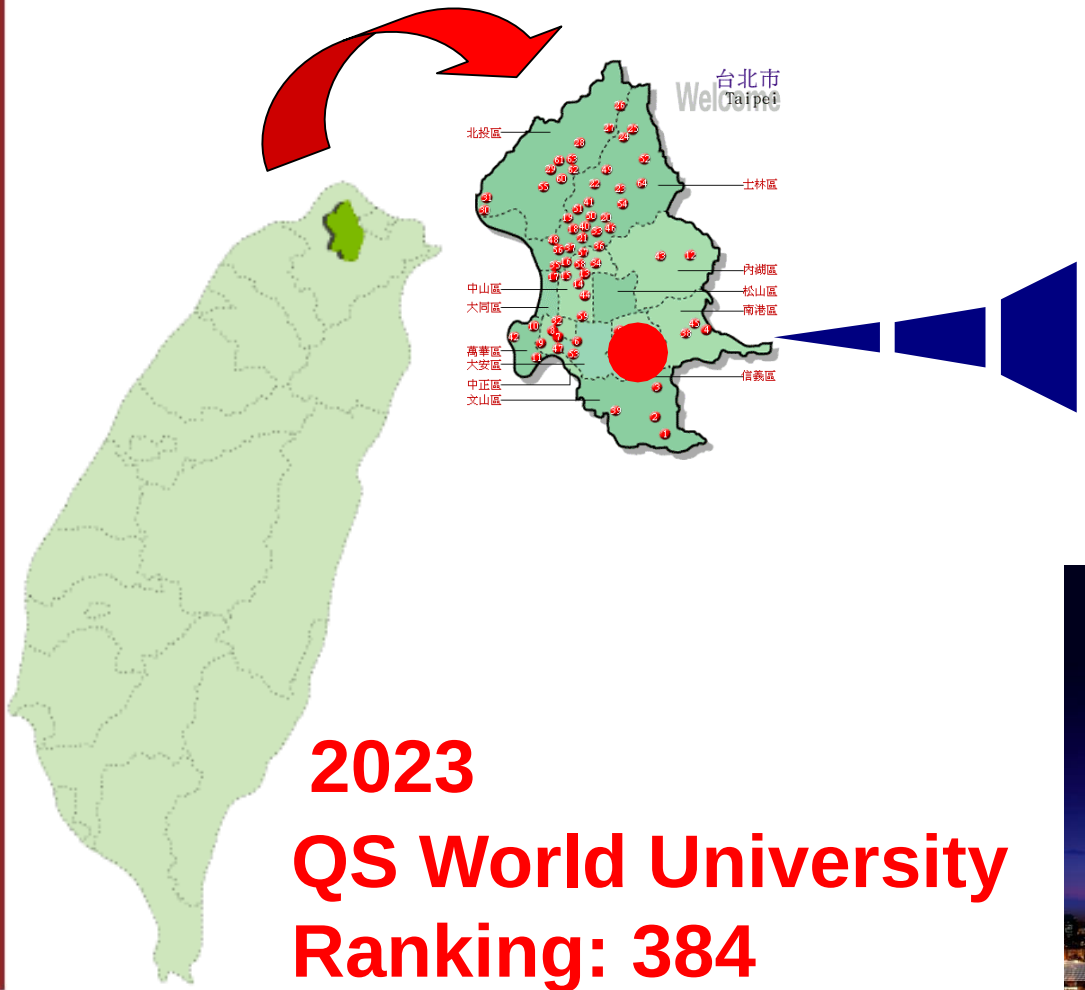
Digital oral engineering in the future

Prof. and Chairman Yung-Kang Shen

School of Dental Technology
College of Oral Medicine
Taipei Medical University

Taipei Medical University
TMU



2023
QS World University
Ranking: 384

Abstract

•The traditional skill by hand keeps so many years for dental technology (DT). Digital oral engineering (DOE) is a feature in response to the digital age.

•The future of digital oral engineering includes the forward engineering, reverse engineering, 3D printing, 4D Printing and artificial intelligence (AI).

•Three major initiatives-renovation of traditional dental technology, recognition of contemporary dental materials, and innovation of the digital oral engineering must be combined together.

Dental Technology Education in TMU

College of Oral Medicine at TMU

- **College of Oral Medicine (COM)**

The college provides a framework for a complete oral medical education system, which includes three schools and Master's and PhD programs.

- ✓ **School of Dentistry**
- ✓ **School of Dental Technology**
- ✓ **School of Oral Hygiene**

School of Dental Technology at TMU

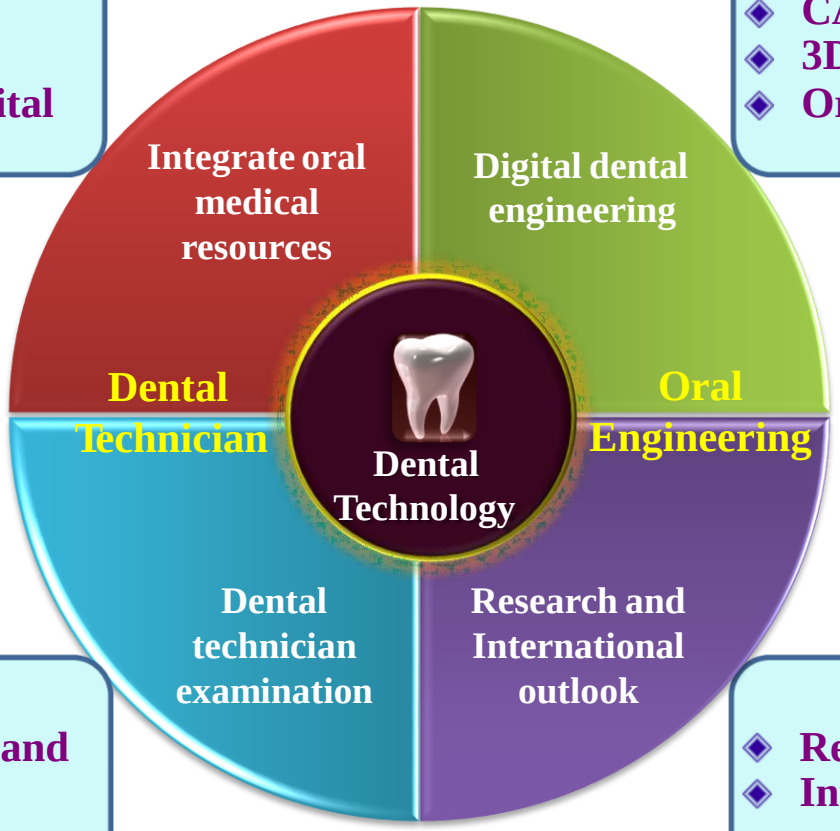
- **History of School of Dental Technology :**
  1.School of Dental Technology was established in August, 2007.
  2.The Master of Science (MS) program was established in August, 2017.

- **Three major initiatives are taken to fulfill this vision:**
  1. Renovation of the traditional dental laboratory technology.
  2.Recognition of the contemporary dental materials and instrumentation.
  3. Innovation of the digital dentistry.

Educational Goal

- College of oral medicine
- School and Hospital

- CAD/CAM
- 3D/4D print
- Oral reconstruction



- Communication and competition

- Research seminar
- Internship abroad

Learn Environment

Laboratory

Video equipment

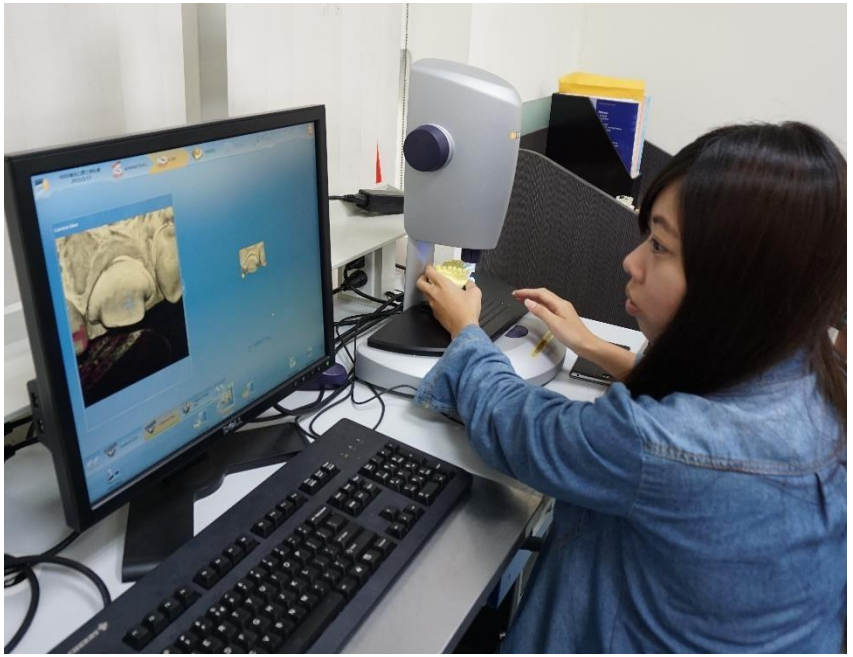
Learn Environment

Technical room

Casting room

Learn Environment

Porcelain oven



Digital oral design

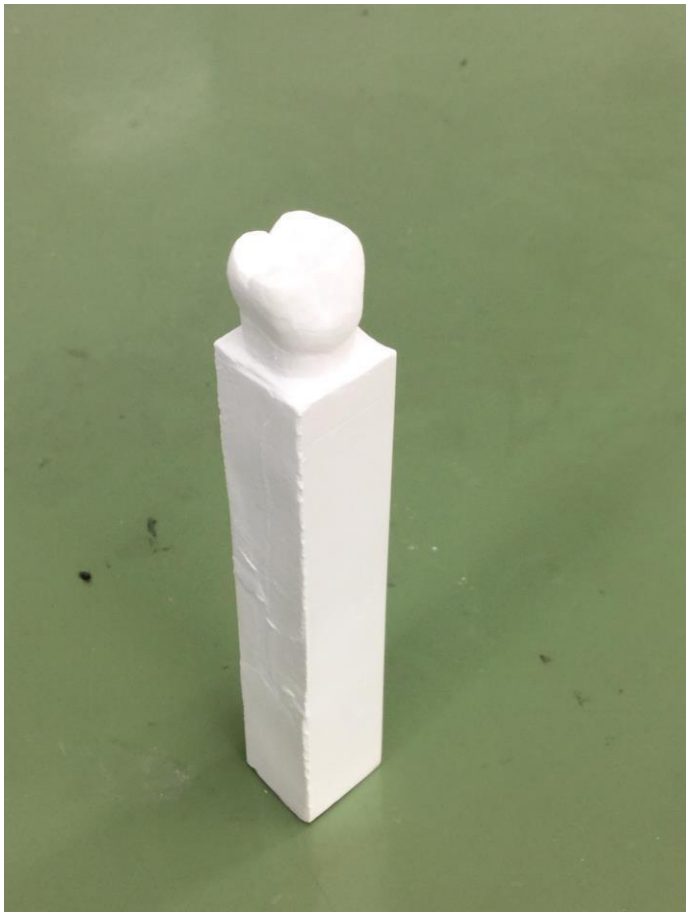
Course Maps

Internship

	Freshman	Sophomore Tear	Junior Year	Senior Year
Technician	• Compulsory subject	• Computer aided drafting • Medicine & the aesthetics of image	• Computer aided design & manufacture • Digital oral engineering	• Dental implant • Operation of digital oral engineering • Operation of dental technology
Core course (Compulsory)				
Research	• Compulsory subject	• Metal materials • Biomedical engineering • Seminar (one) • Seminar (two)	• Biomaterials • Regenerative medicine in dentistry • Seminar (three) • Seminar (four)	• Seminar

Research program

Traditional skill by hand



Digital Oral Engineering

Digital Oral Engineering

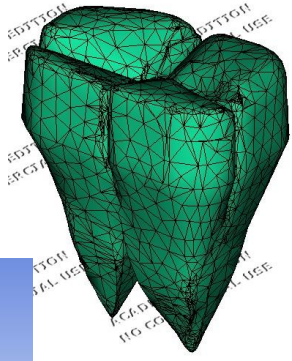
Forward Engineering

Reverse Engineering

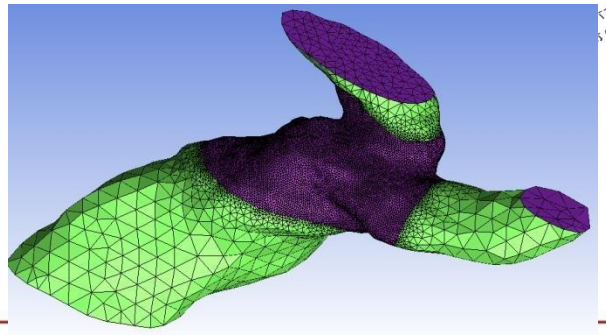
Forward engineering

- Computer Aided Design (CAD)
  - ✓ Solid work

- Computer Aided Engineering (CAE)
  - ✓ ANSYS, MoldFlow



- Computer Aided Manufacturing (CAM)
  - ✓ 3D Shape



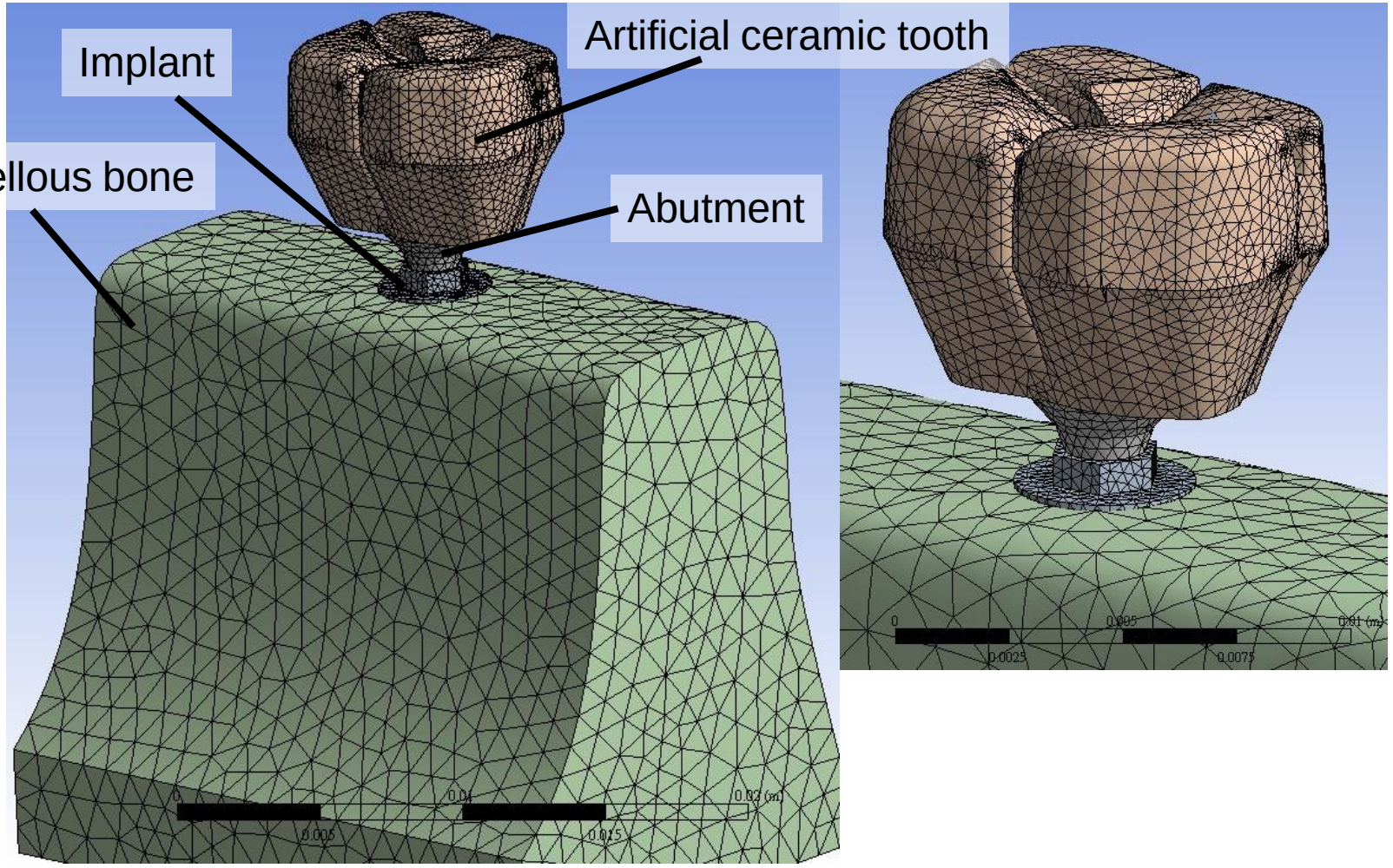
Computer Aided Design (CAD)

Computer Aided Engineering (CAE)

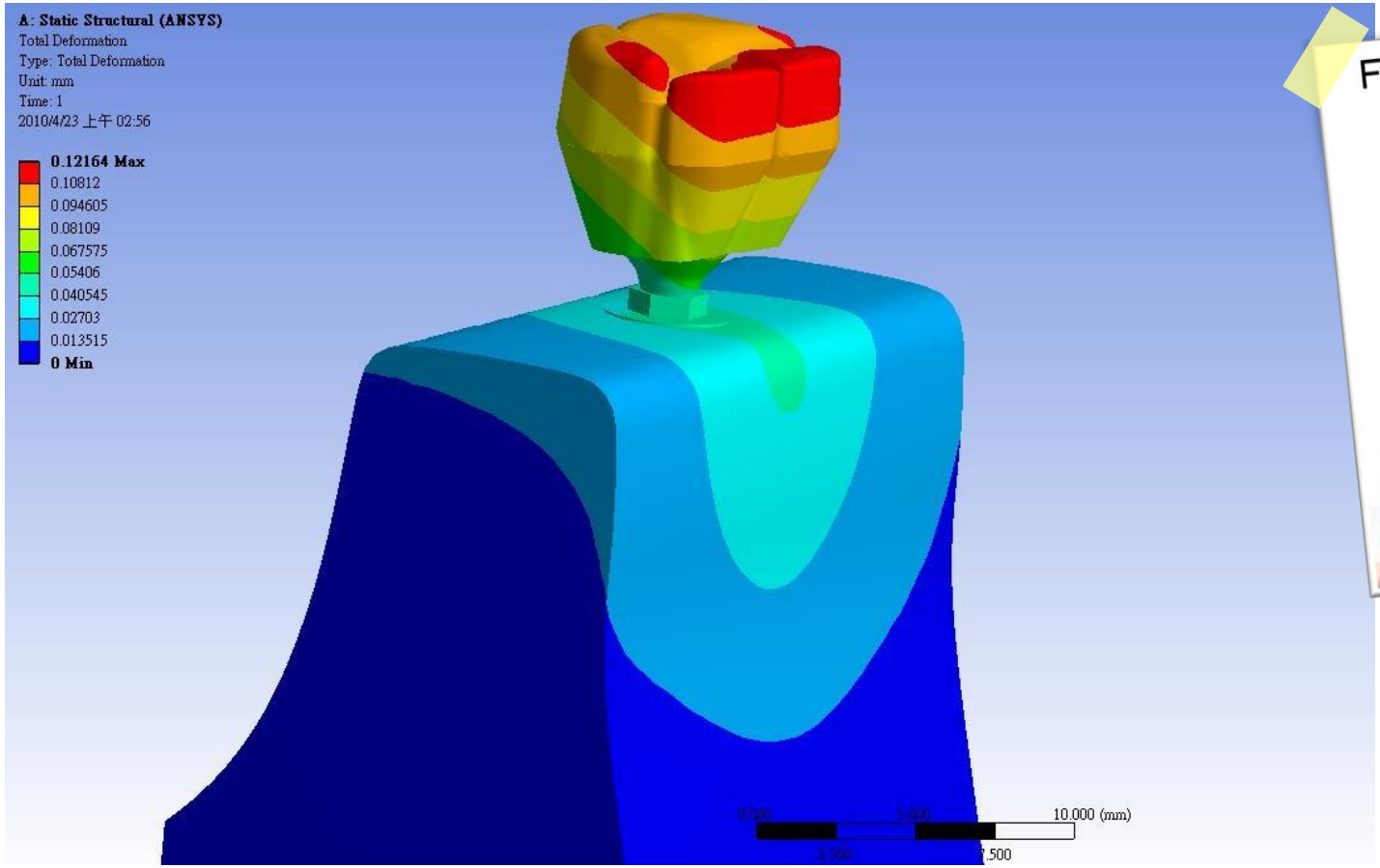
Solid Mechanics (ANSYS Software)

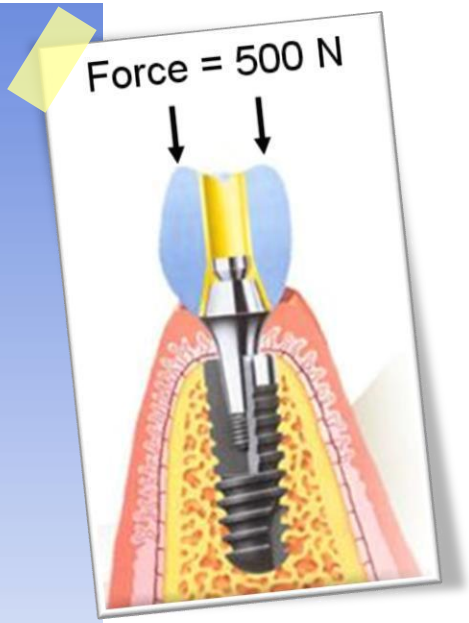
Fluid Mechanics (MoldFlow Software)

FEA model

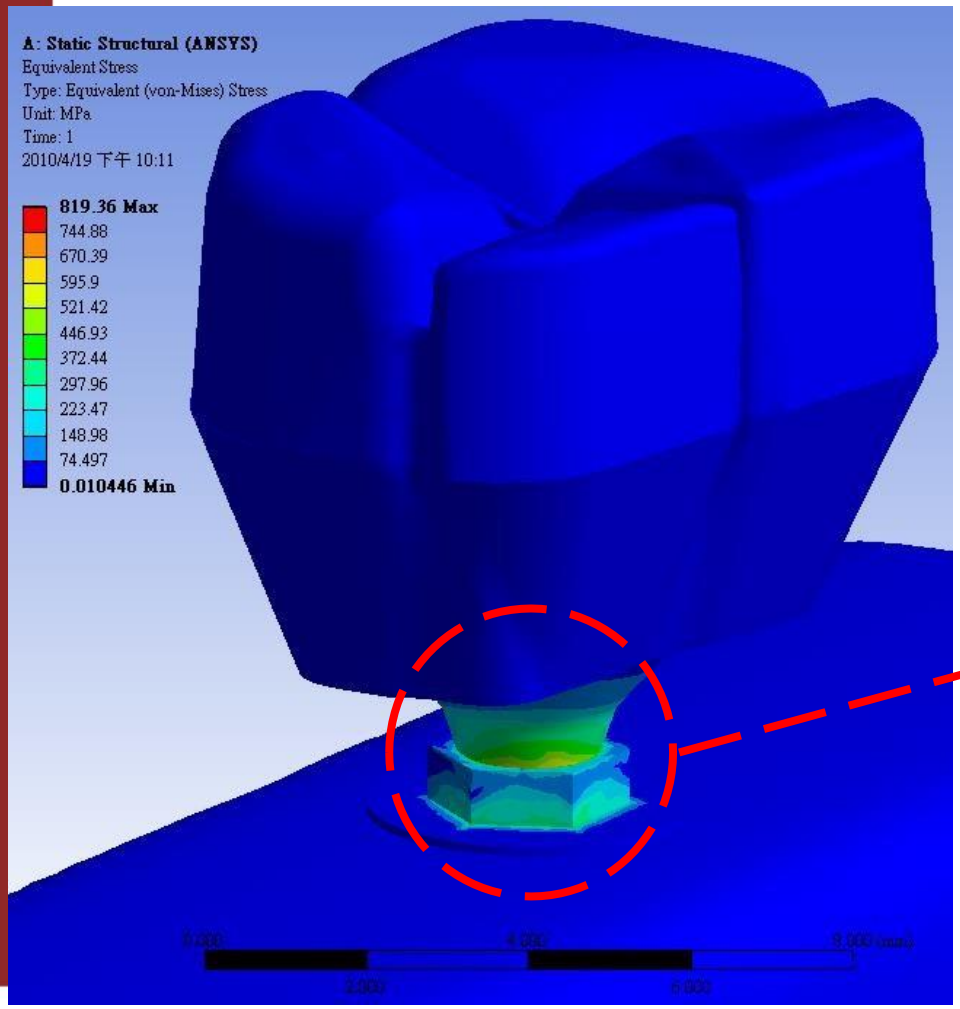

Implant
Artificial ceramic tooth
Cancellous bone
Abutment

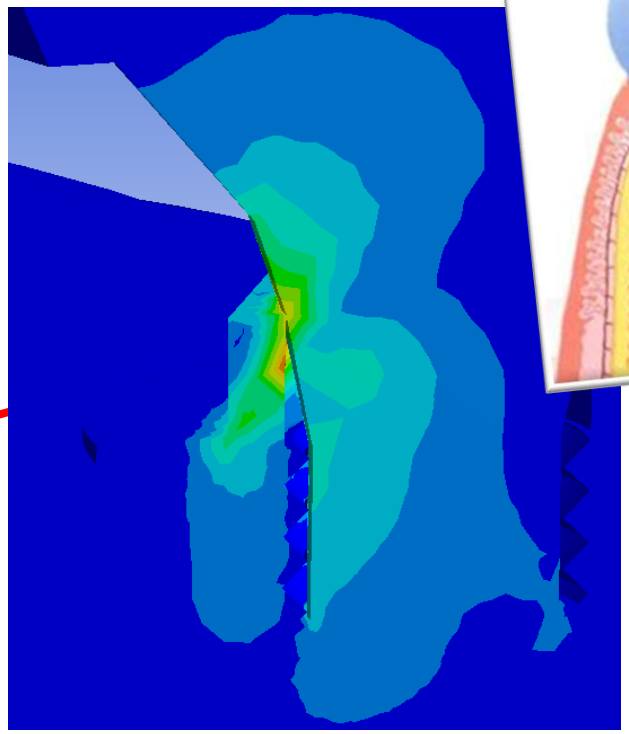
Deformation

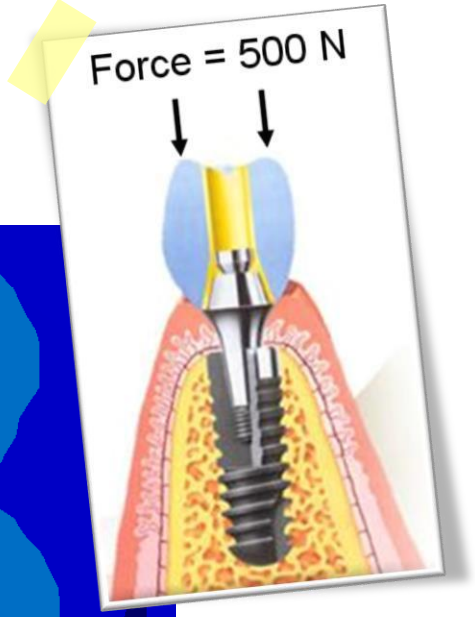




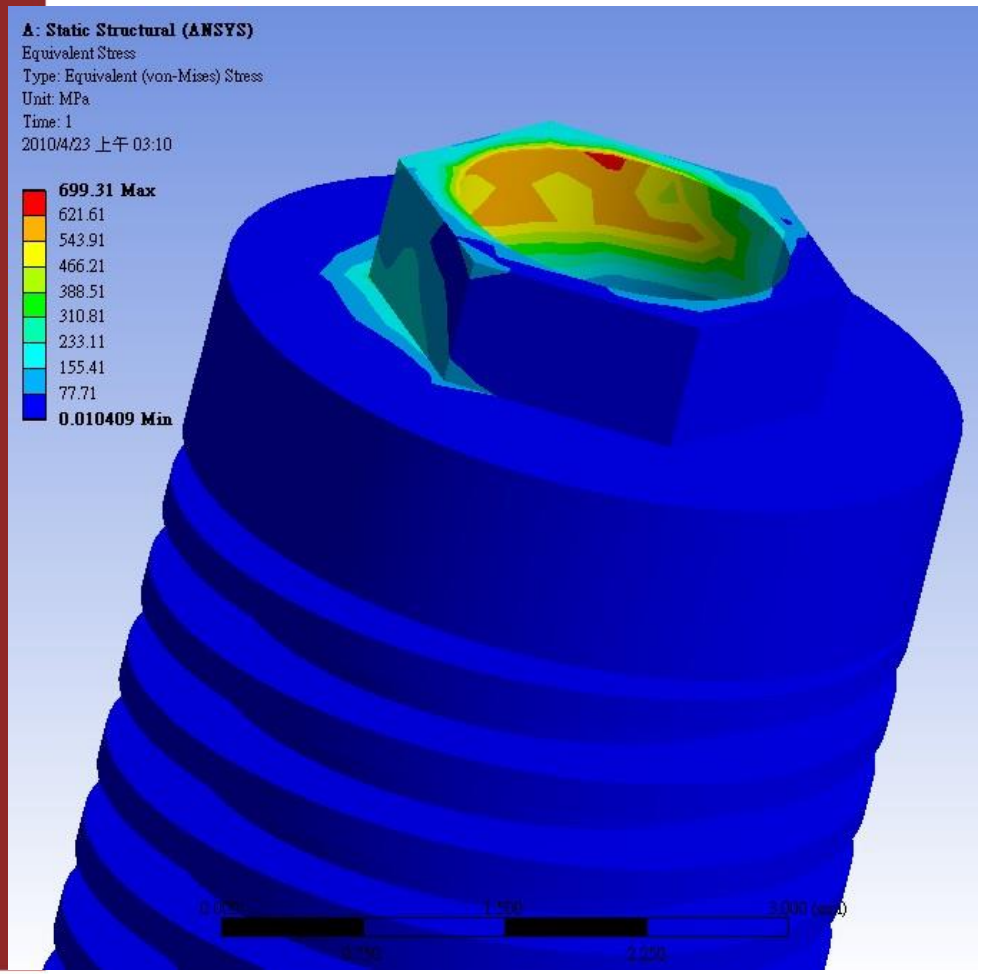
Von-Mises Stress (Abundant)

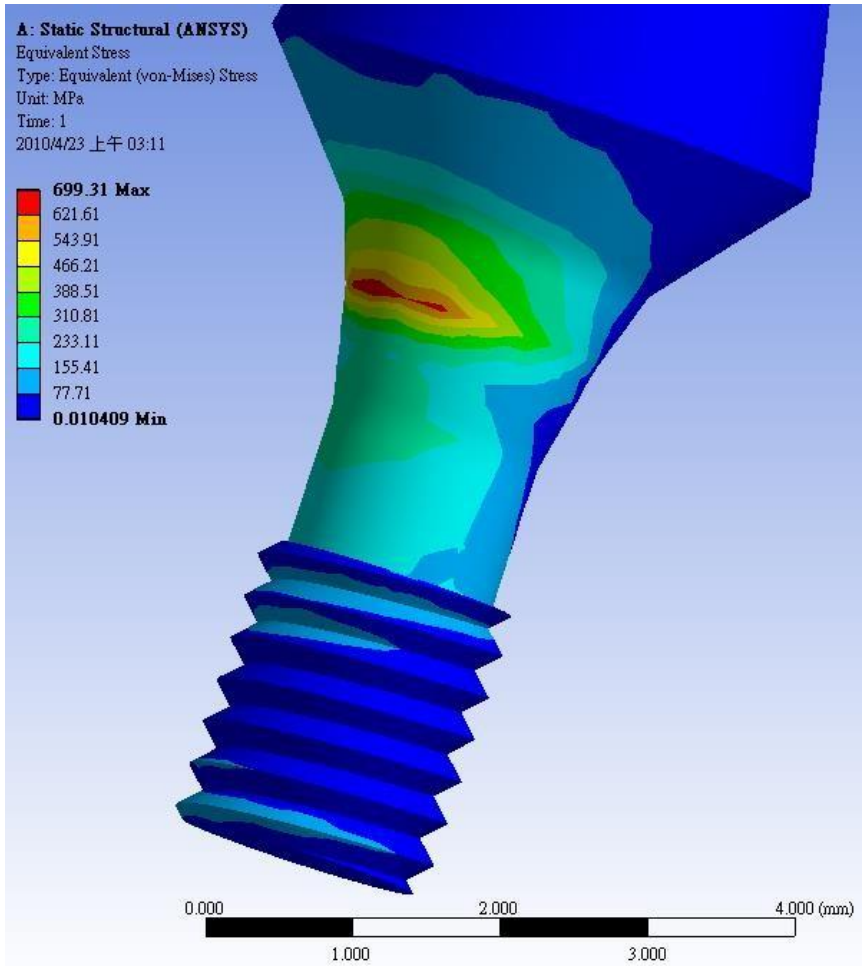




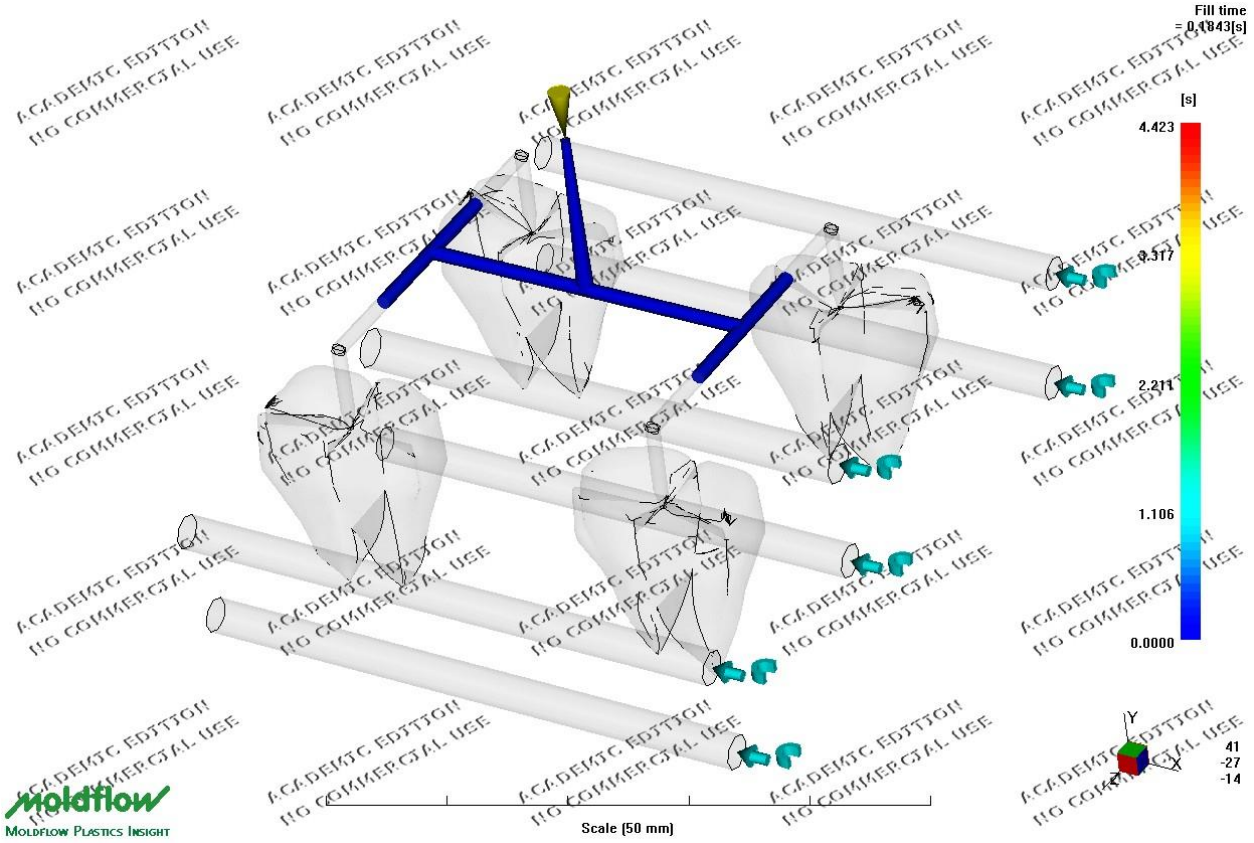


Von-Mises Stress (Abundant)

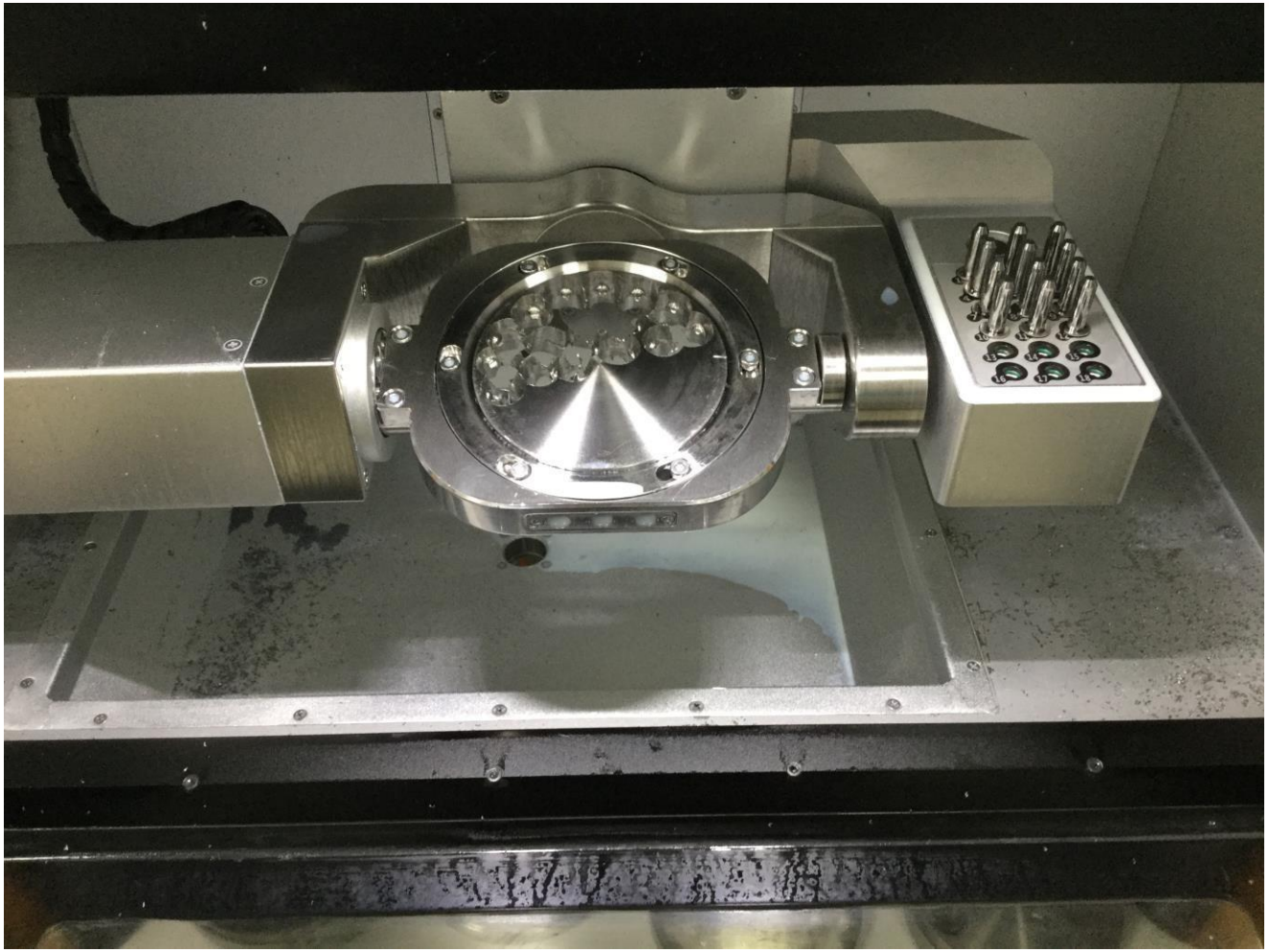




Moldflow Analysis



Computer Aided Manufacturing (CAM)



Reverse engineering

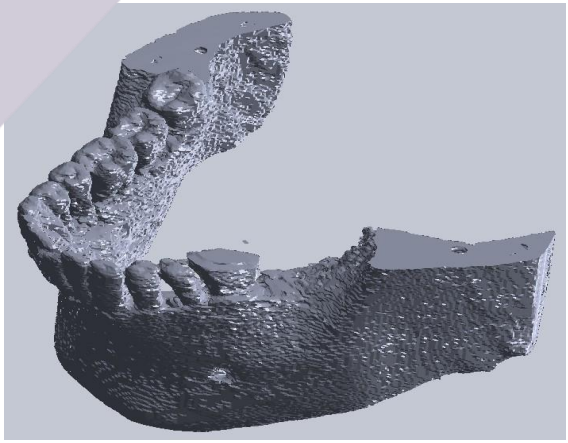
CT image building

Input (.dicom)

Software (MiiL and Amira)

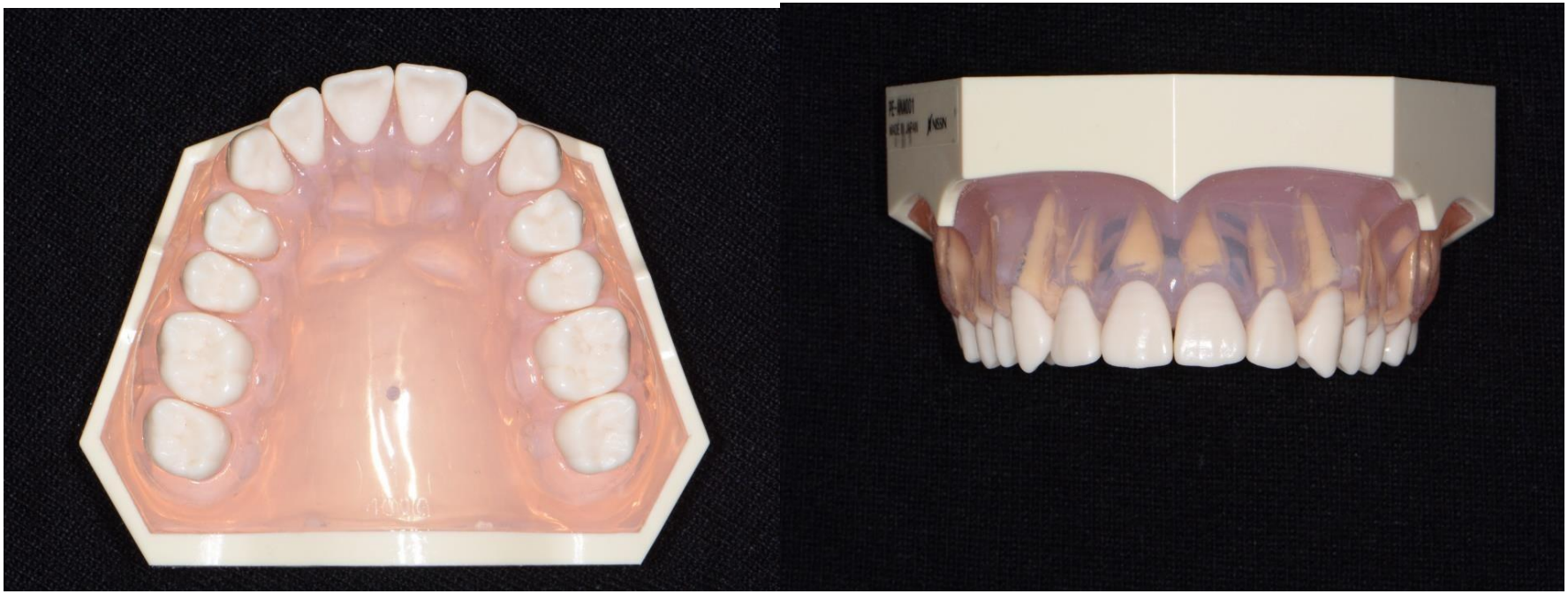
Output (.stl)

圖片來源:
北醫 黃瓊芳醫師提供



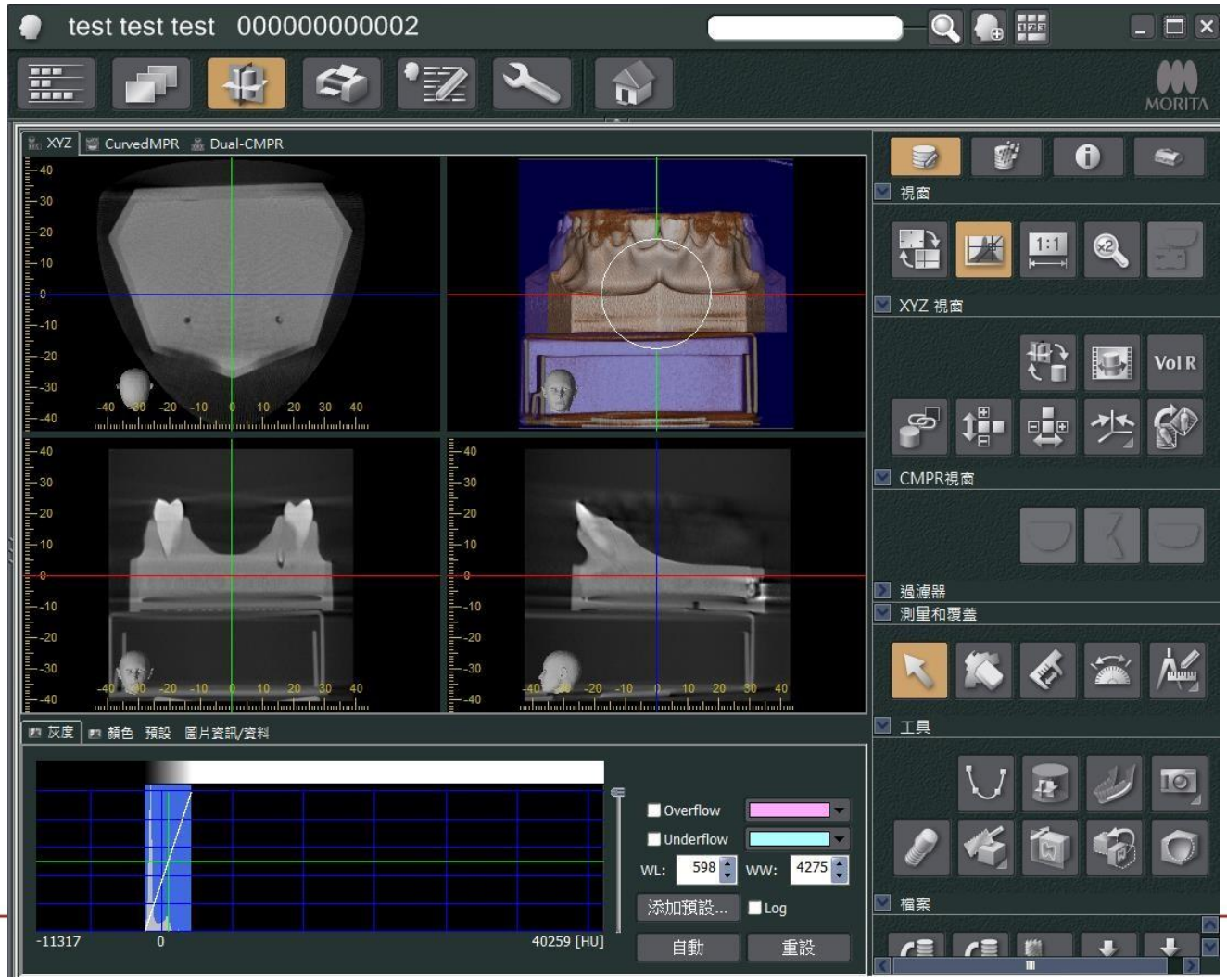
Dental Model

- Nissin Dental Model: I21D-400G



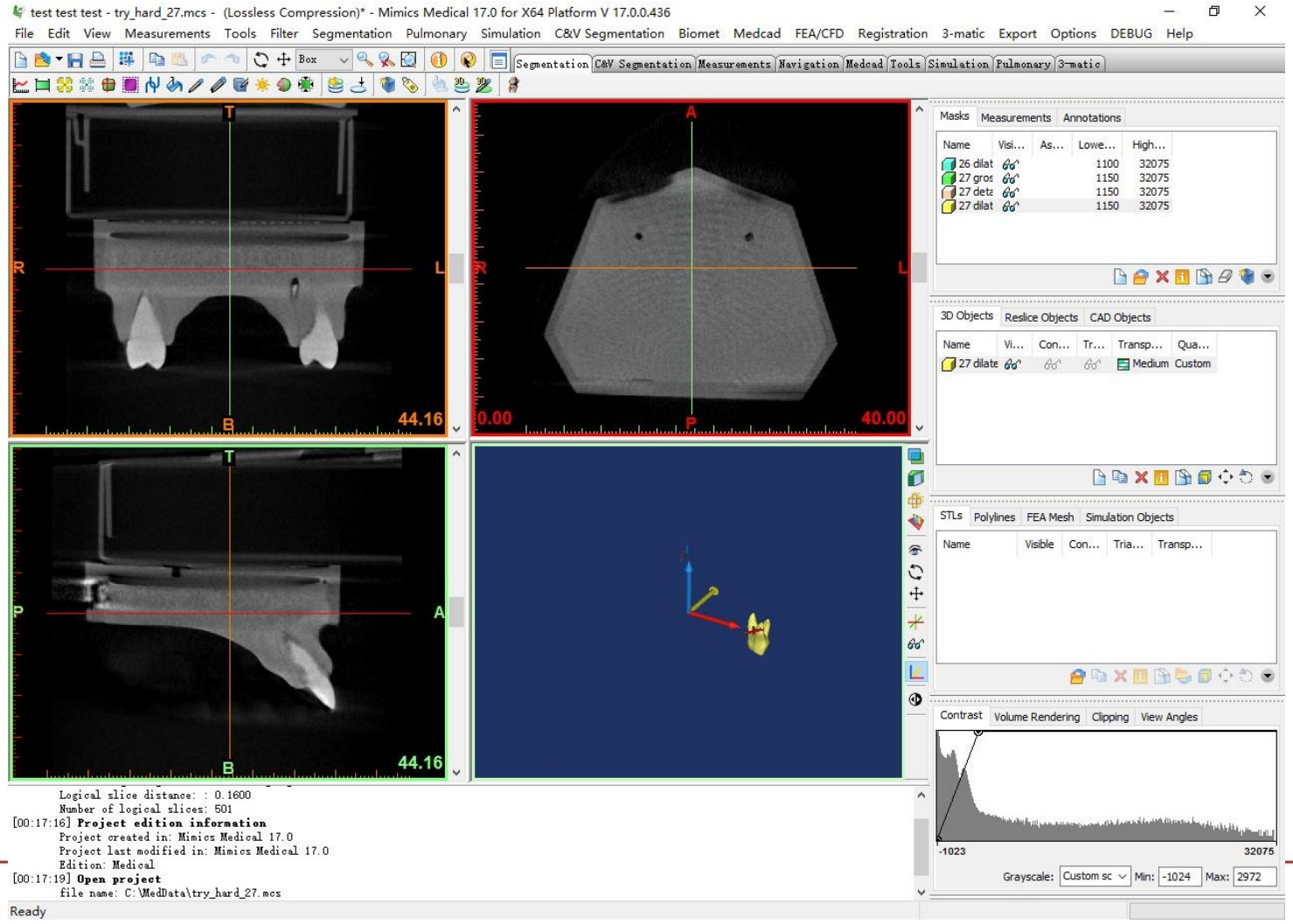
Imaging: Dental cone beam CT *.dicom*

- Morita Veraviewepocs 3D R100



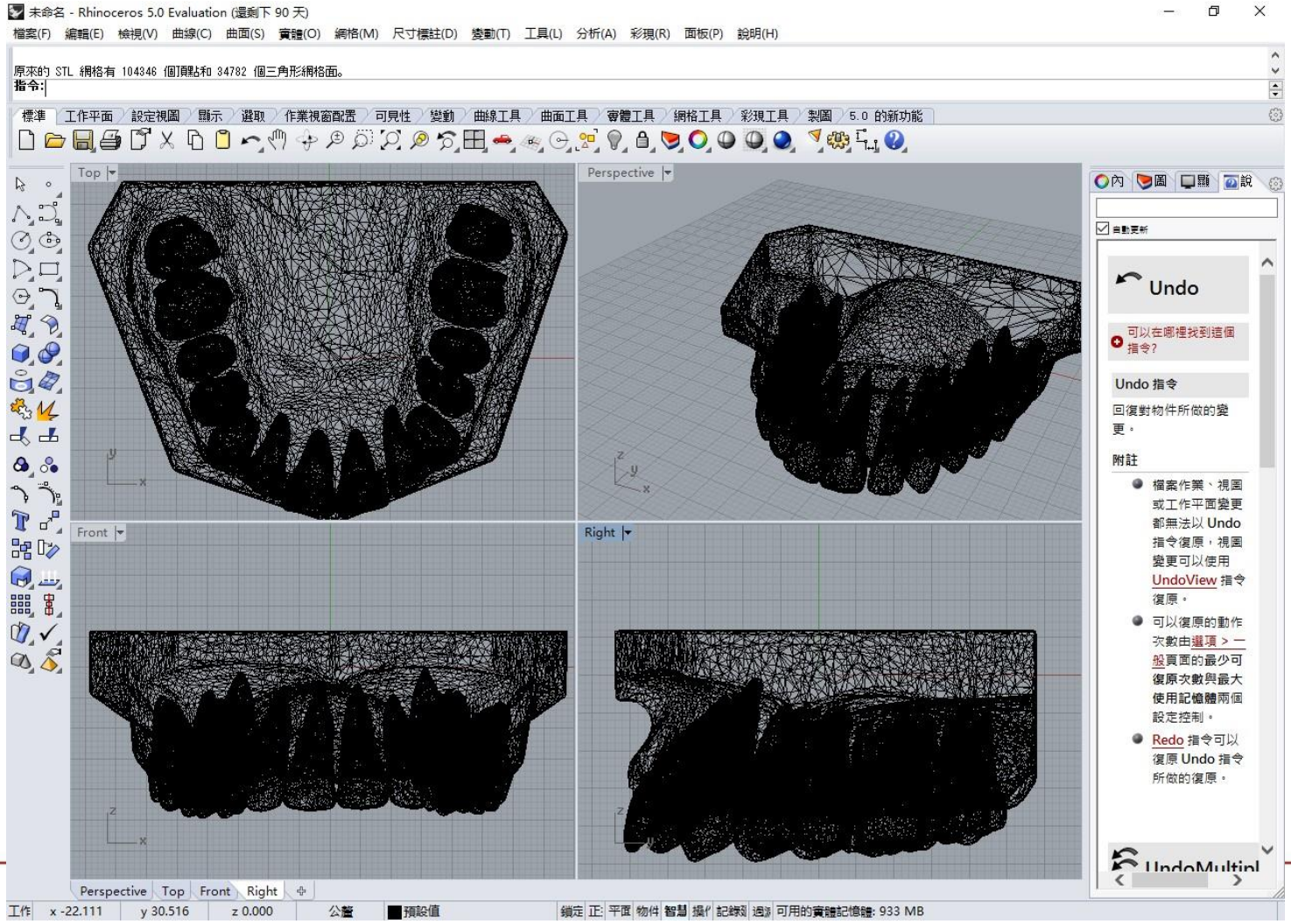
Tooth & bone Modeling: Mimics *.stl*

- Mimics 17.0



PDL & Assembling: Rhino *.3dm*

- Rhino 5.13.60913.21340

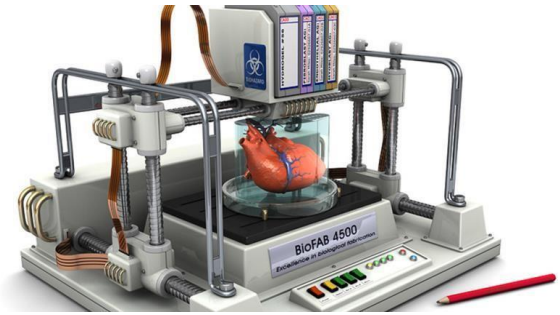


3D/4D Printing

3D/4D printing

Traditional 3D/4D printing
(Metal, Polymer, Ceramic, …etc.)

3D/4D bioprinting
(Cell, Hydrogels, …etc.)



3D printing

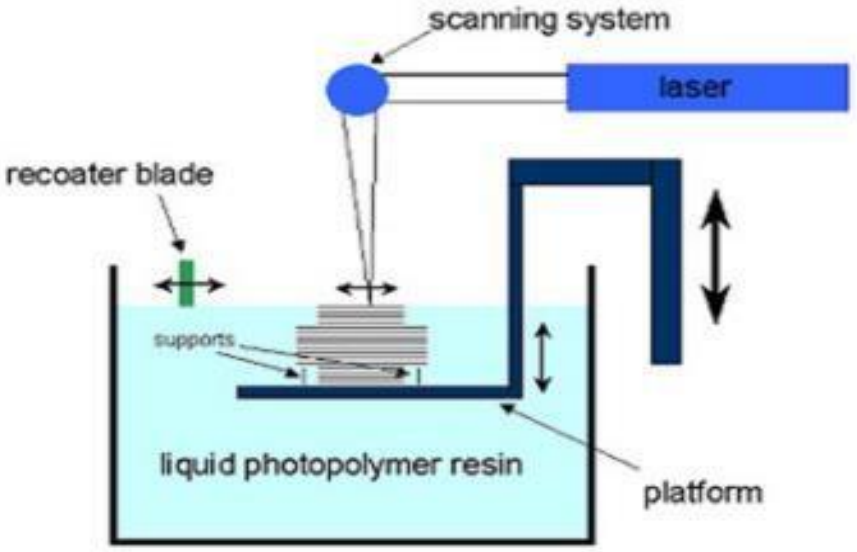
Chuck Hull, 3D Systems, 1984

3D printing

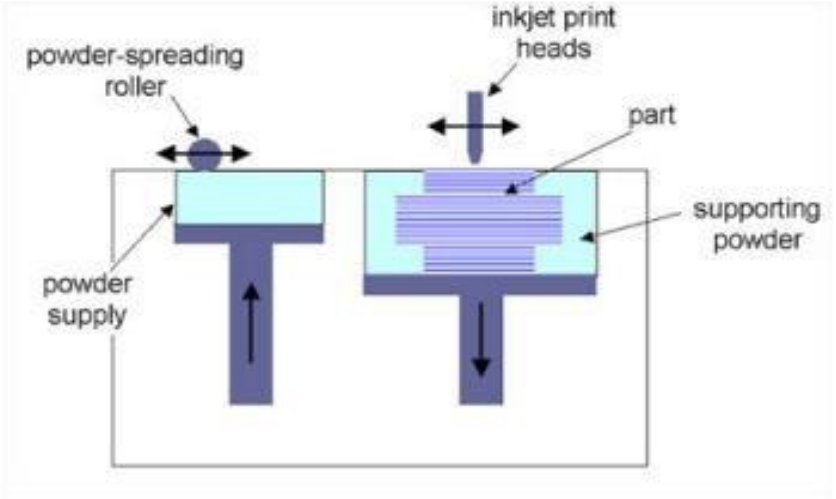
Rapid Prototyping (RP)

Additive Manufacturing (AM)

Types of 3D Printing



(a) SLA



(c) 3D printing

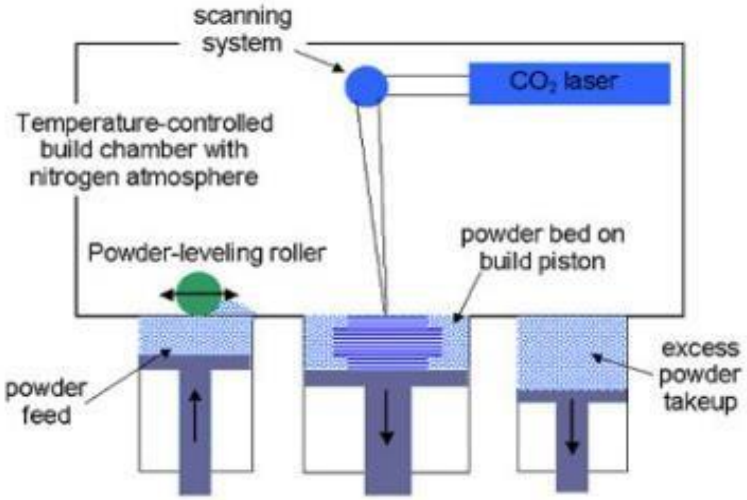
Stereo lithography apparatus (SLA)
(Photo polymer)

3D Printing (3DP)
(Polymer)

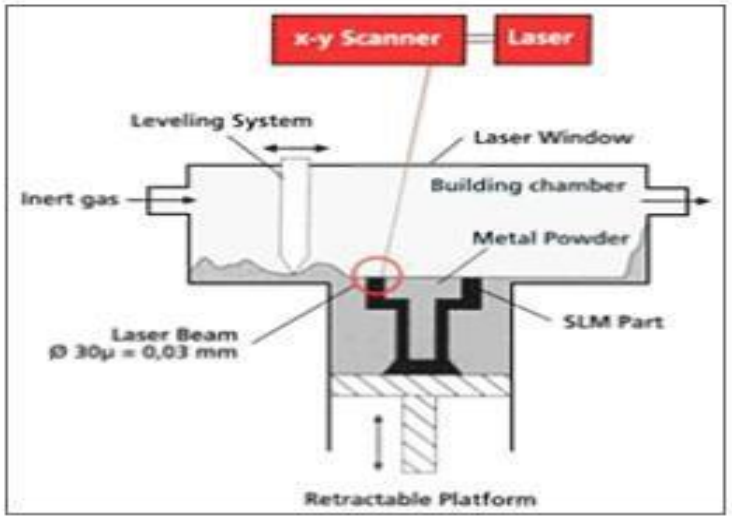
3D Systems, Envision TEC

3D Systems, ExOne, Voxeljet

Types of 3D Printing *(Cont.)*



(b) SLS



(d) SLM

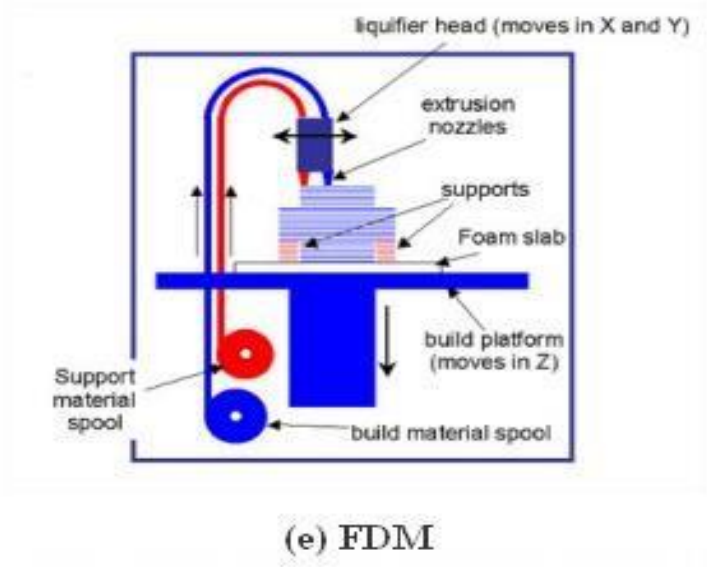
Selective laser sintering (SLS) (Metal, ceramic)

EOS, 3D Systems, Arcam AB

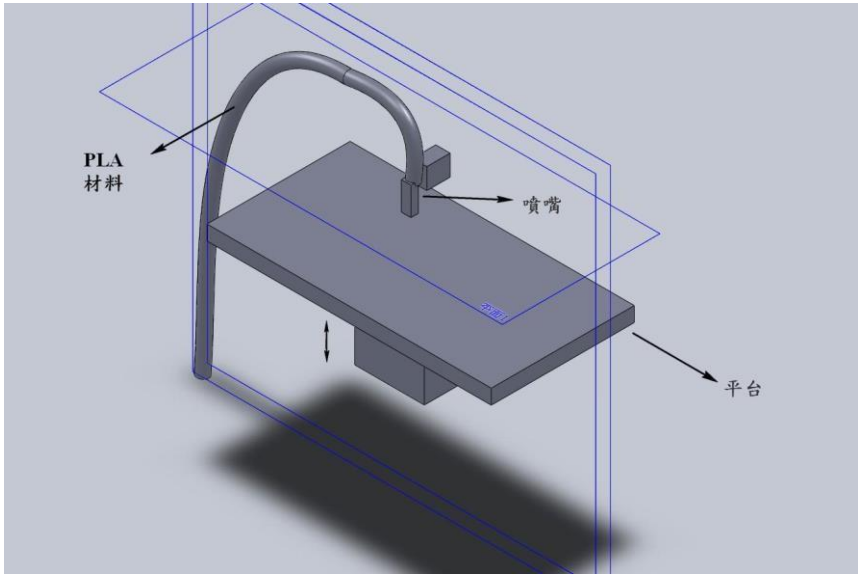
Selective laser melting (SLM) (Metal, ceramic)

EOS, 3D Systems, Arcam AB

Types of 3D Printing *(Cont.)*



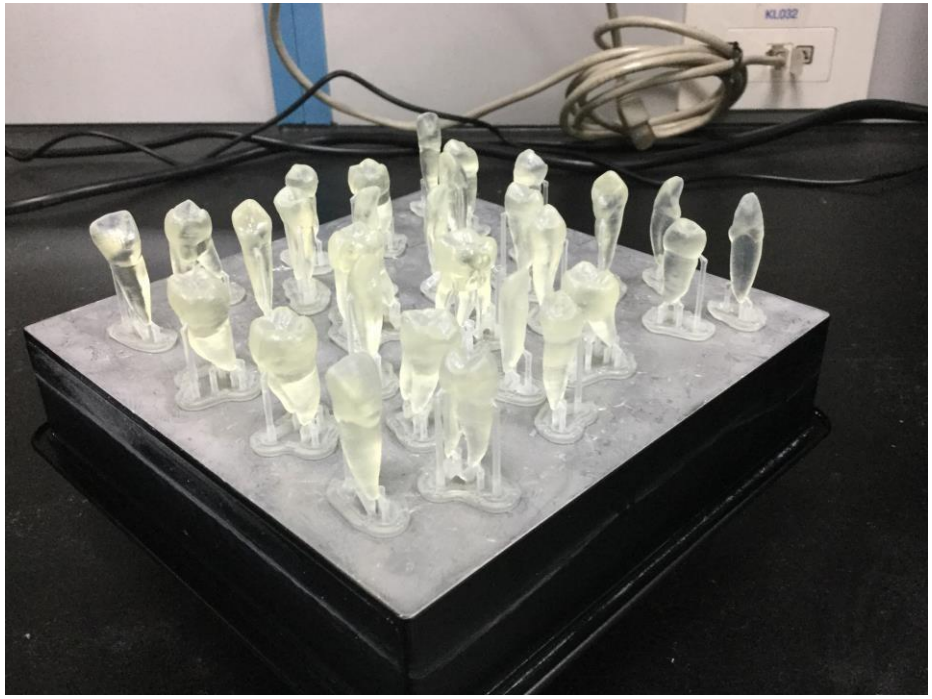
(e) FDM



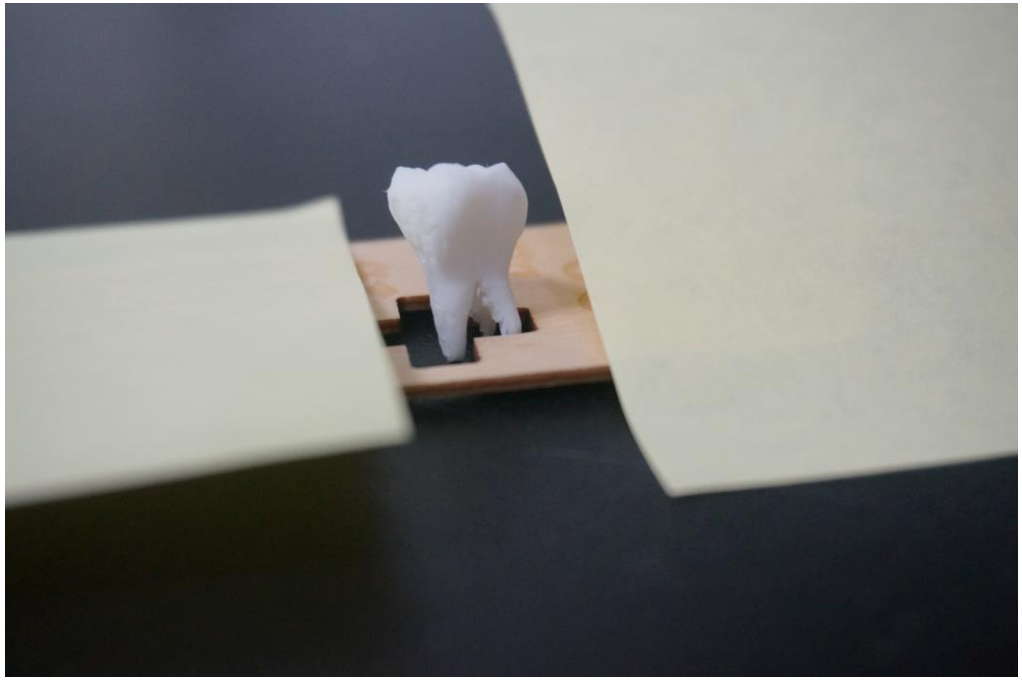
Fused deposition modeling (FDM)
(Polymer)

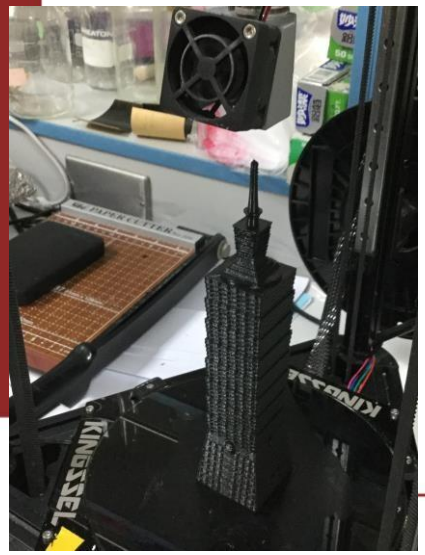
Stratasys, RepRap, Bits from Bytes

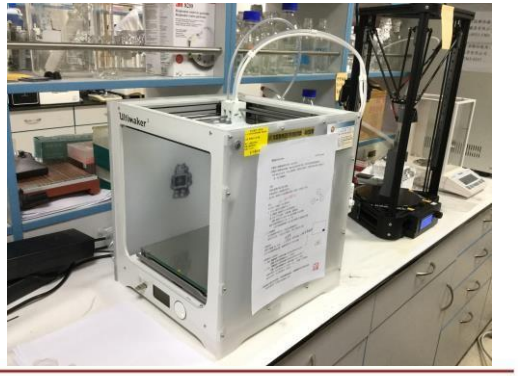
Stereo lithography apparatus (SLA)



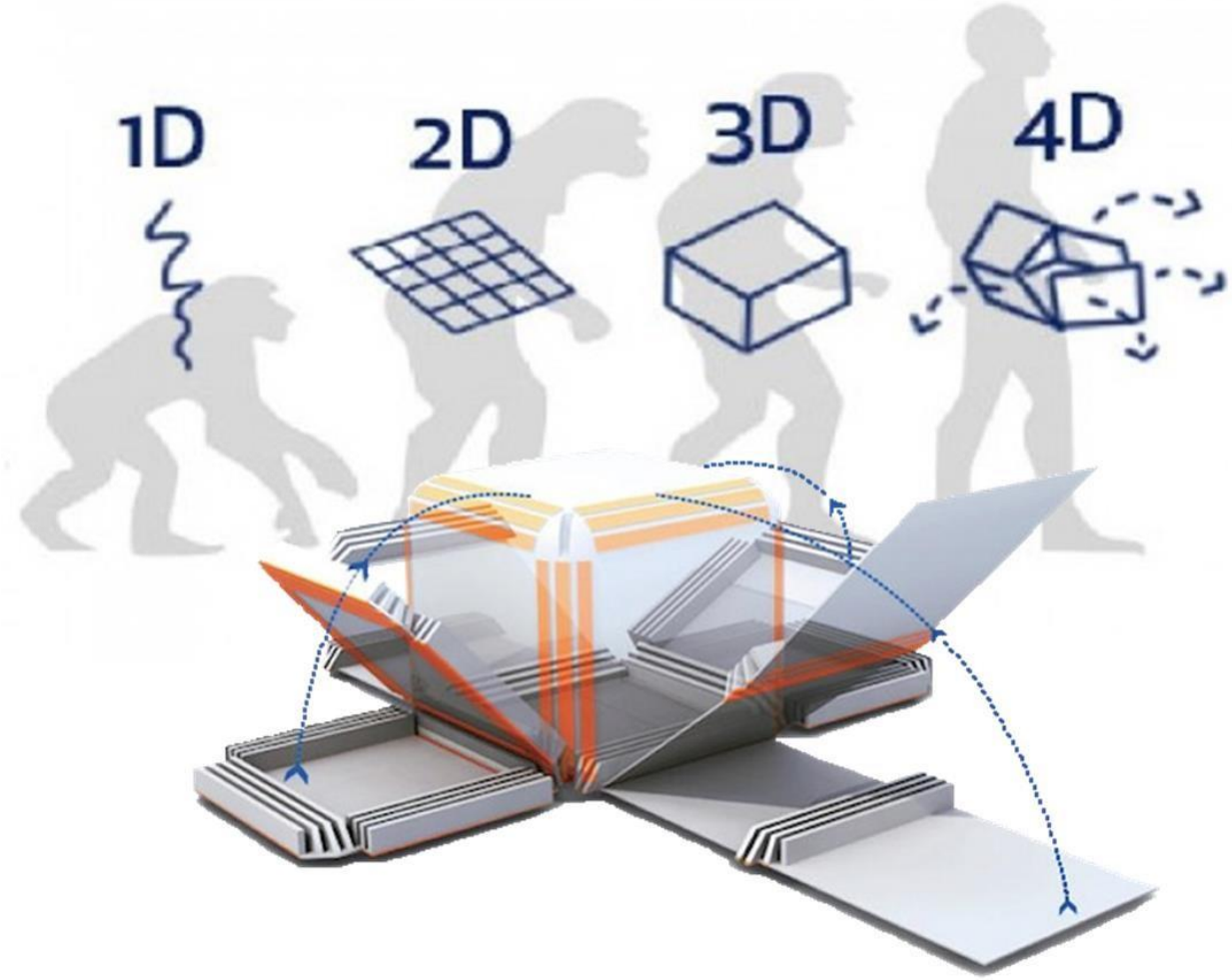
Fused deposition modeling (FDM)





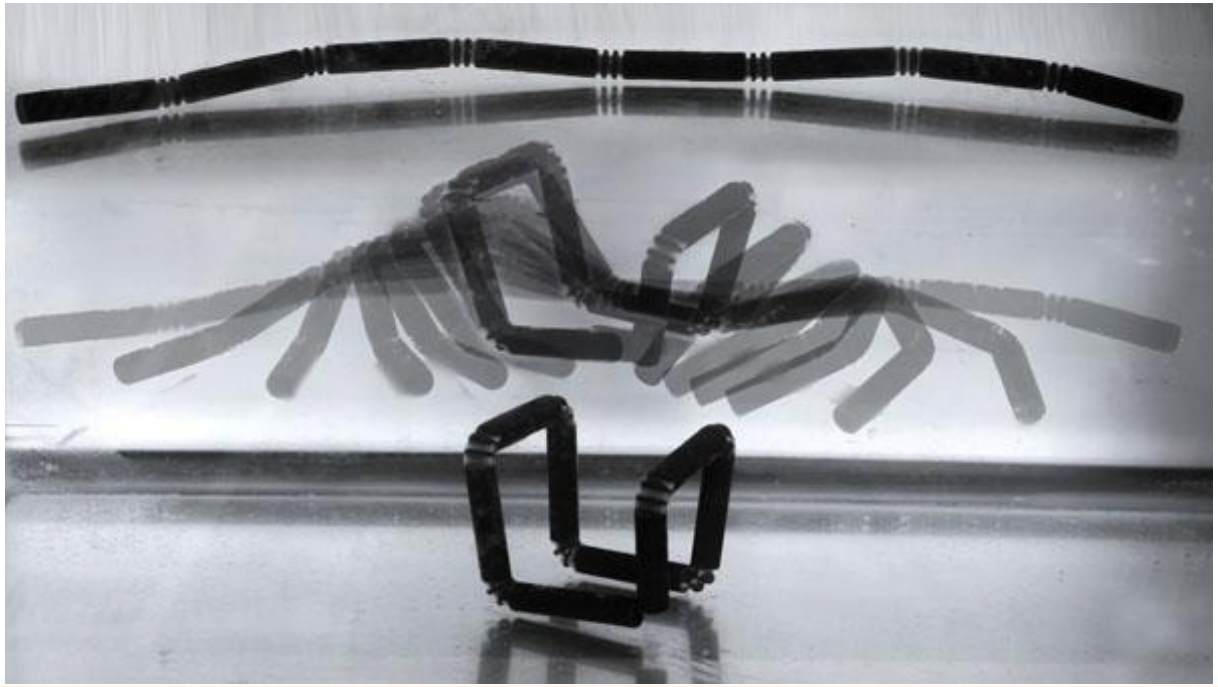


4D printing

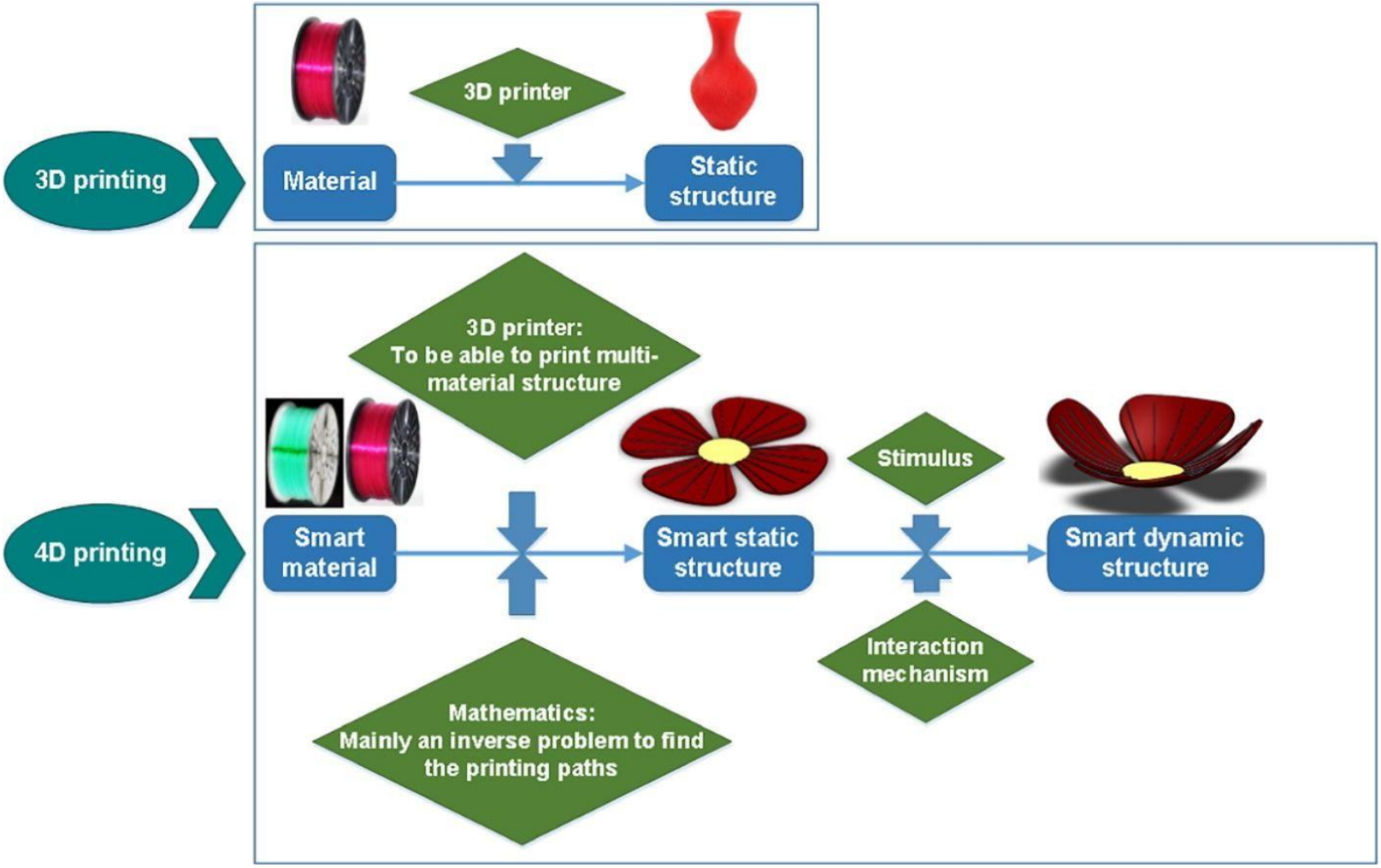


4D printing (Tibbit, MIT, 2013)

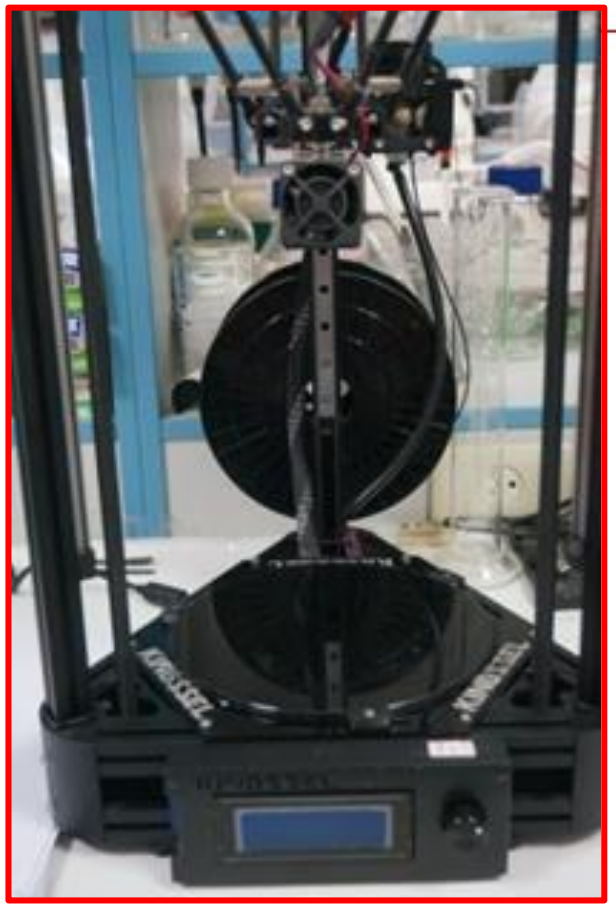
3D printing + Shape memory material + Time = 4D printing



Comparison between 3D and 4D printing



Materials and methods

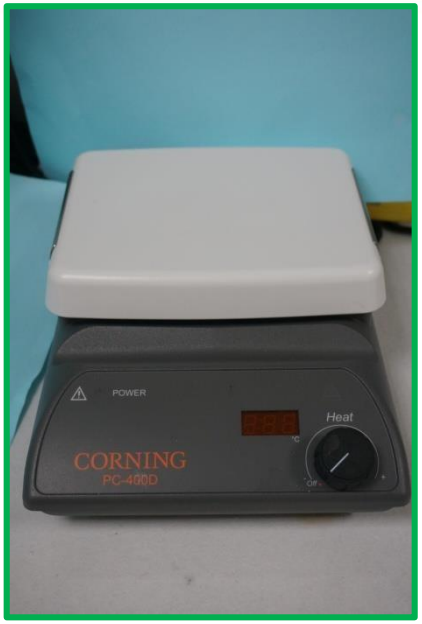


3D printer

FDM , Kingssel, Taiwan

Smallest dimension: 400 μm

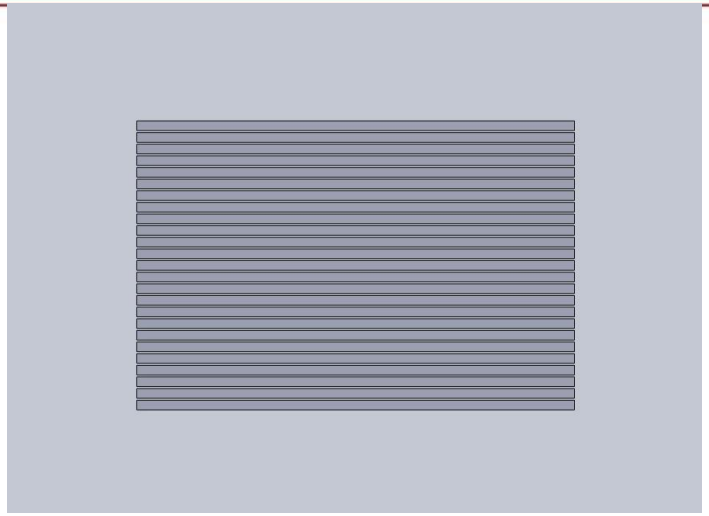
Stimulus (Temperature)

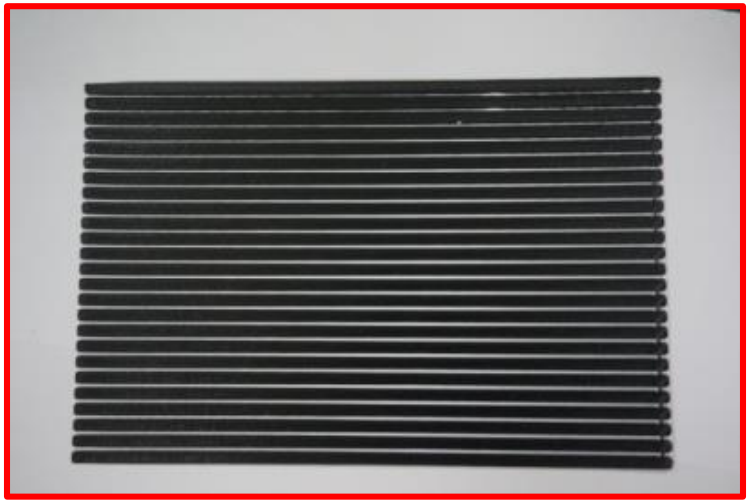


Hot plate, Corning, USA,
Heating range: 0-500℃

Temperature: 145℃、150℃、180℃
Time: 0 -18 sec

Shape memory composites (paper/PLA)





Rectangle (paper or bamboo) : 90mm×59.2mm×0.11mm

Strip (polylactic acid (**PLA)): 90mm×1.6mm×0.4mm**

Pitch for strip: 0.8mm

$\alpha_{paper} = 0$

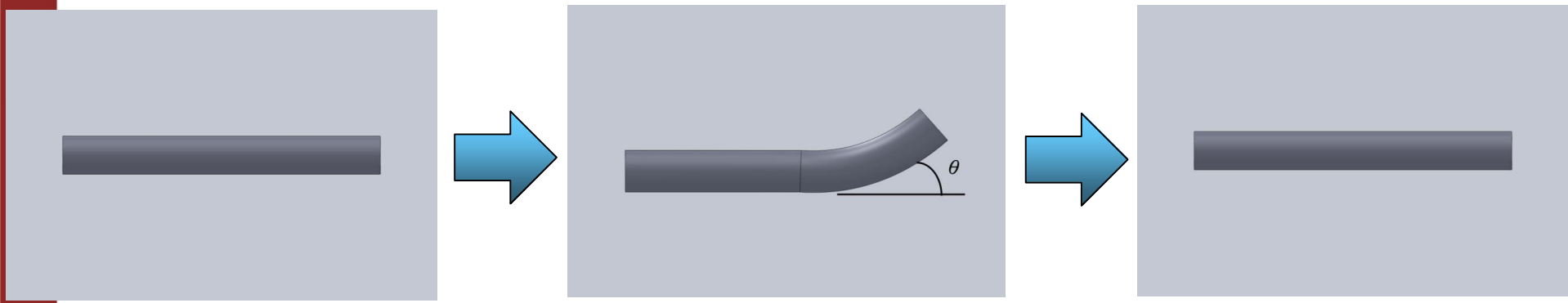
$\alpha = 6*10^{-5} / K$

E = 3.5 GPa

$\rho = 127\ kg/m^3$

$\nu = 0.33$

Deformation & recovery



Original

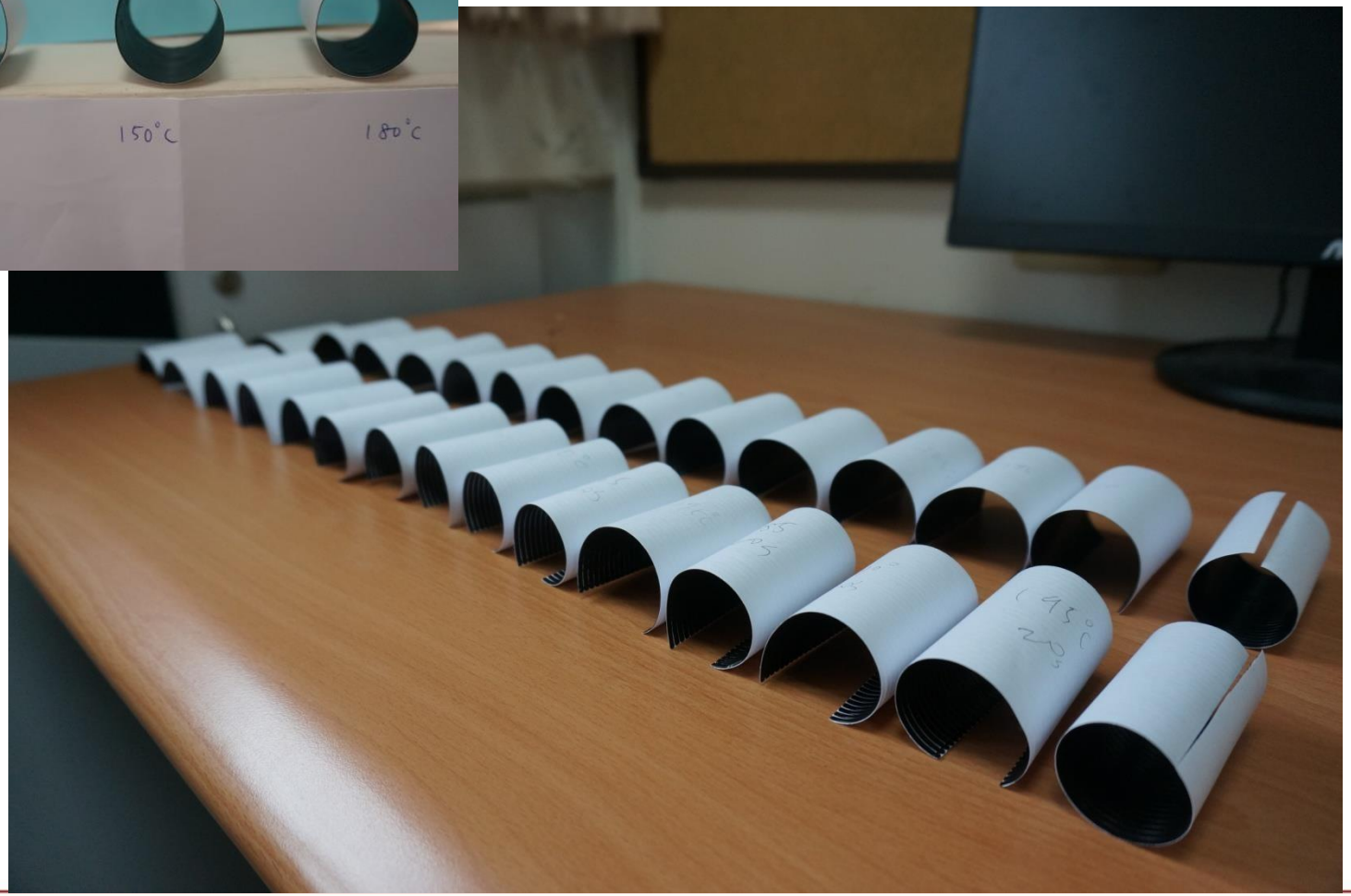
Deformation

Maximum

Recovery

Minimum

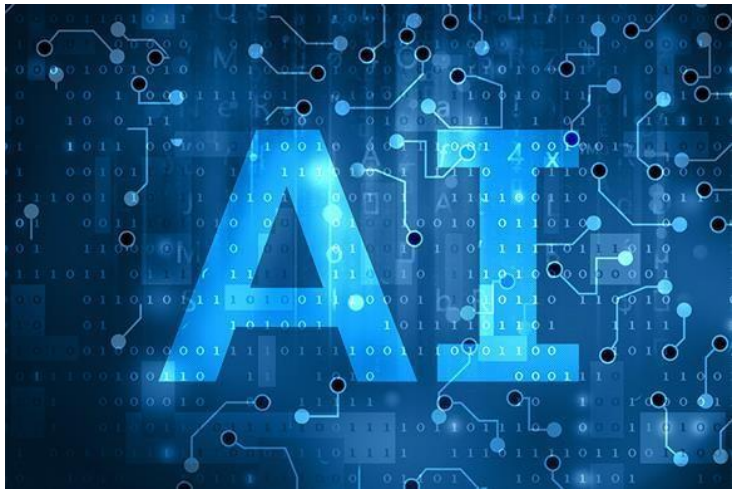
Different situations in experiment

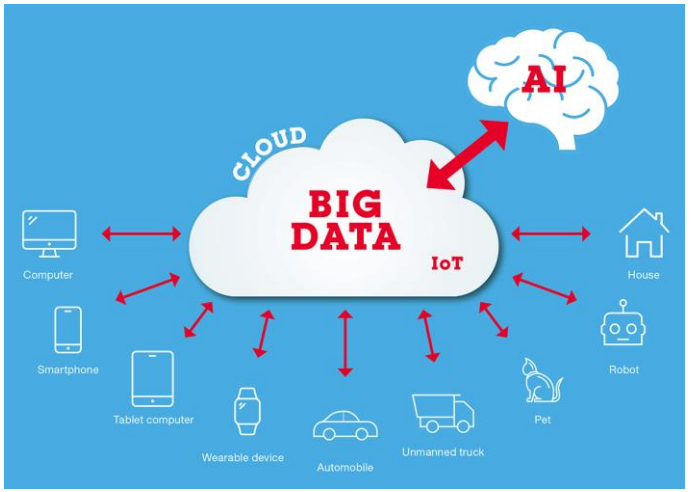


Traditional technique

By hand, Experience, Training → **Good Morphology**

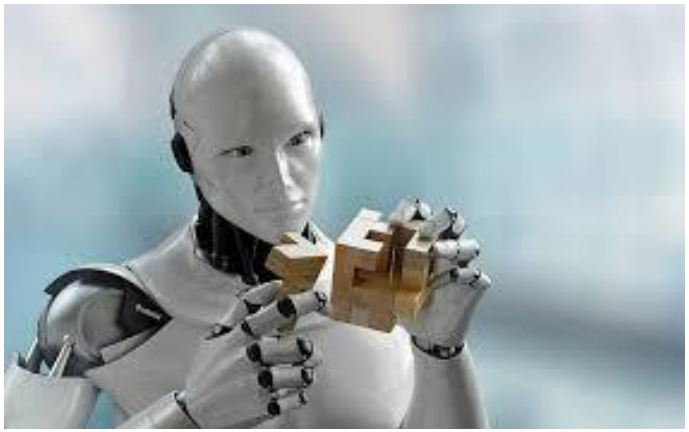
Artificial intelligence (AI)

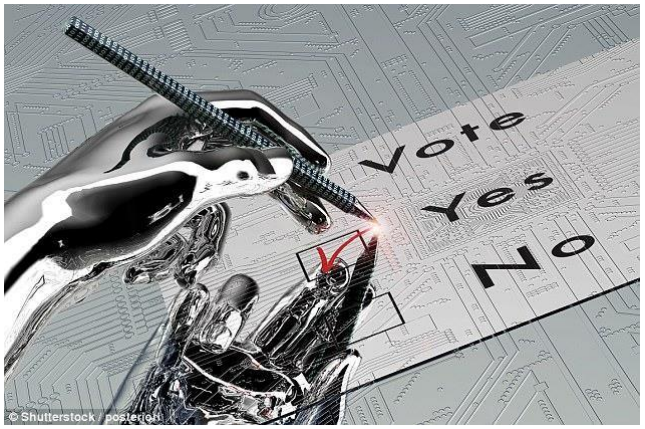




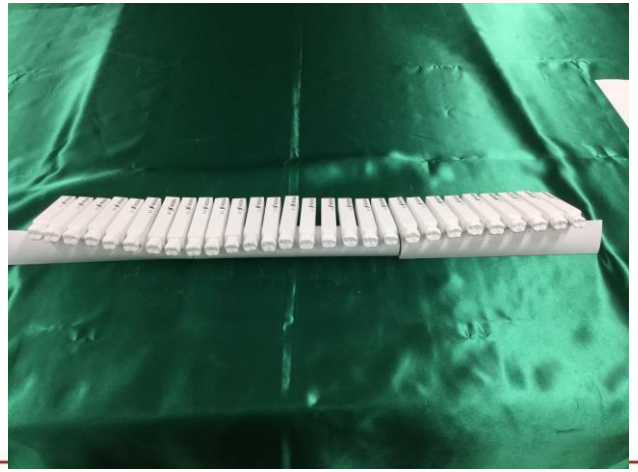
AI, Big Data, Cloud → Judgment → Well Morphology

Artificial intelligence (AI)





Deep Learning, AI Robot → **Excellent Morphology**



Conclusions

Tradition v.s. Technology

Hand v.s. Machine

Concept v.s. Innovation

- **Traditional dental technology should continue to be preserved, but the 21st century new era dental technology should also advance.**
- **Manual technology continues to strengthen.**
- **Digital oral engineering technology is a necessary for dental technicians.**
- **In an era of change, the only constant is to change.**

Thank you for your
kind attention
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