3D Microfabrication based on two-photon polymerization

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Workshop on 3D Printing, Robotics and Medicine

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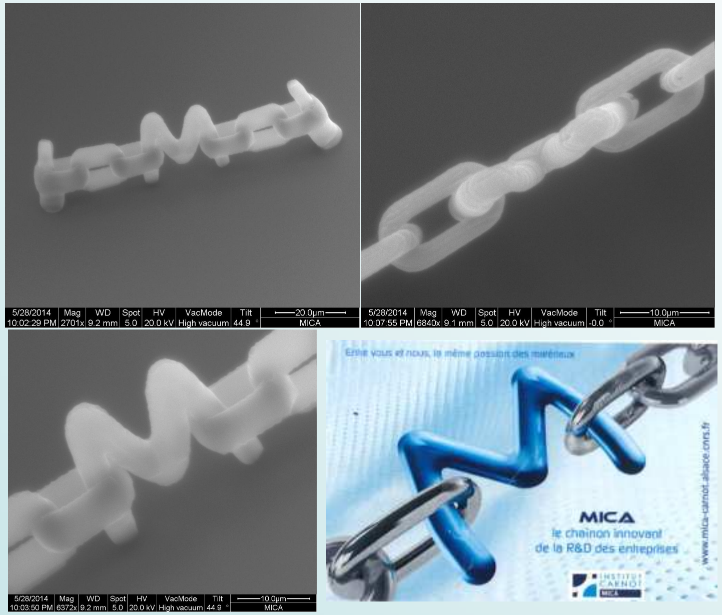
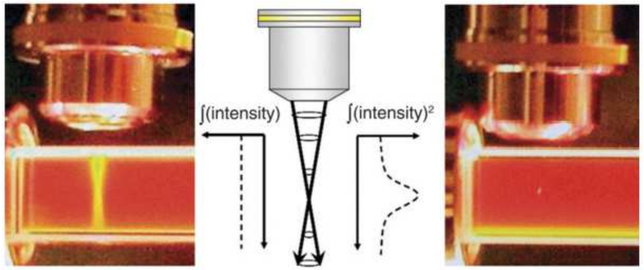


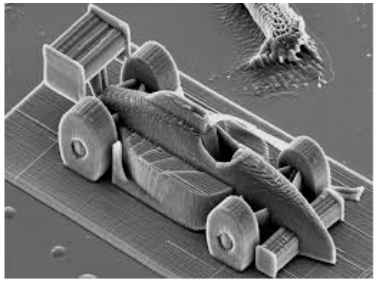
Outline

1



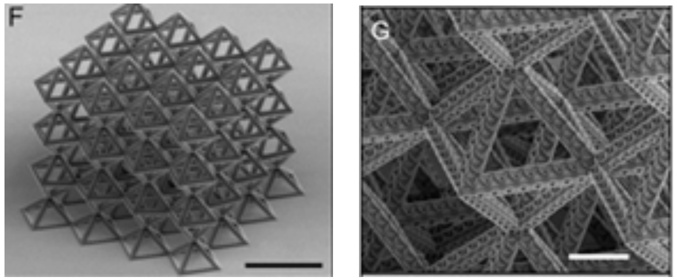
History & Principles of TPS

2



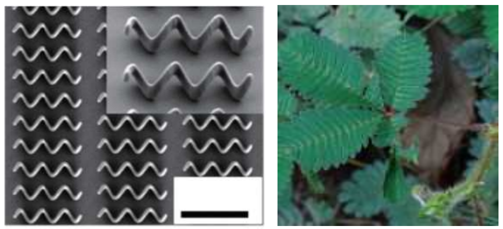
Writing speed & resolution

3



Applications
Medecine & Robotics

4

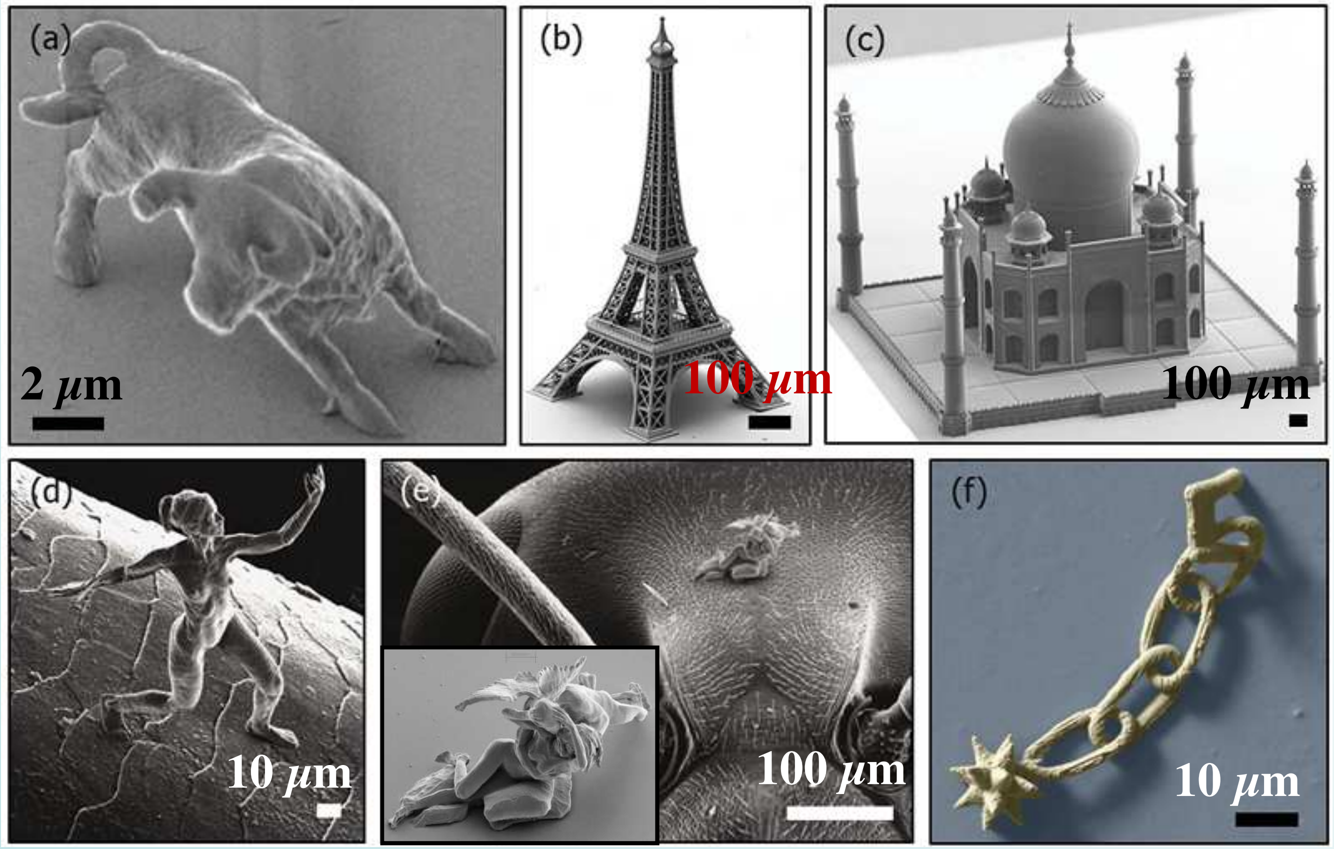


Advanced Functional
Materials

Two Photon Stereolithography (TPS)

3 D Microstructuration by TPS:

- Nano-/microfabricated artwork by two-photon polymerization (TPP)



Yetisen et al. *Advanced Materials*, **2016**, *28*, 1724.

a) Bull sculpture (*Kawata group*); **b)** Eiffel Tower, (*Nanoscribe GmbH*); **c)** Taj Mahal, (*Nanoscribe GmbH*)
d) Human sculpture. / Guiness World Record (80 x 100 x 20 micron), (*Jonty Hurwitz, artist*)
e) “Cupid and Psyche” on an ant head, (*Jonty Hurwitz, artist*); **f)** A morningstar with a chain (*Shear group*)

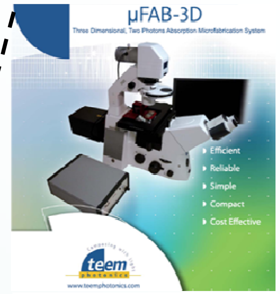
Significant milestones for TPS

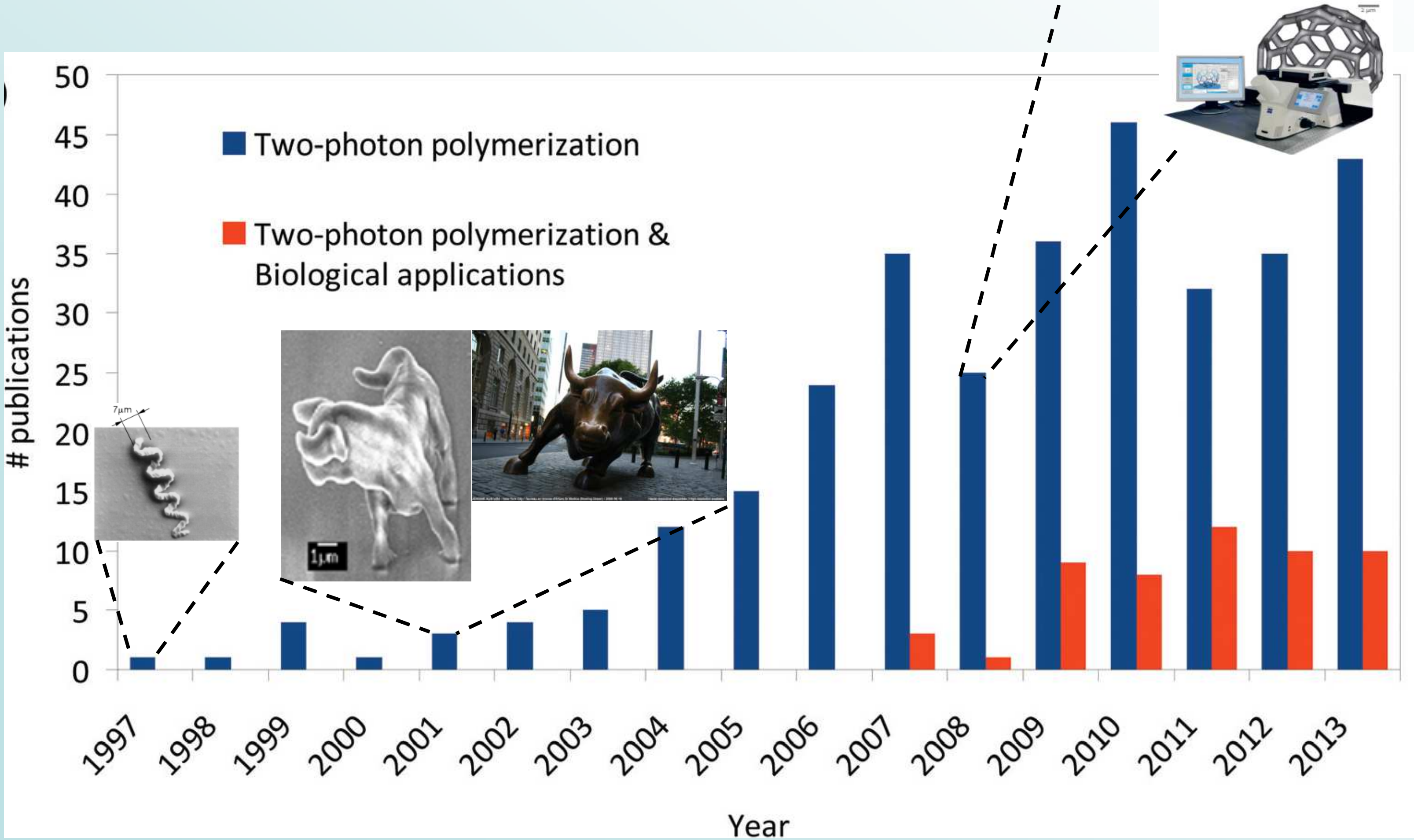
1992: two-photon lithography concept (*Strickler & Webb*)

1997: 1st experimental demonstration of TPS (*Maruo & Kawata*)

2001: Microbull (*Kawata*)

2008: commercial set-up for TPS (*µm.s*$^{-1}$)





Significant milestones for TPS

1992: two-photon lithography concept (*Strickler & Webb*)

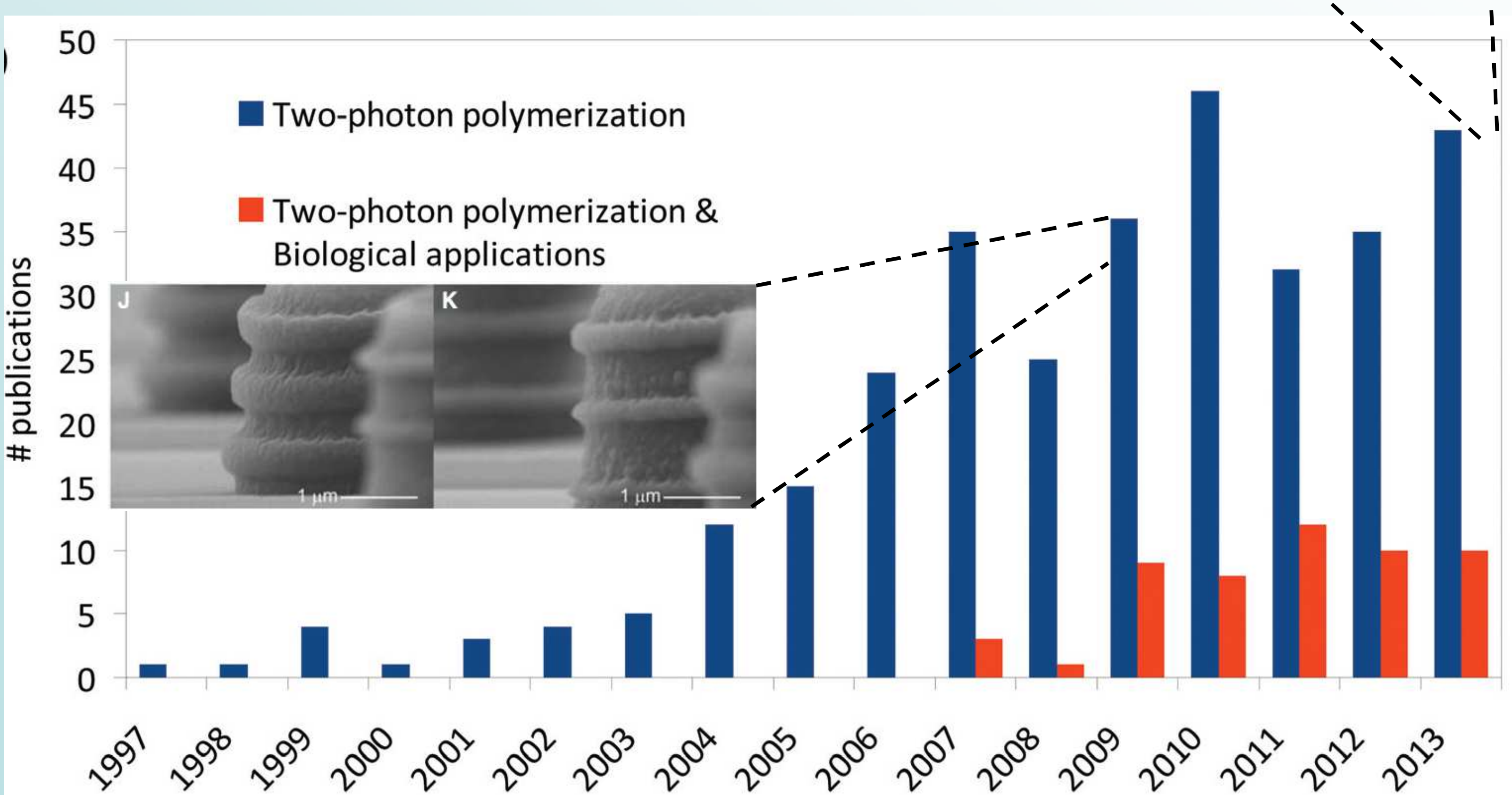
1997: 1st experimental demonstration of TPS (*Maruo & Kawata*)

2001: Microbull (*Kawata*)

2008: commercial set-up for TPS ($\mu m.s^{-1}$)

2009: STED-like TPS (*high resolution 3D microfabrication, Fourkas*)

2014: commercial set-up for fast TPS ($m.s^{-1}$)



Spangenberg, Malval, Baldeck et al. ***Intech, Book Chapter* 2013**, *Recent advances in two-photon stereolithography*.

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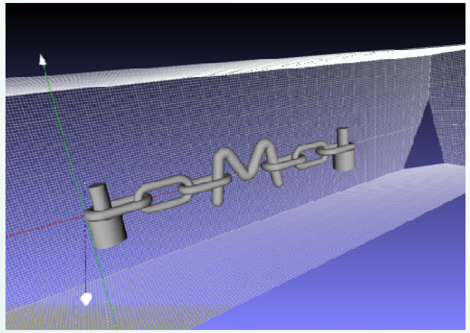
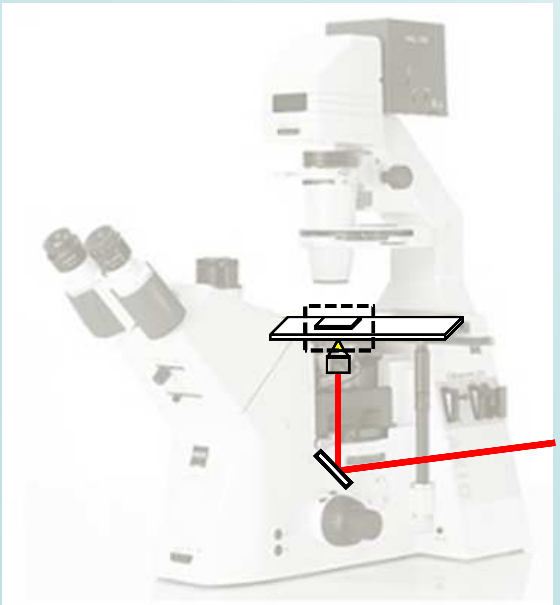
Key steps in two-photon stereolithography (TPS)

1. Identification of user needs (shape, type of materials)

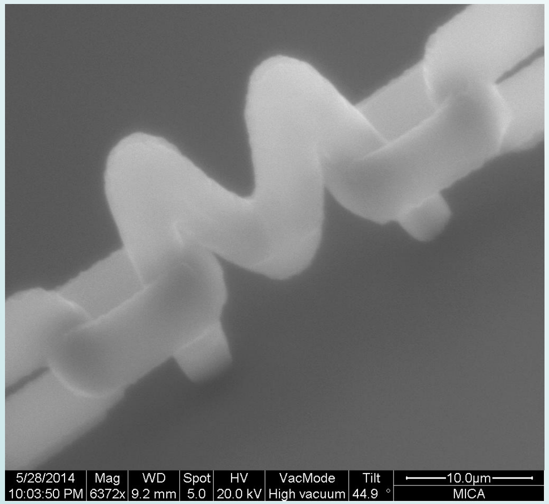
2. Computer aided design software (CAD)



3. 3D Micro/Nanofabrication



4. Characterization (geometric, chemical, mechanical properties, …)



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Photopolymers in micro-nanofabrication

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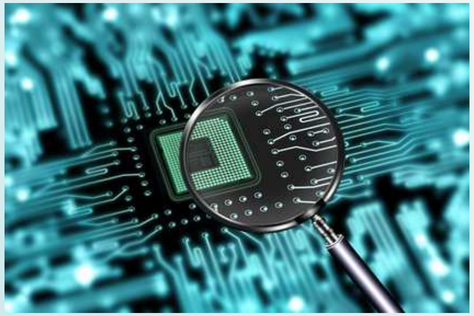
Photopolymers



Micro/Nanotechnologies

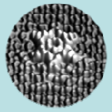
Medecine (dentistery,…)

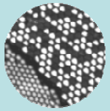
Optics

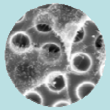
Adhesive (UV glues)

Cosmetics

Coating (car, painting,…)

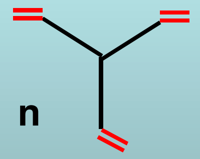






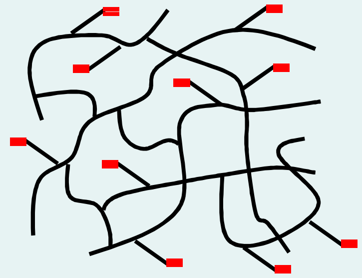
Photopolymers in micro-nanofabrication

Liquid Resin



light

Insoluble 3D polymer



Key components of Photopolymer:

- **Photoinitiators**
  - irradiation wavelength (from DUV to NIR)
  - excitation with 1 or 2 photons
  - efficiency (irradiation time and power)
- **Monomers**
  - final properties of materials (optical, mechanical)
  - conversion (% of reacted monomer)
- **Inhibitors**
  - confinement of the photoinduced reaction
- **Additives**
  - fluorescent, metallic, (…) NPs
  - dyes
  - other properties (conduction, magnetism,…)

Advantages :

- Broad range of materials / applications
- Ultra-fast polymerization (<1 sec)
- Reaction at room temperature, under air
- Low energy consumption
- Temporal and spatial control of the reaction