Current status and future prospects of laser stereolithography

Industrial application [26-1]#049

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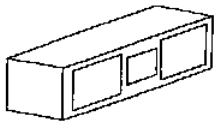
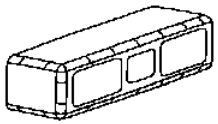
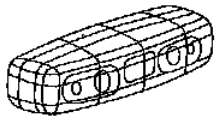
Today's talk:

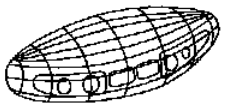
- background
  - rapid prototyping
- about laser stereolithography
- technology & application
  - current status
  - future trend
- summary

Change in design (radio cassette-recorder)

before 1970  square box

1970's  corner R

1980's  6 curved surfaces

1990～  free curved surfaces

Prototypes are needed before production.

Change in manufacturing method to get prototypes

hitherto	rapid prototyping
hand making • 2-D draws • cut & paste scrape	computer aided • 3D-CAD • uniform • thin/small
Skilled/ long time	Automated/ short time

What is rapid prototyping (RP)

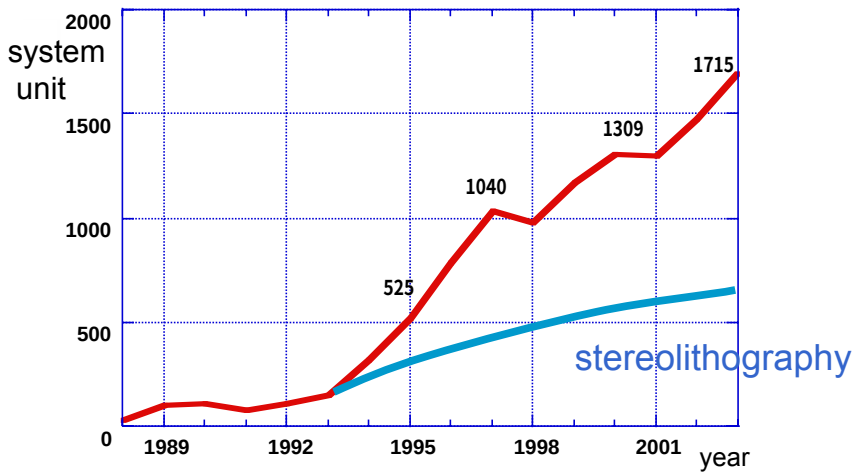
- from 3D-CAD data to prototypes
- with liquid photo-curable resin, thermoplastic resin, nylon powder, metal powder
- using LASER beam, ink-jet, or fused deposition etc
- accumulate layer by layer

photo-curable resin / LASER beam
=> stereolithography

History of rapid prototyping

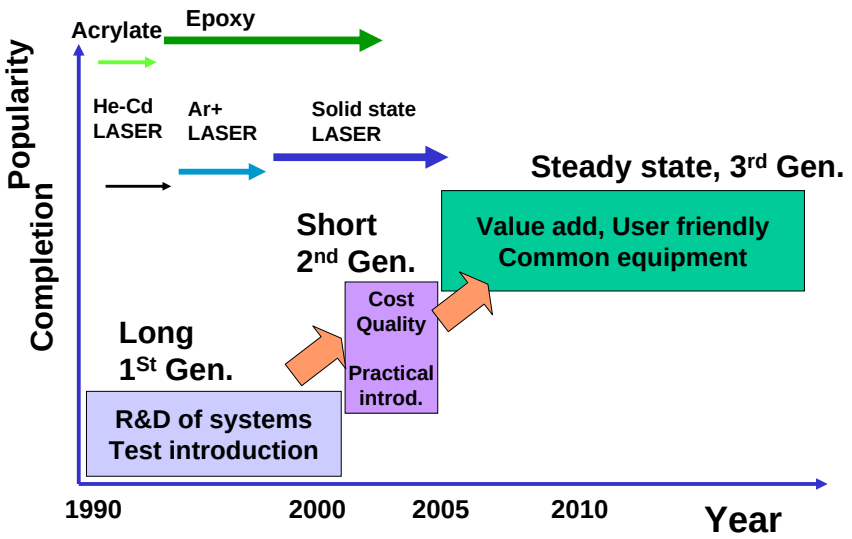
1981 Invention of stereolithography by Mr. Kodama (Nagoya) (Patent, paper)
1982 Paper of stereolithography by A. J. Herbert (3M, USA)
1984 Paper of stereolithography by Dr. Marutani (Osaka)
1984 US Patent application by C. Hull (UVP=3D systems)
1987 First commercial system (SLA-1) by 3D Systems
1988 Mitsubishi Corp. put into Japanese market with stereolithography system "SOUP" by the technology transferred from Dr. Marutani
1989 Sonny/JSR, started to sell stereolithography system "SCS"
1989 SLA-250 by 3D Systems
1992 TEIJIN SEIKI started to sell stereolithography system "SOLIFORM"
1992～94 More than 10 RP manufacturer sells various RP systems
2000 TEIJIN SEIKI bought NTT-Data CMET, Helisis quit LOM
2001 3D Systems bought DTM, canceled the contract with vantico
2002 Toyotsu, TOYOKO, KIRA established DICO
2003 SONY entered US market, TOYOKO quit RP business

sales change of RP systems (worldwide)



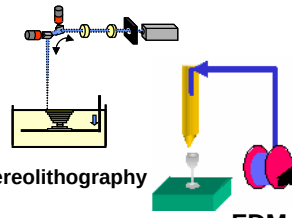
Installed RP systems in the world (Wohlers Report2003)

Situation of RP Systems



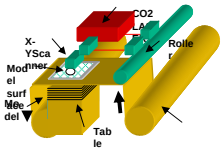
Rapid prototyping (RP)

- Stereolithography
  - liquid photo-resin, laser beam
- Fused Deposition Modeling (FDM)
  - ABS wire
- Selective Laser Sintering (SLS)
  - Nylon powder, CO2 laser beam
- LOM, Paper Lamination Technology
  - paper, CO2 laser beam or knife
- Ink-Jet
  - starch powder, plaster powder, water
- Near net shaping (LENS method etc.)
  - Fe, Ni metal powder
  - CO2 laser beam


Stereolithography

FDM

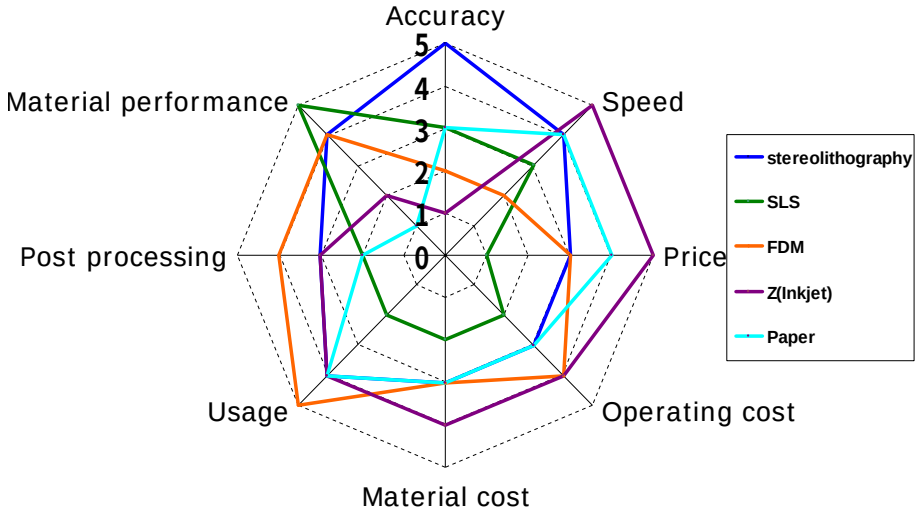

SLS



LOM


Inkjet

Comparison of RP systems

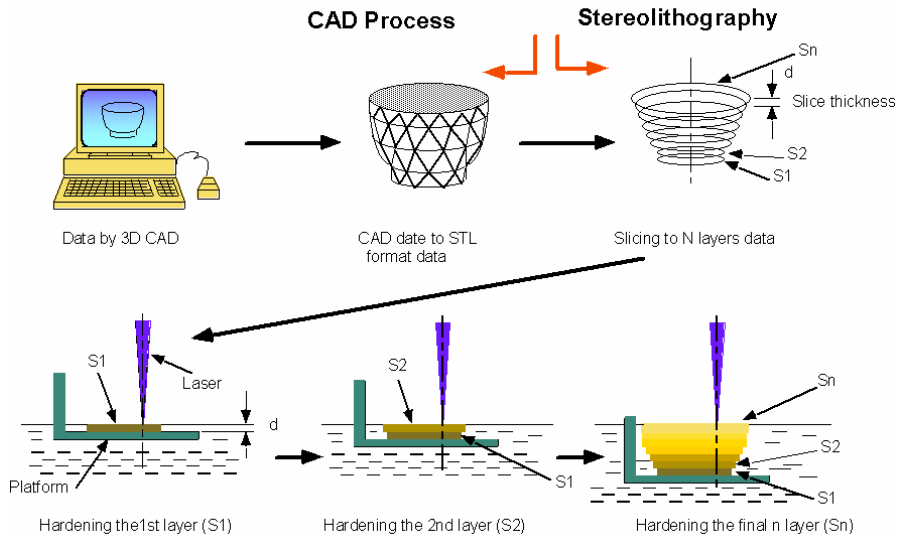


Why stereolithography is important in Japan?

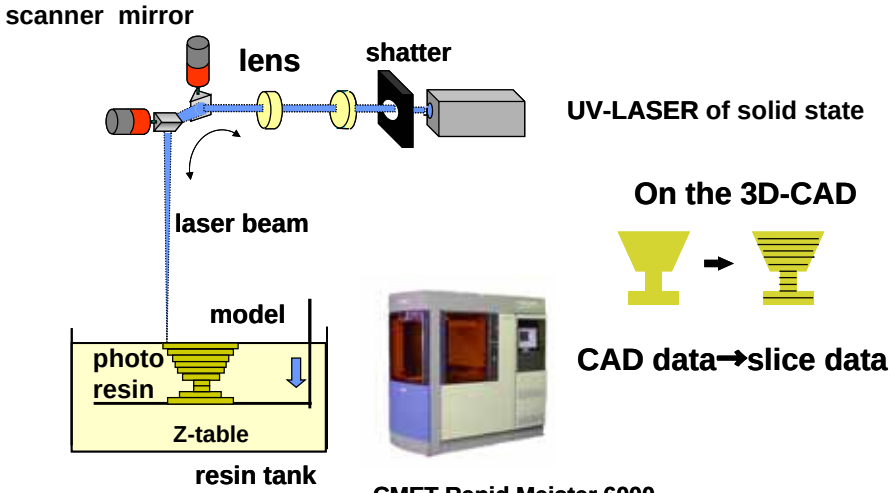
- Originally born in Japan
- Well balanced RP system
  - accuracy, quality, post-processing etc.
- Easy to make accurate prototype in reasonable period
  - accuracy is very important in Japan
- Most effective tool for R&D in Japan
  - reduce developing cost and time
- Customers can use a various type of resins.
  - durable resin, high temperature resin, rubber like resin, water resist resin etc.

Process of stereolithography

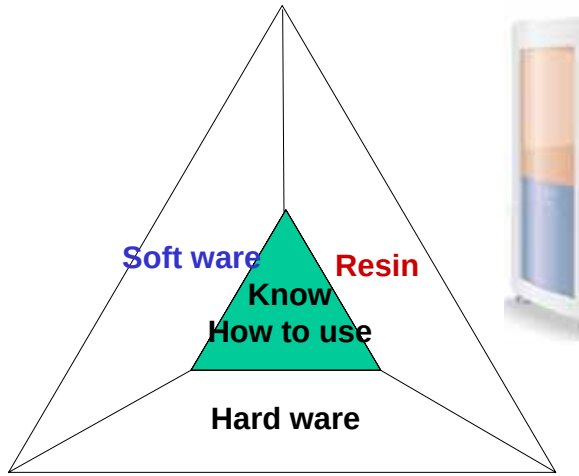
(video)



Schematic diagram of stereolithography



Stereolithography

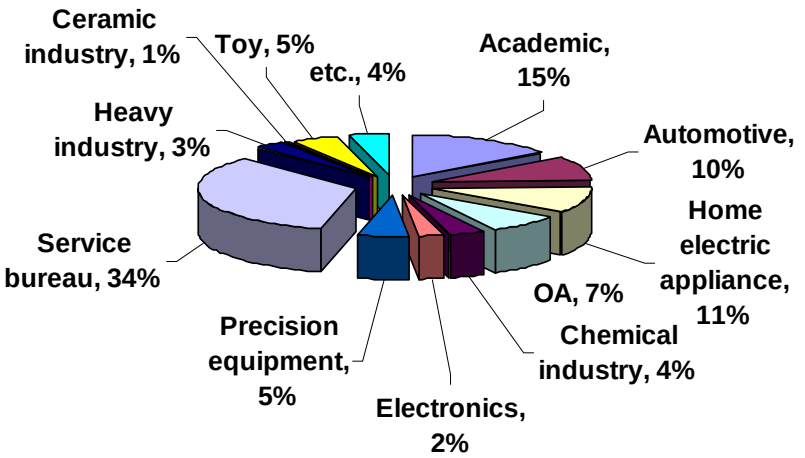


Usage of stereolithography model

from 3D CAD data to 3D model

- Verification (as a 3D printer)
- Functional test
- Master model for metal casting, vacuum casting, die applications
- Medical
- Others
- Future: mass production parts

Customers of stereolithography in Japan



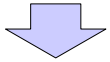
Data from CMET 2003/E

Usage of the fabricated model

Usage	Japan(%)	US(%)	Remarks
Verification	30	45	communication tool medical
Master model for vacuum casting	40	15	home electronics, automotive
Working model	20	20	high performance resin
Die application	10	20	direct die metal resin, wooden pattern

Change in manufacturing using stereolithography

- trend of "trial-production-less" at R&D process
- by digital engineering using CAD, CAE
  - Use of CG, VR for verification



- only verification: low value
- change of roll from design stage to development or engineering stage
  - demand of high performance resin
  - expectation of rapid manufacturing (RM) resin

Resin is key for stereolithography

- ► resin performance is the key factor for stereolithography
- ► a new resin make a new market and usage
- ► trend for Rapid Manufacturing (RM)

  - ➞ ABS performance is the Greatest Common Divisor
  - ➞ high temperature, durable resin (POM, PC performance) creates new markets

change in resin R&D

Year	～1993	1994	1998
generation	dawn	1st	2nd
R&D item	only model	accuracy	humidity
base resin	UA (epoxy*)	epoxy	epoxy

UA: urethaneacrylate,
* only CMET used epoxy material from starting

stereolithography resin (around 1999)

- accuracy: OK
- brittle
- low HDT
- hardening: slow
- difference in layer
- yellow

→

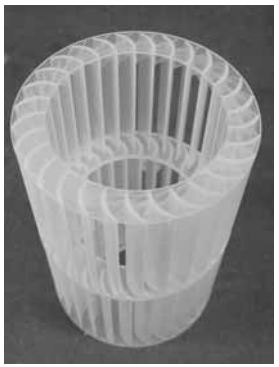
- remove fault
- enhance performance

change in resin R&D (continued)

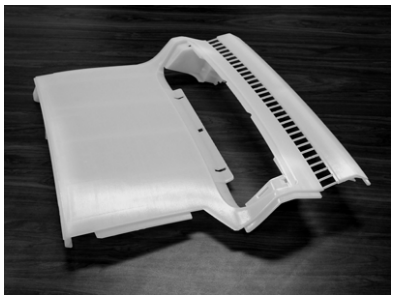
Year	2001-	2003-2005	2005-
generation	3rd	4th	5th
R&D item	durable	ABS	Durable high temperature
base resin	epoxy	epoxy	epoxy UA

UA: urethane acrylate

Current typical examples



Durable resin
CMET TSR-821

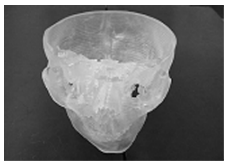


ABS like resin
CMET TSR-825

Typical example of CMET resins

Engine block

- functional test
- verification



Medical

- simulation

Car lamp

- functional test
- verification

Direct injection molding die

-injection molding
-Rapid manuf.

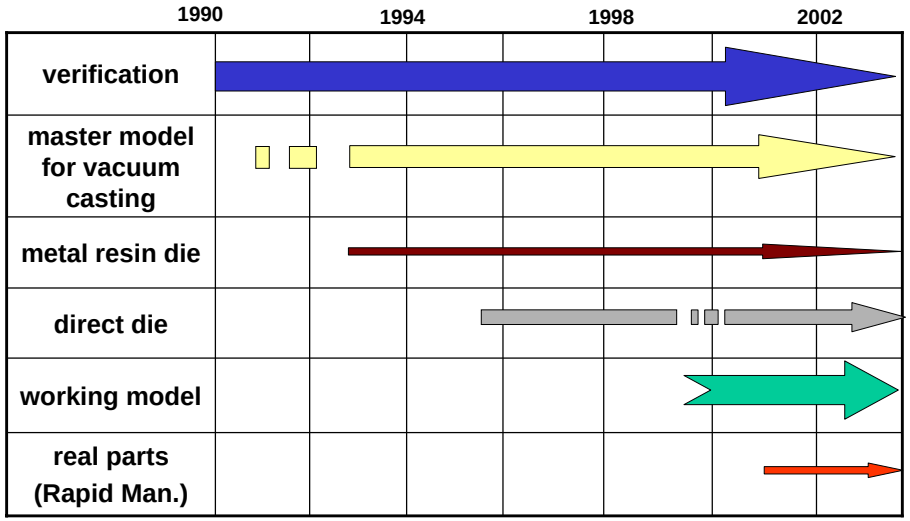
Intake manifold

-verification
-functional test

Rubber model

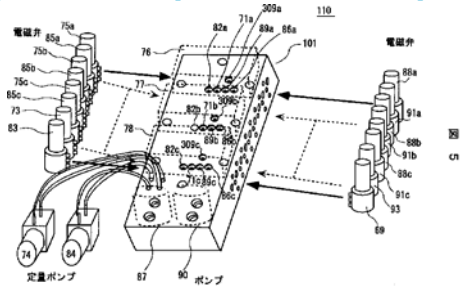
-verification
- functional testing

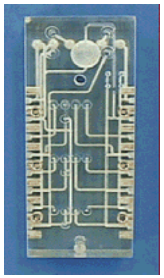
History of the usage



Data from CMET 203/E

First example of real parts in mass production



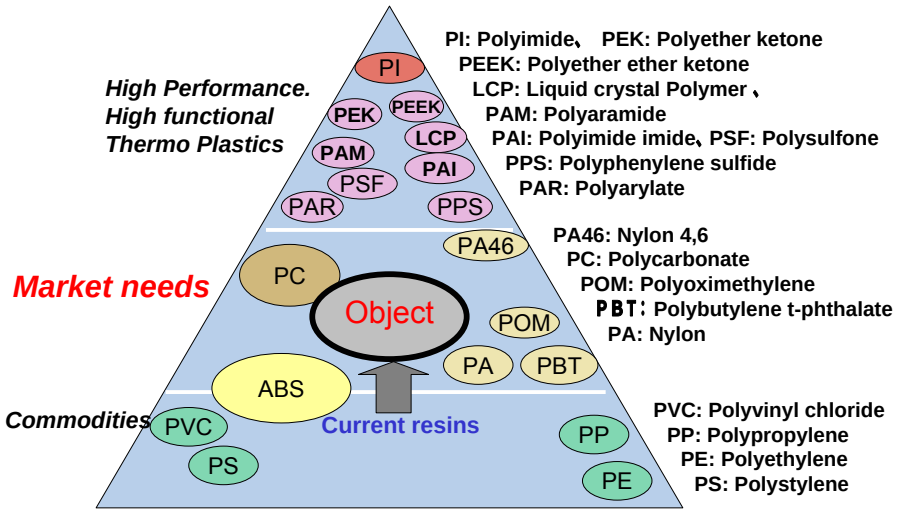


- Manifold for water analyzer
  - Imide based resin
  - The parts were put into the market 1999 by HITACHI Ltd.
  - Stable more than
    1 year in the water

AN-500

From Material Fair at Yokohama Oct. 2002

Market needs and thermoplastics



PI: Polyimide、 PEK: Polyether ketone
PEEK: Polyether ether ketone
LCP: Liquid crystal Polymer、
PAM: Polyaramide
PAI: Polyimide imide、PSF: Polysulfone
PPS: Polyphenylene sulfide
PAR: Polyarylate

PA46: Nylon 4,6
PC: Polycarbonate
POM: Polyoximethylene
PBT: Polybutylene t-phthalate
PA: Nylon

PVC: Polyvinyl chloride
PP: Polypropylene
PE: Polyethylene
PS: Polystylene

ABS: Acrylic-nitril, butadiene, styrene copolymer

SUMMARY

- The stereolithography is suitable for R&D in Japan
- Resin is the key item in stereolithography
- High performance resin is requested
- Durable resin expands the usage
- Current target is ABS performance
  - Next is POM, PC performance
- New resin makes new market and usage
  => Rapid Manufacturing