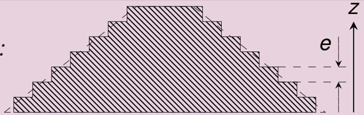

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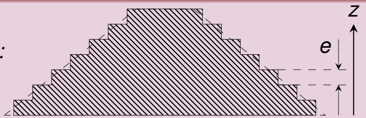


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- *the resolution is limited by two independant factors:*
  (1) *the dimensions of the smallest matter element to be added:*
    - *UV-cured or molten volume, deposited liquid droplet,...*

  (2) *the positionning accuracy of the system depositing or inducing the consolidation of that element:*
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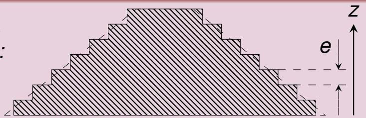


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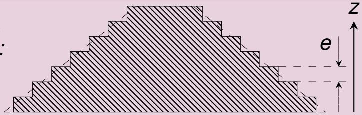


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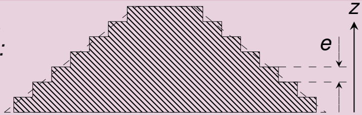


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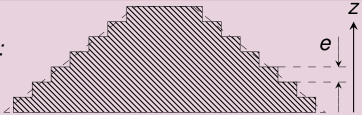


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## Build speed (material consolidation rate MCR)

- *In AM, the fabrication time is essentially **proportional** to the volume of the part and **does not depend** on its geometrical complexity .*
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$$\text{fab. time} \simeq \frac{\text{volume}}{MCR}.$$

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Table 3d: How is the fabrication time computed in subtractive processes (machining)?

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The mutualization is a pricewise mutualization: what can be shared is the price to pay for the layering time of course

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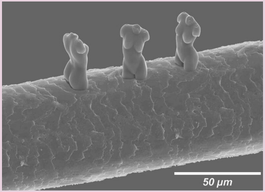
$$\text{fab. time} \simeq \frac{\text{volume}}{MCR}.$$

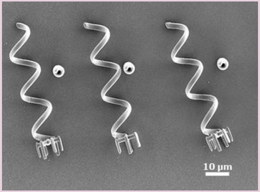
- *For a particular process, the build speed MCR varies between limits as a function of the used material.*
- *For most processes, the above formula only **underestimates** the fab. time. An accurate computation of the fabrication time of a part by an additive process also involves a term proportional to the construction height of the part :*

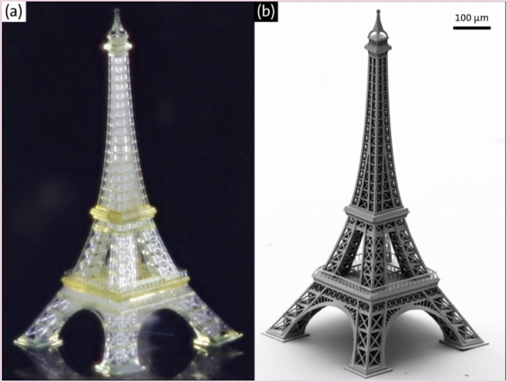
$$\text{fab. time} \simeq \frac{\text{volume}}{MCR} + \frac{\text{height}}{e} \times \frac{\tau_{layer}}{N}. \quad (1)$$

*where e is the layer thickness and $\tau_{\text{layer}}$ the **time to prepare a layer**: the ratio height$/e$ represents the total number of layers. Note that the layering time can be **mutualized** between the N parts built in the same batch.*

## Very small parts can be obtained by scaling down the process




*source: Fraunhofer-Institut für Lasertechnik Aachen*

# Micro-stereolithography

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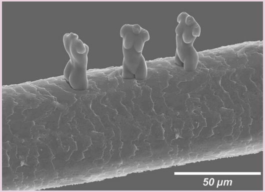


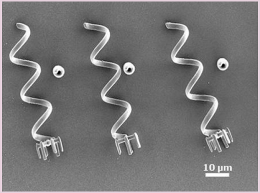


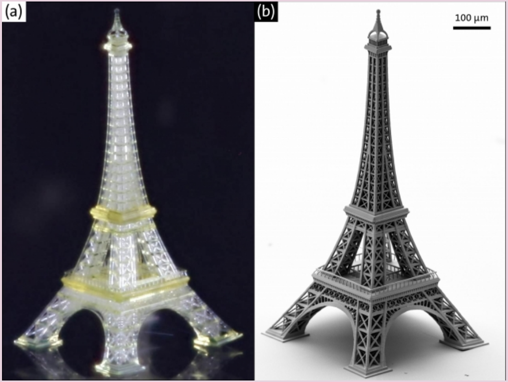


*source: Fraunhofer-Institut für Lasertechnik Aachen*

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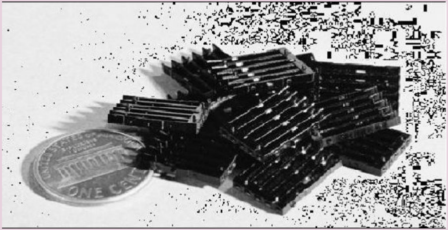
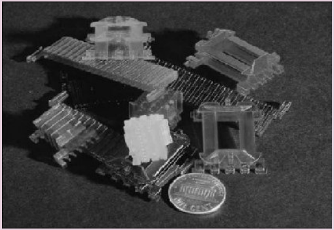
# Manufacture of small series

## Electrical components



*source: Fraunhofer-Institut für Lasertechnik Aachen*

- *16'000 parts to produce*
  - *The **injection** and **SLA** processes are considered*
  - *SLA proves to be slightly more expensive*
  - *SLA is finally **chosen** due to shorter lead time (2 weeks against 2 month)*

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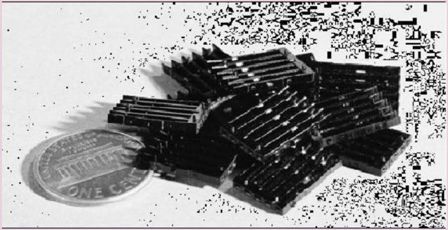


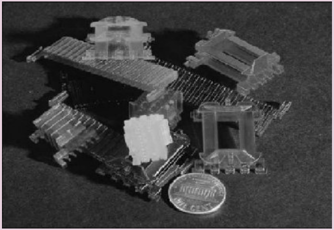

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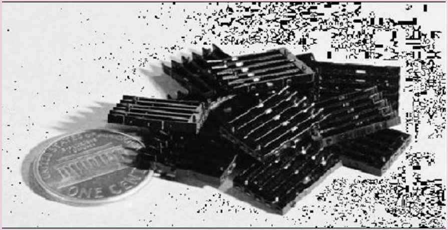


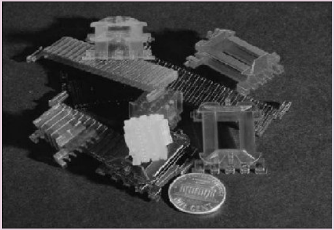

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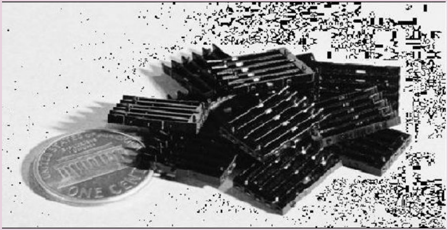

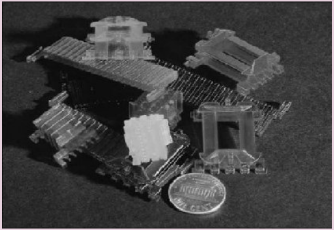

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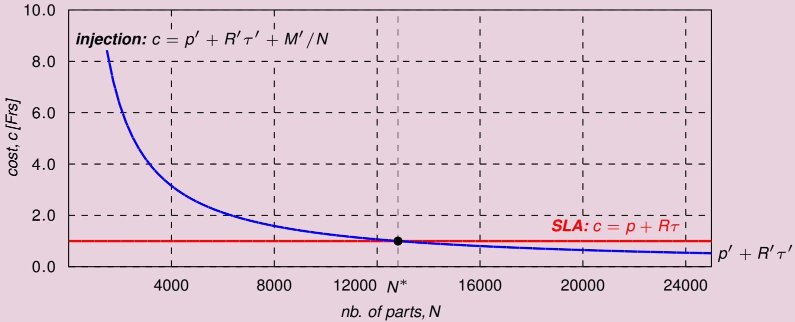
# Cost comparison SLA-injection.

## Determining parameters and cost comparison

| | material cost, Frs | hourly rate (men+mach.), Frs/h | fab. time, h time, h | tool cost, Frs |
|---|---|---|---|---|
| ***SLA*** | $p$ | $R$ | $\tau$ | – |
| ***injection*** | $p'$ | $R'$ | $\tau'$ | $M'$ |



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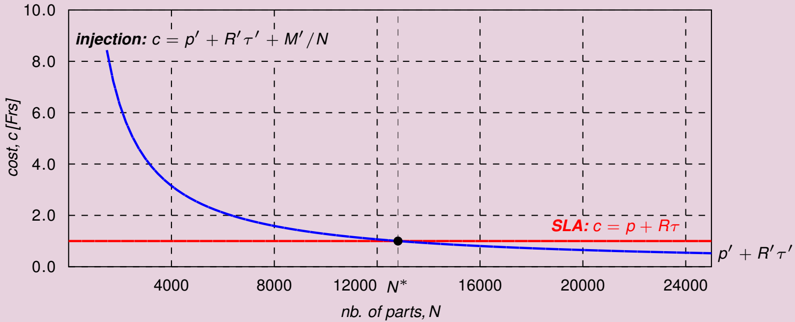


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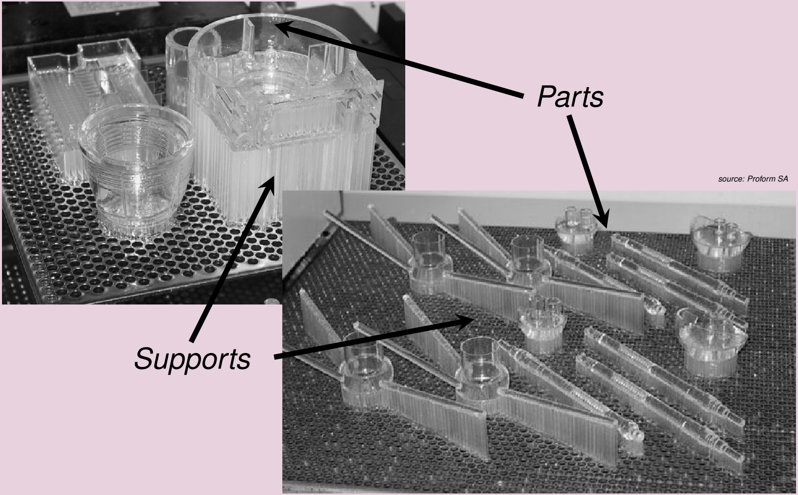
# Supports

## Example of support structures




source: Proform SA

# Supports

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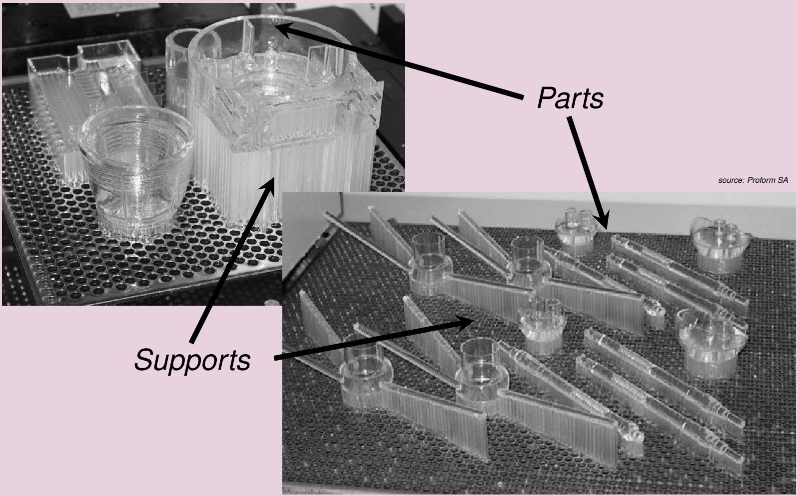


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