The LIGA Process

What is LIGA?

German	English
LI thogrphie	Lithogrphy
Gavanoformung	Electroforming / Electroplating
Abformung	Moulding

Definition of LIGA

- LIGA is a German acronym that stands for Lithographie, Galvanoformung and Abformung.
- When translated it means lithography, electroplating and molding.

LIGA: Background

- LIGA is a three stage micromachining technology used to manufacture high aspect ratio microstructures.
- Originally LIGA technology was researched in Germany in order to be used for the separation of uranium isotopes.
- Henry Guckel of the University of Wisconsin brought LIGA technology to the USA.
- Two main types of LIGA Technology: X-ray LIGA and Extreme Ultraviolet (EUV) LIGA.
- X-ray LIGA can fabricate with great precision high aspect ratio microstructures.
- EUV LIGA can fabricate lower quality microstructures.

LIGA Process

- LIGA is a hybrid fabrication technique
- The LIGA Process
  - Lithography
    - Electron beam lithography
    - Focused ion beam lithography
    - Optical and exciter laser lithography
    - Deep X-ray lithography using synchrotron radiation
  - Electroplating
    - metalized layer (seed layer)
  - Molding
    - Machining process to remove overplated metal region

Function of LIGA

- To produce high aspect ratio
- To manufacture 3-D microstructures from a wide variety of materials

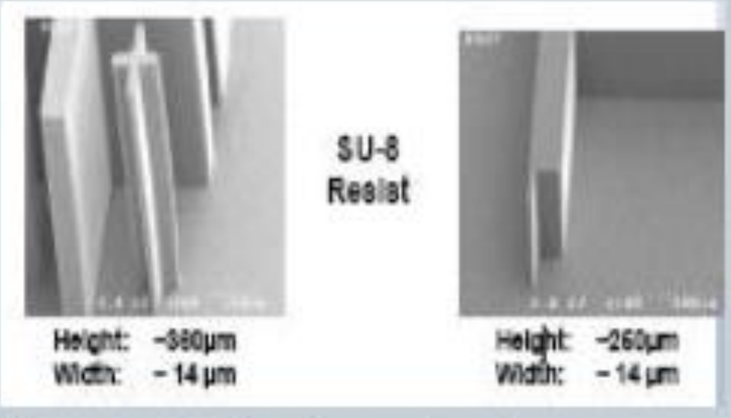


Figure1: 3-D microstructure

LIGA Process

- Deep X-ray lithography
  - Historically chosen as a source for LIGA process
  - superior to optical lithography
    - Utilize short wavelength
    - very large depth of focus
    - Synchrotron Light Source maintains energy anywhere from 10^6 to 10^9 eV

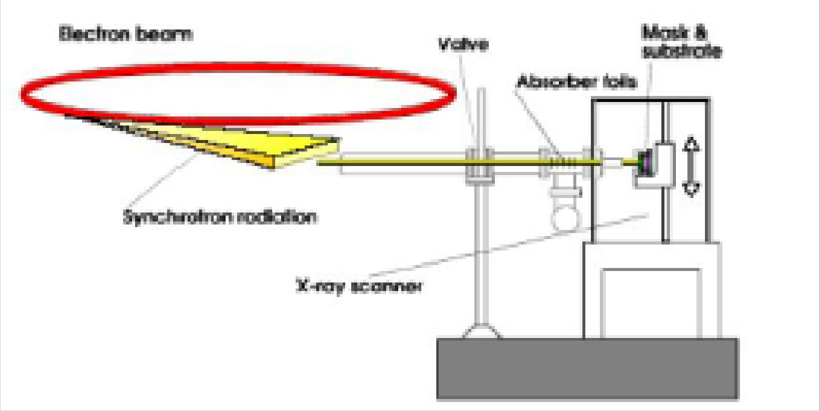
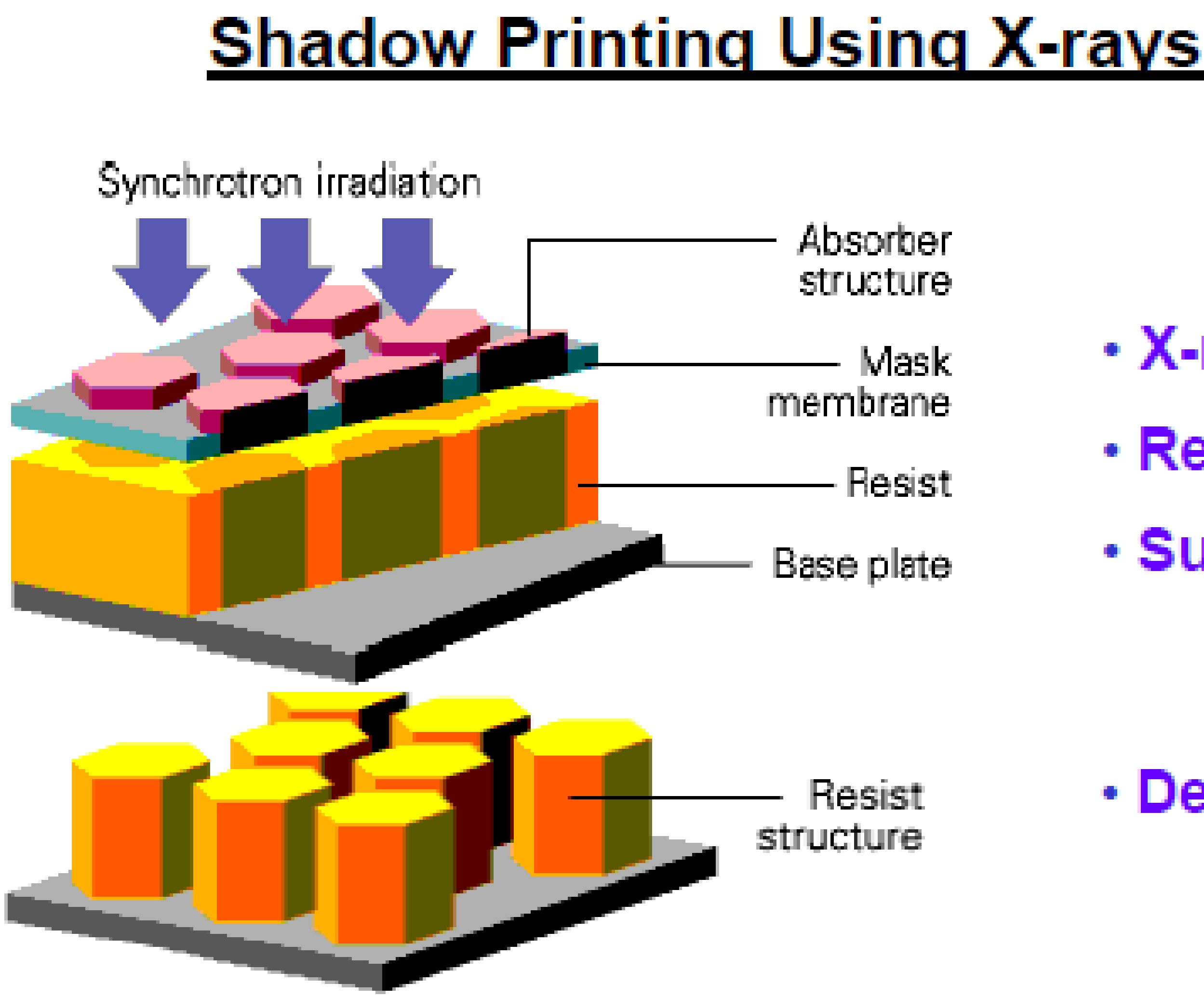


Figure2: Synchrotron Light Source setup

X-ray Lithography

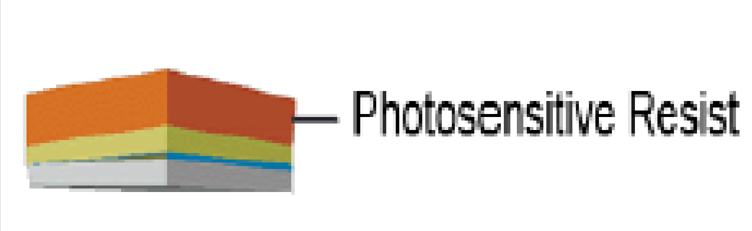


- X-ray mask
- Resist
- Substrate
- Development

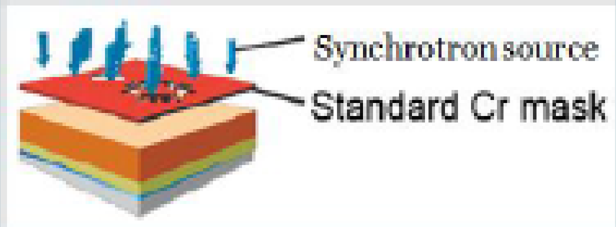
Deep X-ray Lithography Techniques

- Step 1:
  -Deposition of Adhesion
  -Seed layer

- Step 2:
  -resist coating



- Step 3:
  -expose the PMMA resist



Step 4:
-development of the exposed resist

Deep X-ray Lithography Techniques

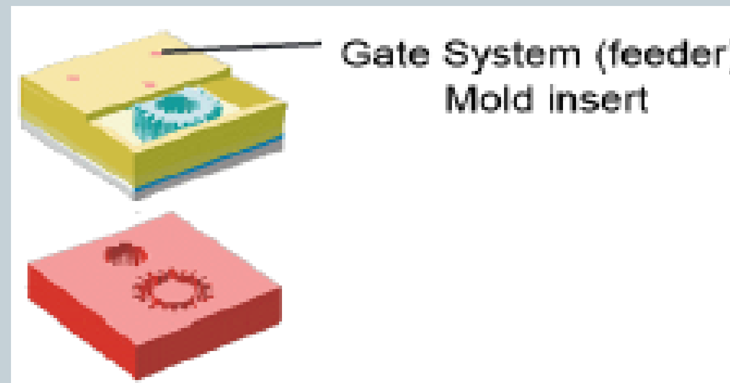
Electroplating and Micro-Molding Techniques

- Electroplating is a process to fill in the voids between the polymeric features.
- Step 5:
  -metal plating

- Step 6:
  -removal of the remaining resist

Molding is process of machining the overplated region filling the microstructure

- Step 7:



Advantages and Disadvantages

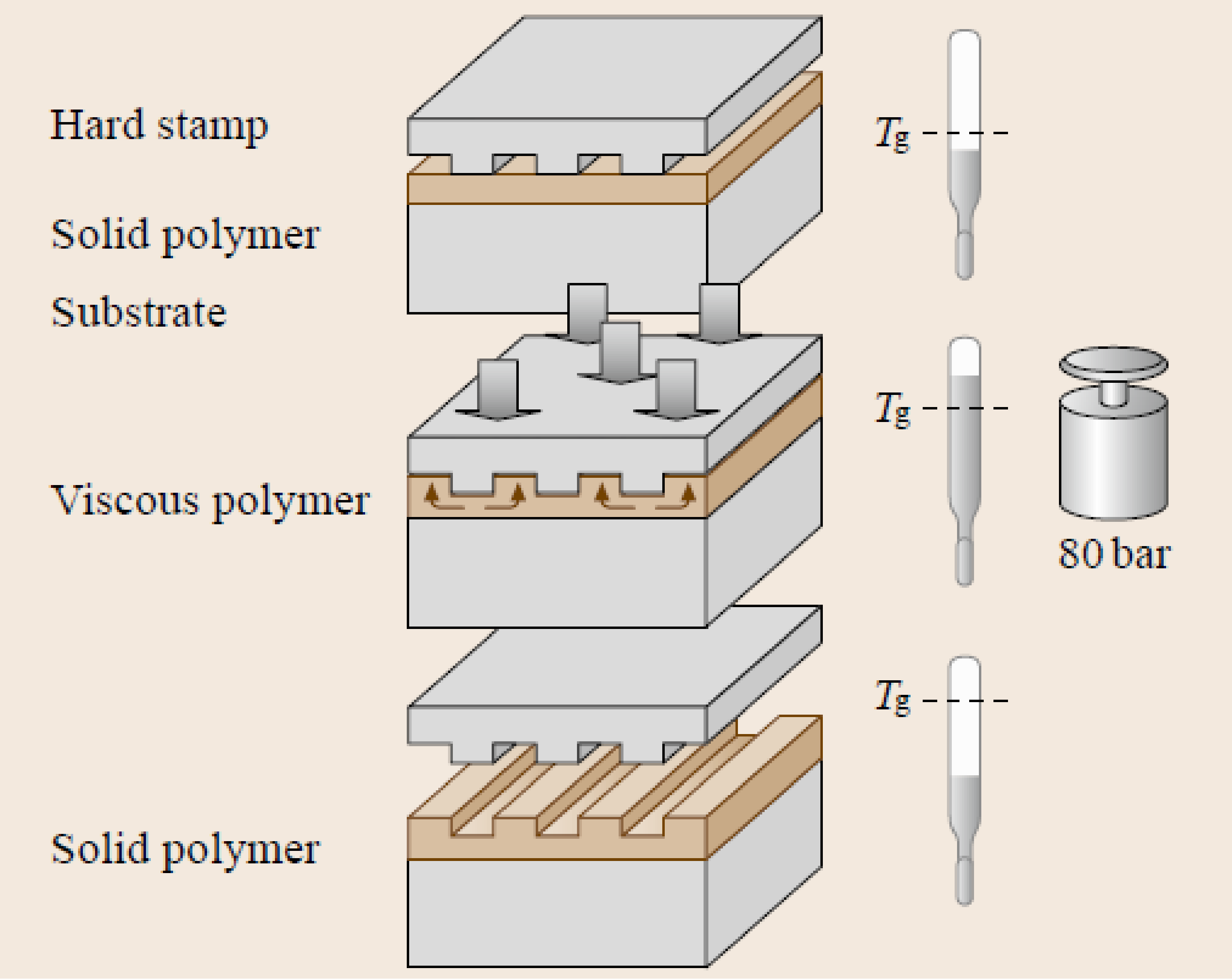
- Large structural height and sidewall properties.
- Thickness ranging from 100-1000 µm.
- Spatial resolution.
- High aspect ratios.
- EUV LIGA is a cheaper alternative.

- X-ray LIGA is expensive due to the equipment required.
- Slow process.
- Complicated process.
- Difficulty transitioning from research to production.

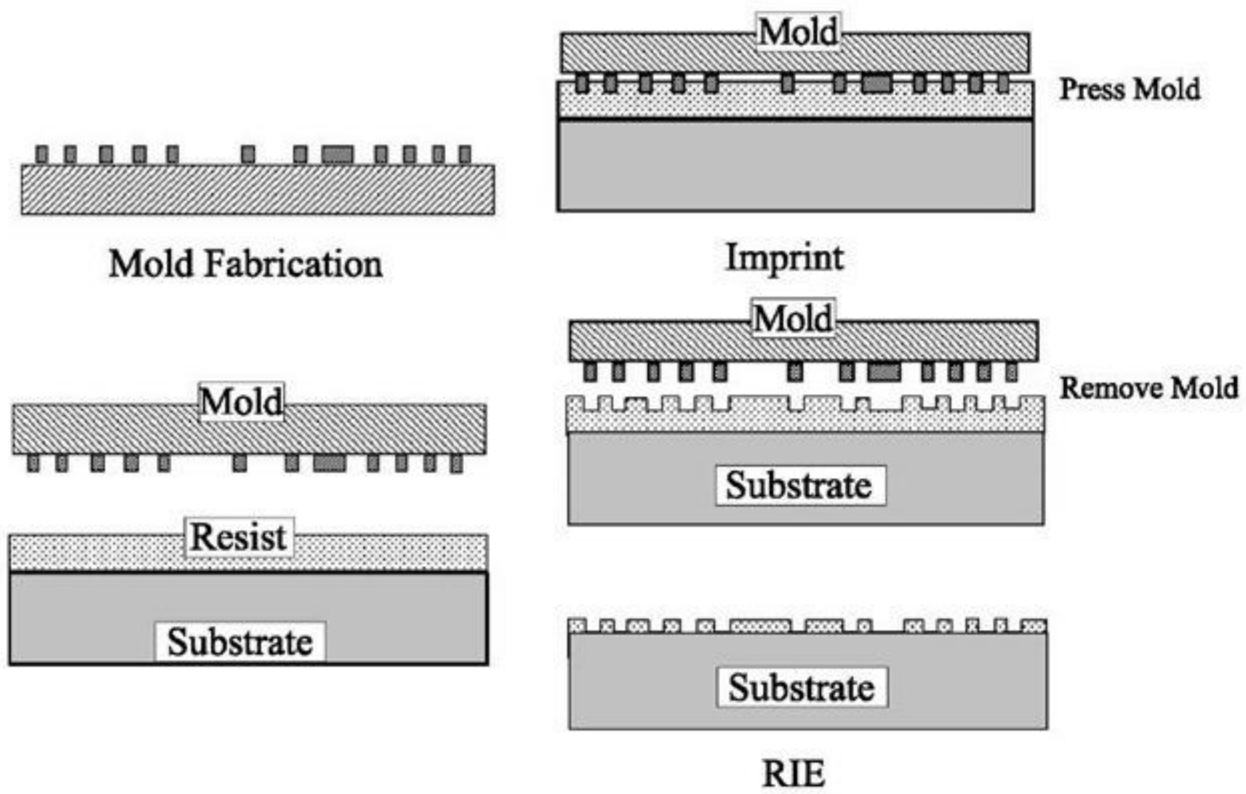
Applications

- MEMS Components
- Sensors
- Actuators
- Trajectory Sensing Devices
- Mass Spectrometers
- Microoptical Components

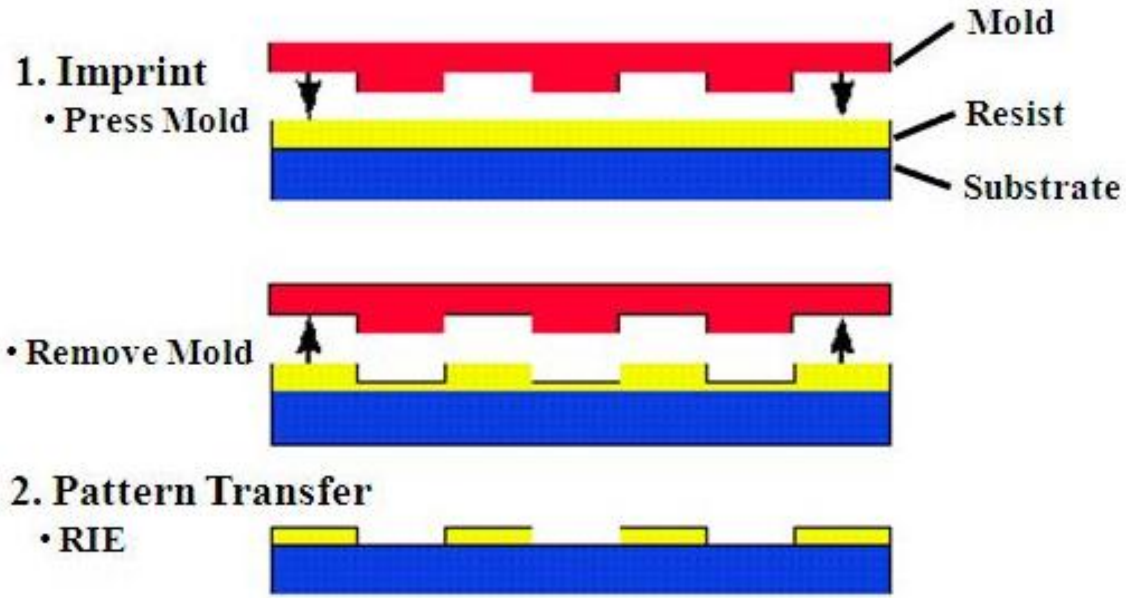
Hot Embossing

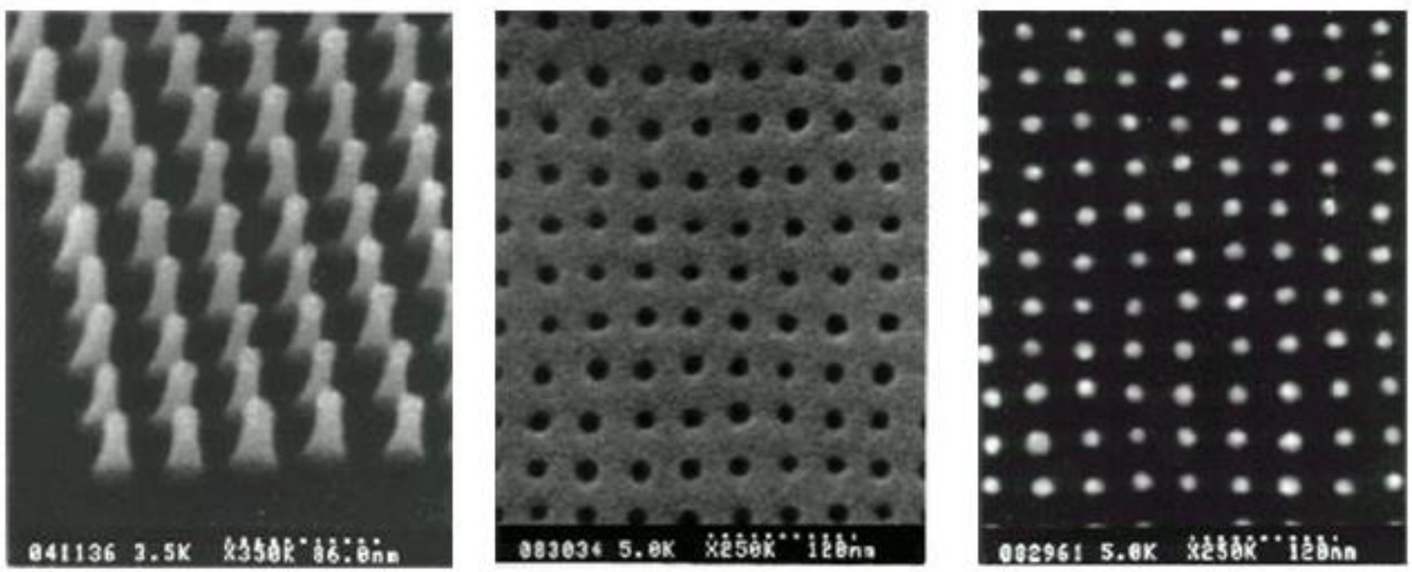


Hot Embossing



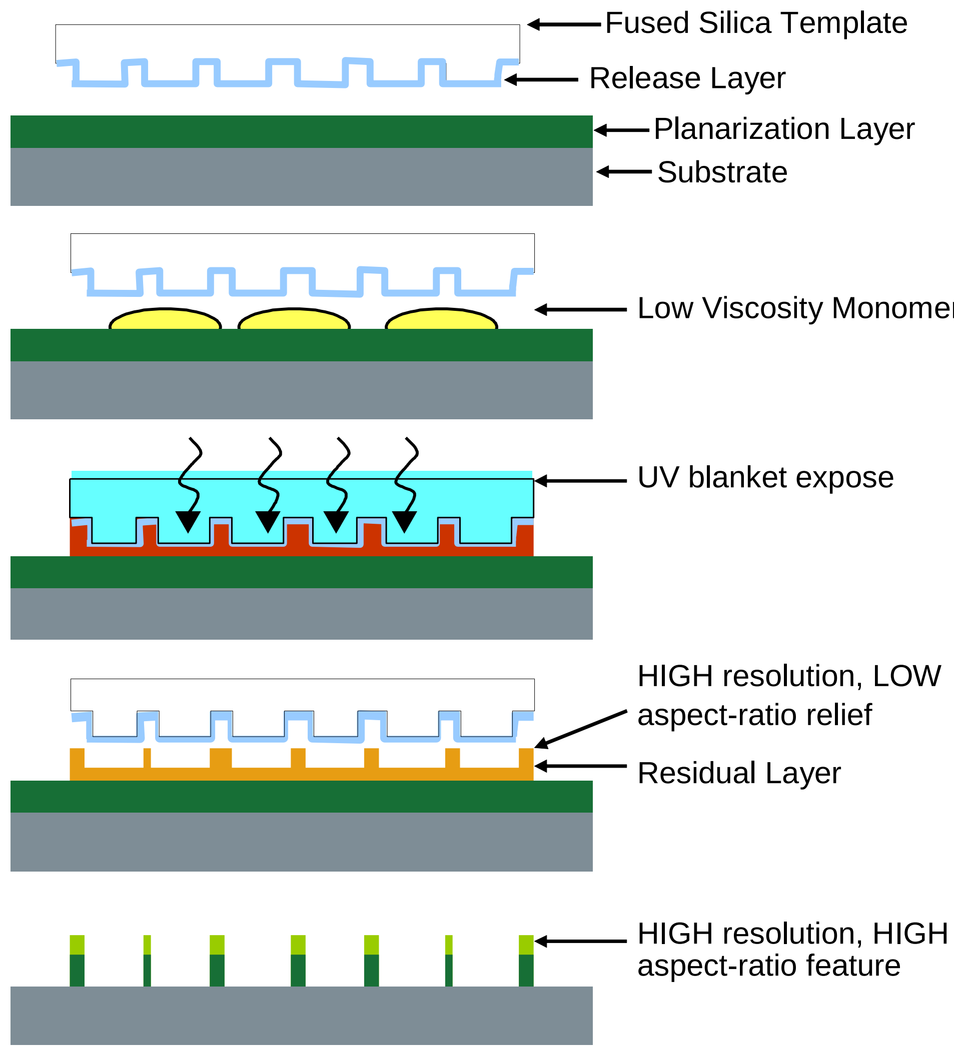
Nanoimprint Lithography





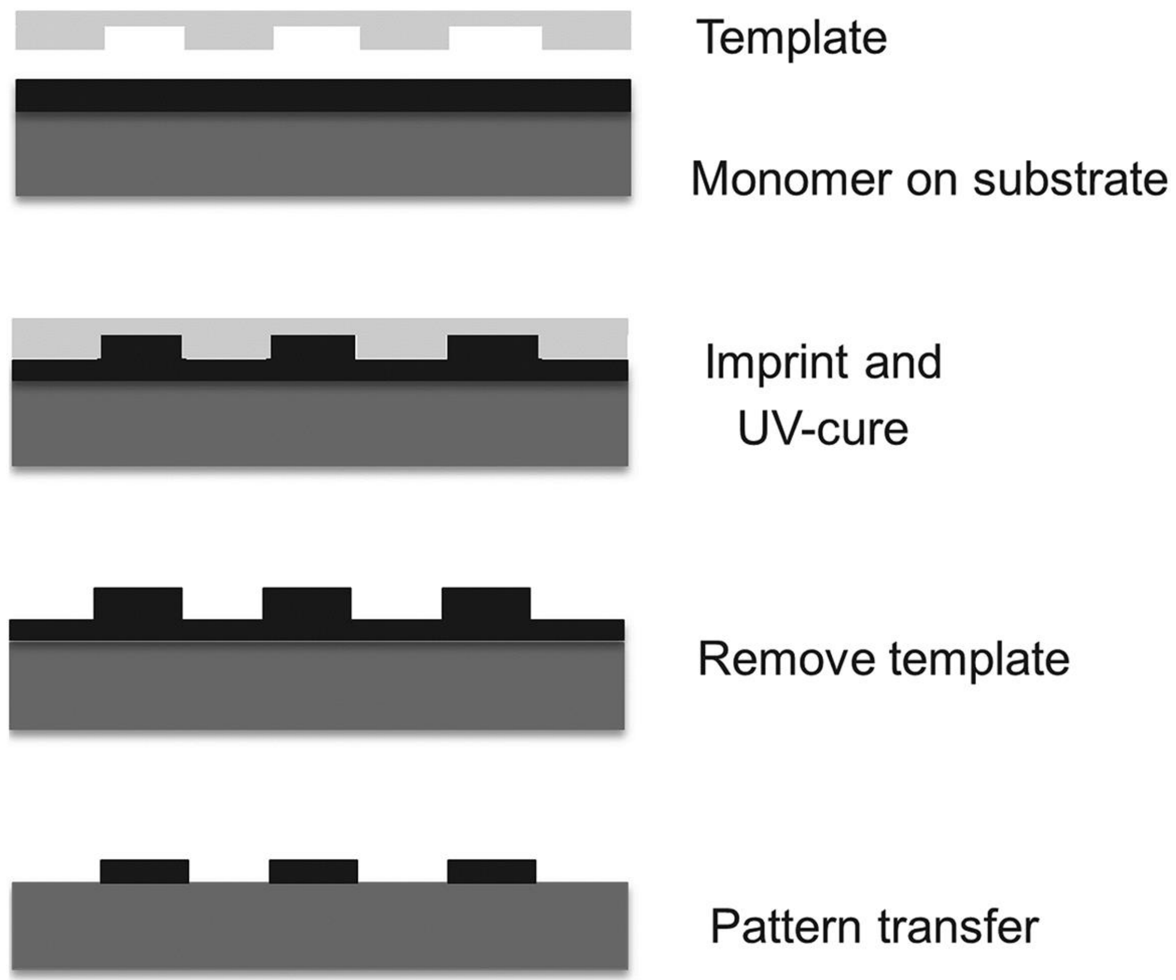
Nano-imprinting Lithography:

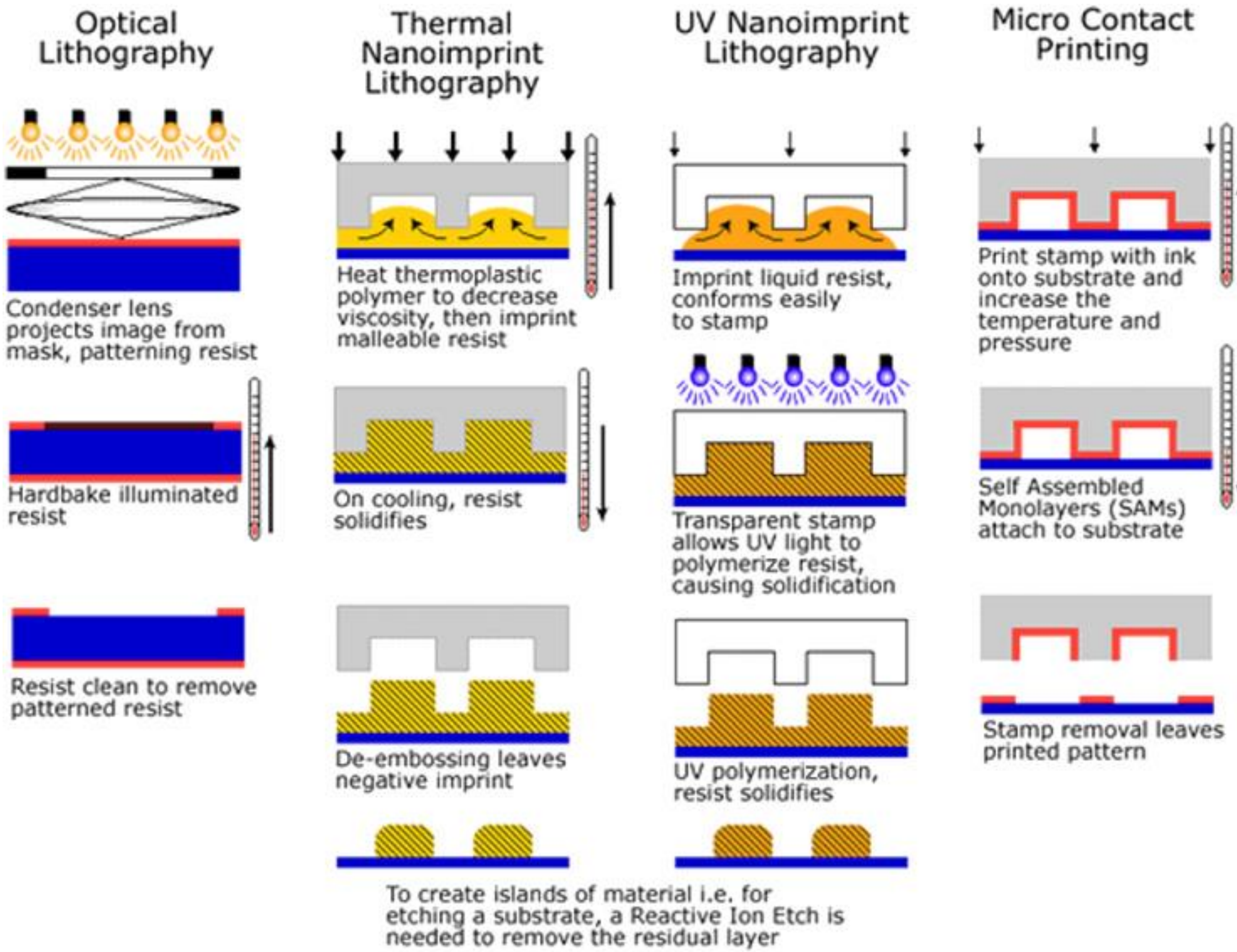
1. Orient substrate and treated template
2. Dispense drops of low viscosity UV curable low viscosity organosilicon monomer
3. Close gap and illuminate with UV (Room Temperature, Low Pressure)
4. Separate the template from the substrate
5. Halogen break-thru etch followed by oxygen etch



Step and Flash Imprinting Lithography (S-FIL™)

Thermal Modeling of UV Nanoimprint Lithography




Optical Lithography
Thermal Nanoimprint Lithography
UV Nanoimprint Lithography
Micro Contact Printing
Condenser lens projects image from mask, patterning resist
Hardbake illuminated resist
Resist clean to remove patterned resist
Heat thermoplastic polymer to decrease viscosity, then imprint malleable resist
On cooling, resist solidifies
De-embossing leaves negative imprint
Imprint liquid resist, conforms easily to stamp
Transparent stamp allows UV light to polymerize resist, causing solidification
UV polymerization, resist solidifies
Print stamp with ink onto substrate and increase the temperature and pressure
Self Assembled Monolayers (SAMs) attach to substrate
Stamp removal leaves printed pattern
To create islands of material i.e. for etching a substrate, a Reactive Ion Etch is needed to remove the residual layer

MEMS Fabrication Techniques

There are three basic building blocks in MEMS technology

- **Deposition (Additive Method)** :
  - Thin Film Deposition

- **Etching (Subtractive Method)** :
  - Wet Etching
  - Dry Etching

- **Patterning (Pattern Transfer Method)** :
  - Photo Lithography
  - E-beam Lithography
  - Nano-imprinting Lithography
  - LIGA

MEMS Applications in the Car