The LIGA Process

What is LIGA?

German	English
<u>LI</u> thogrphie	Lithogrphy
<u>G</u>avanoformung	Electroforming / Electroplating
<u>A</u>bformung	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

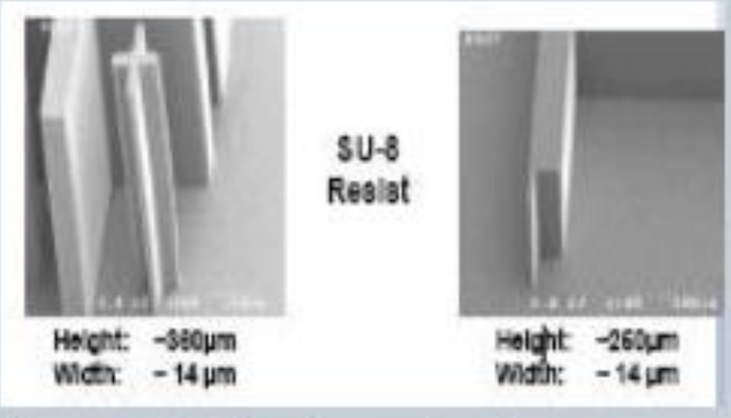
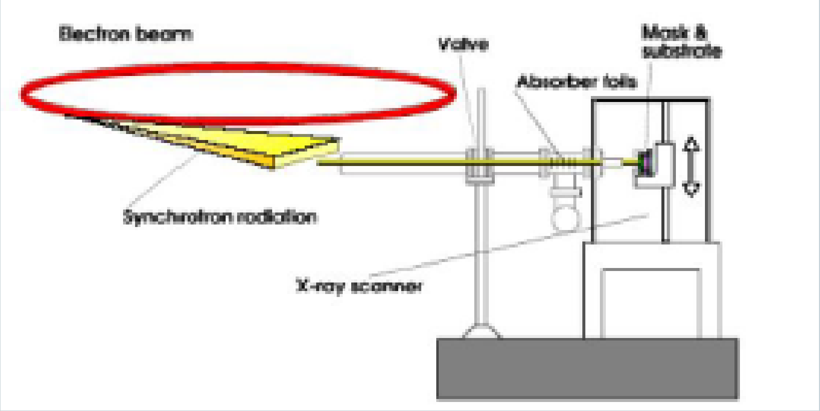


Figure1: 3-D microstructure

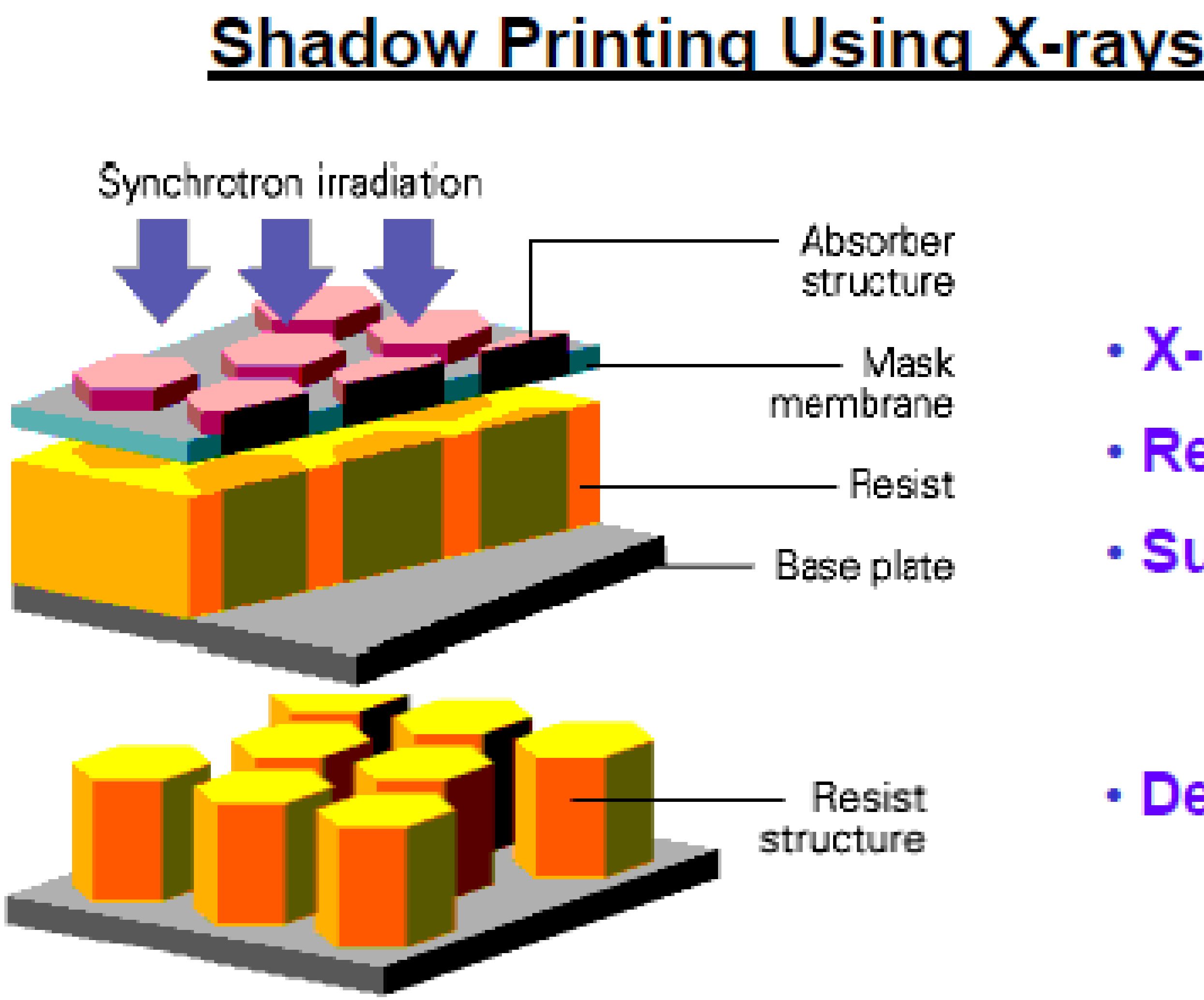
LIGA Process

- 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

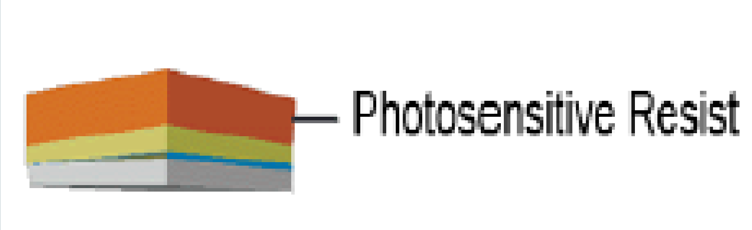


- X-ray mask
- Resist
- Substrate
- Development

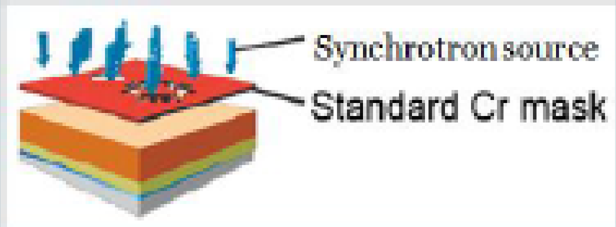
Deep X-ray Lithography Techniques

- 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

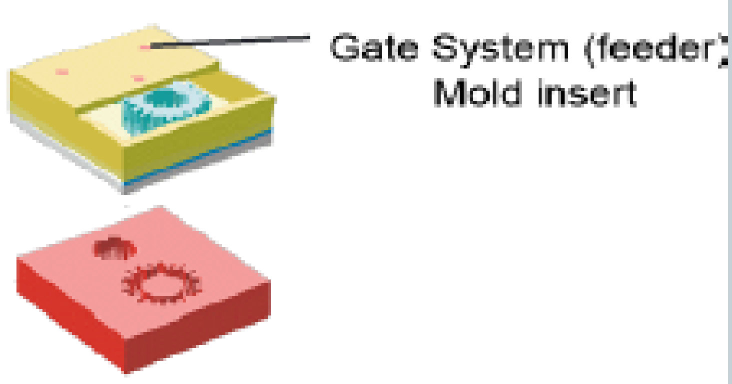
Electroplating and Micro-Molding Techniques

- 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

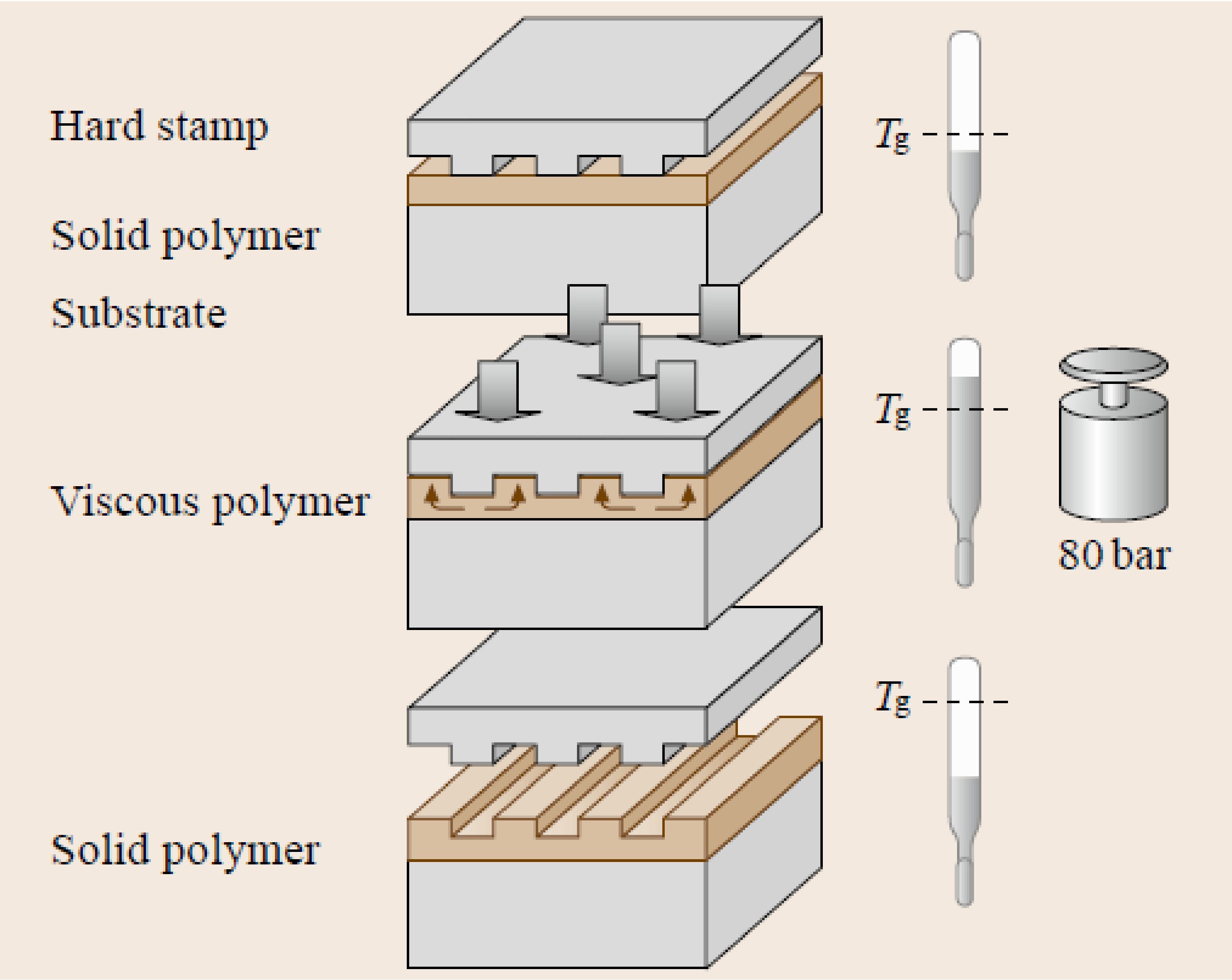
- Large structural height and sidewall properties.
- Thickness ranging from 100-1000 µm.
- Spatial resolution.
- High aspect ratios.
- EUV LIGA is a cheaper alternative.

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

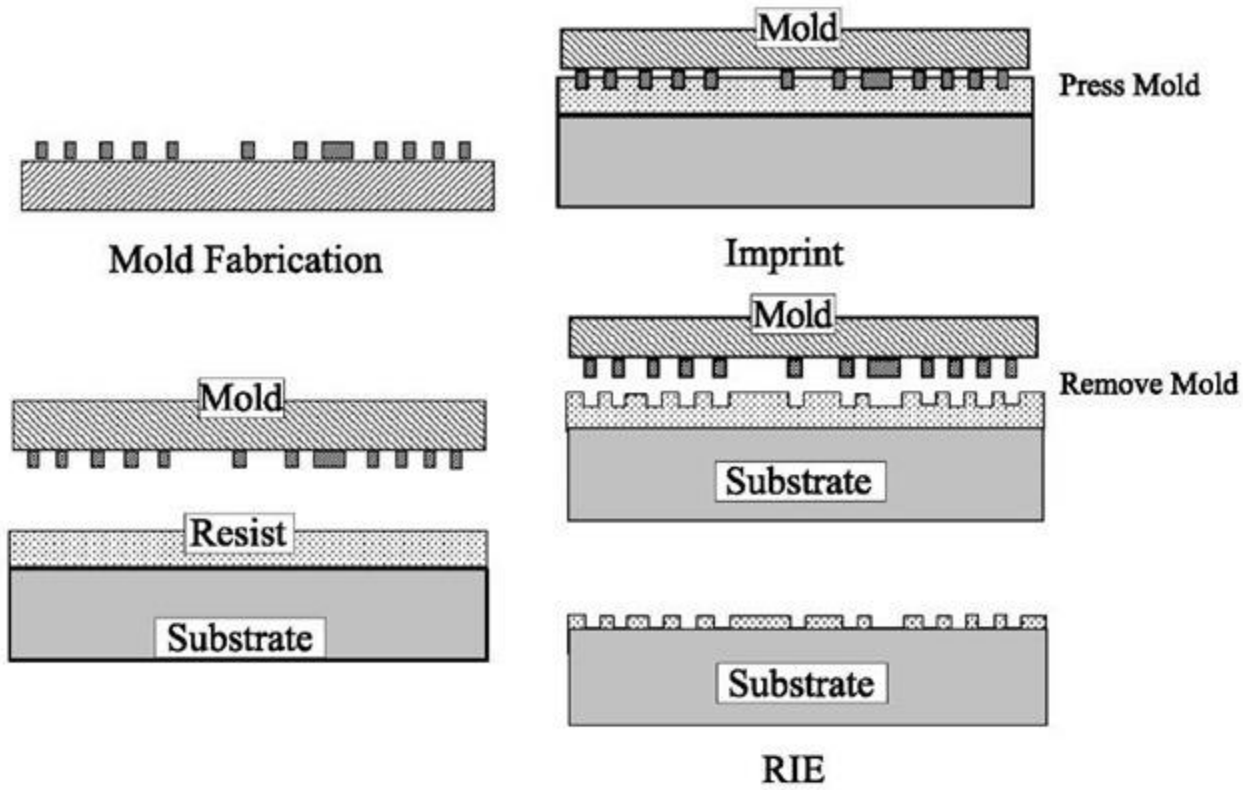
Applications

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

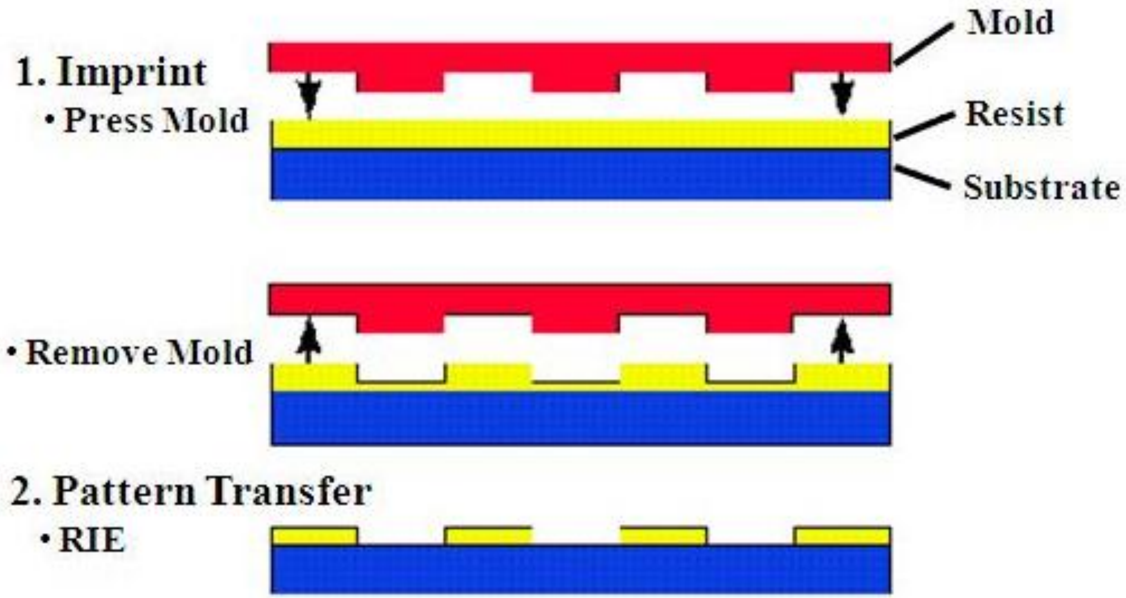
Hot Embossing

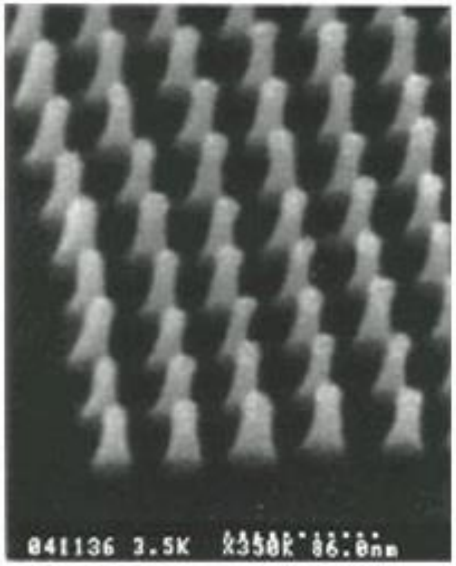


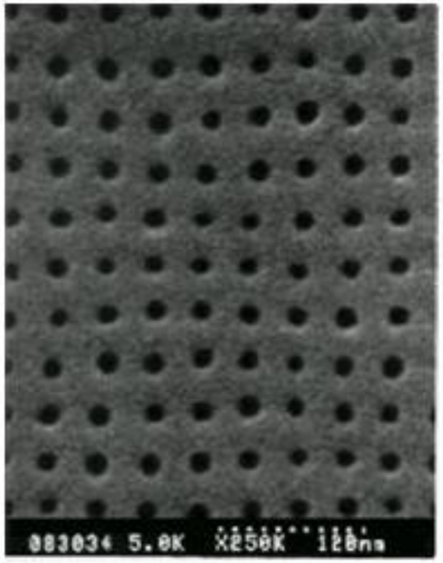
Hot Embossing

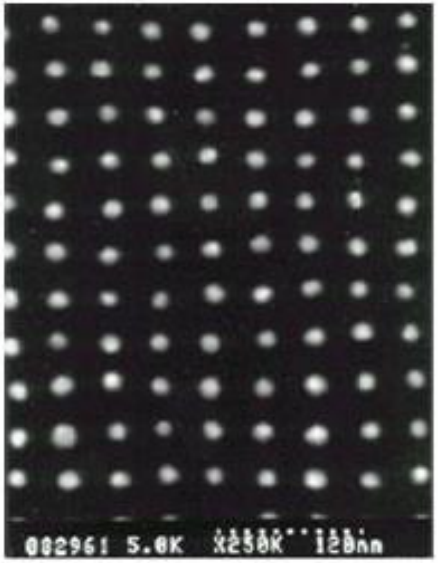


Nanoimprint Lithography



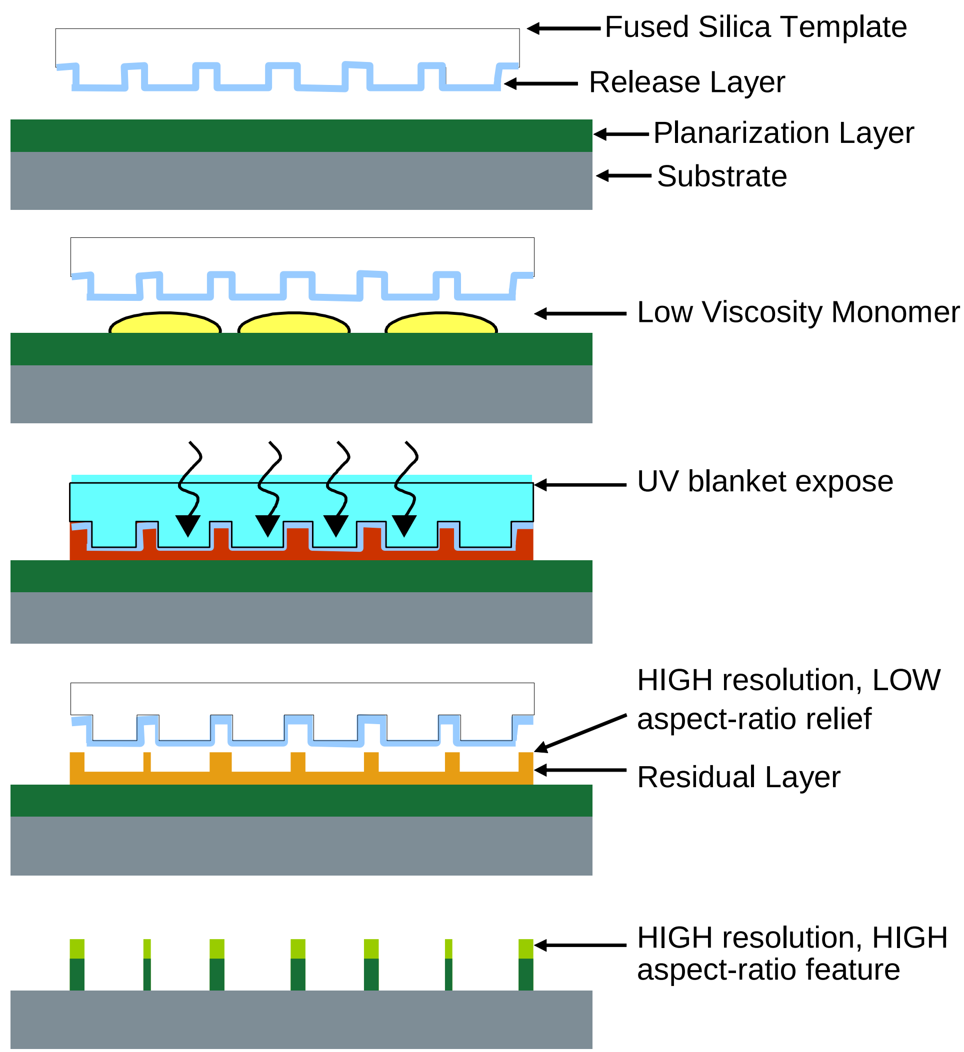






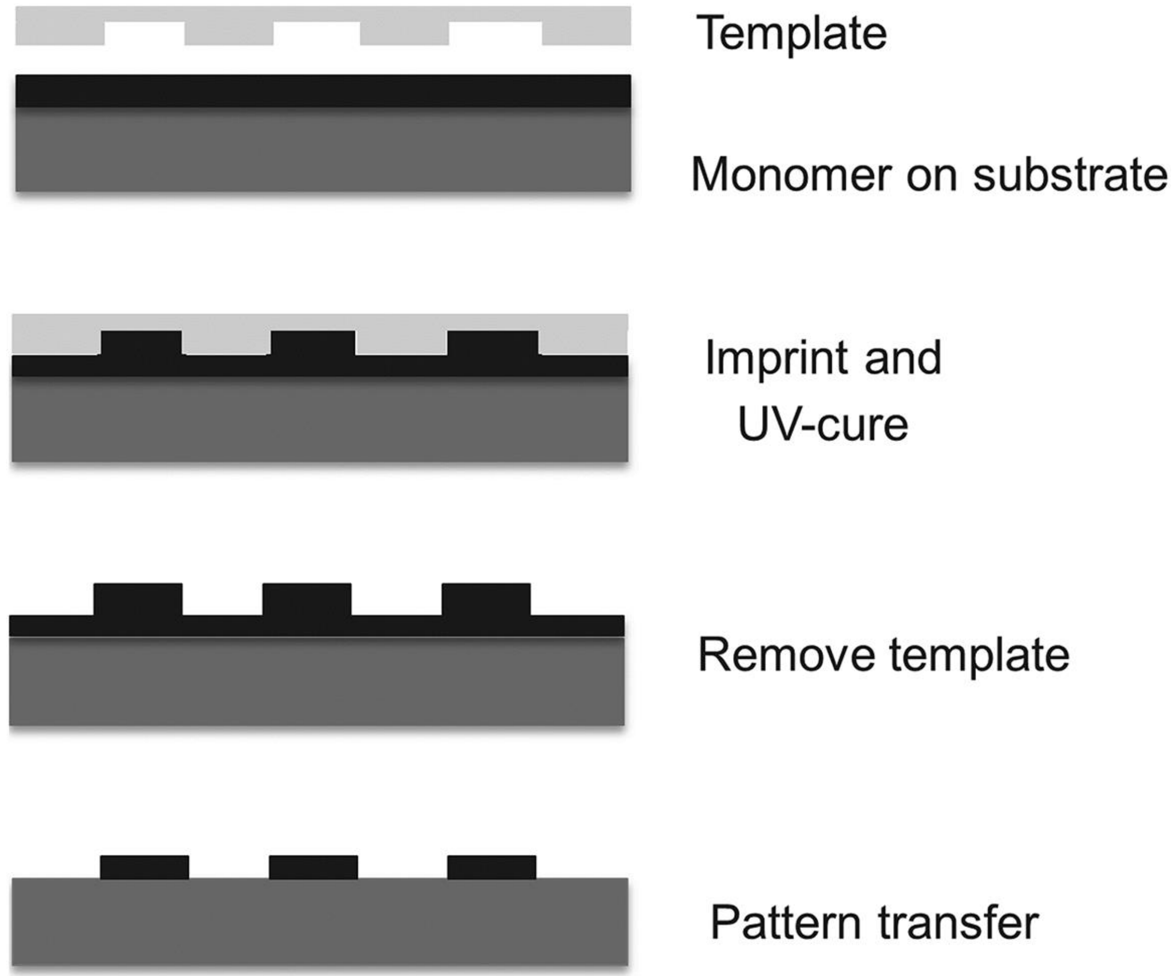
Nano-imprinting Lithography:

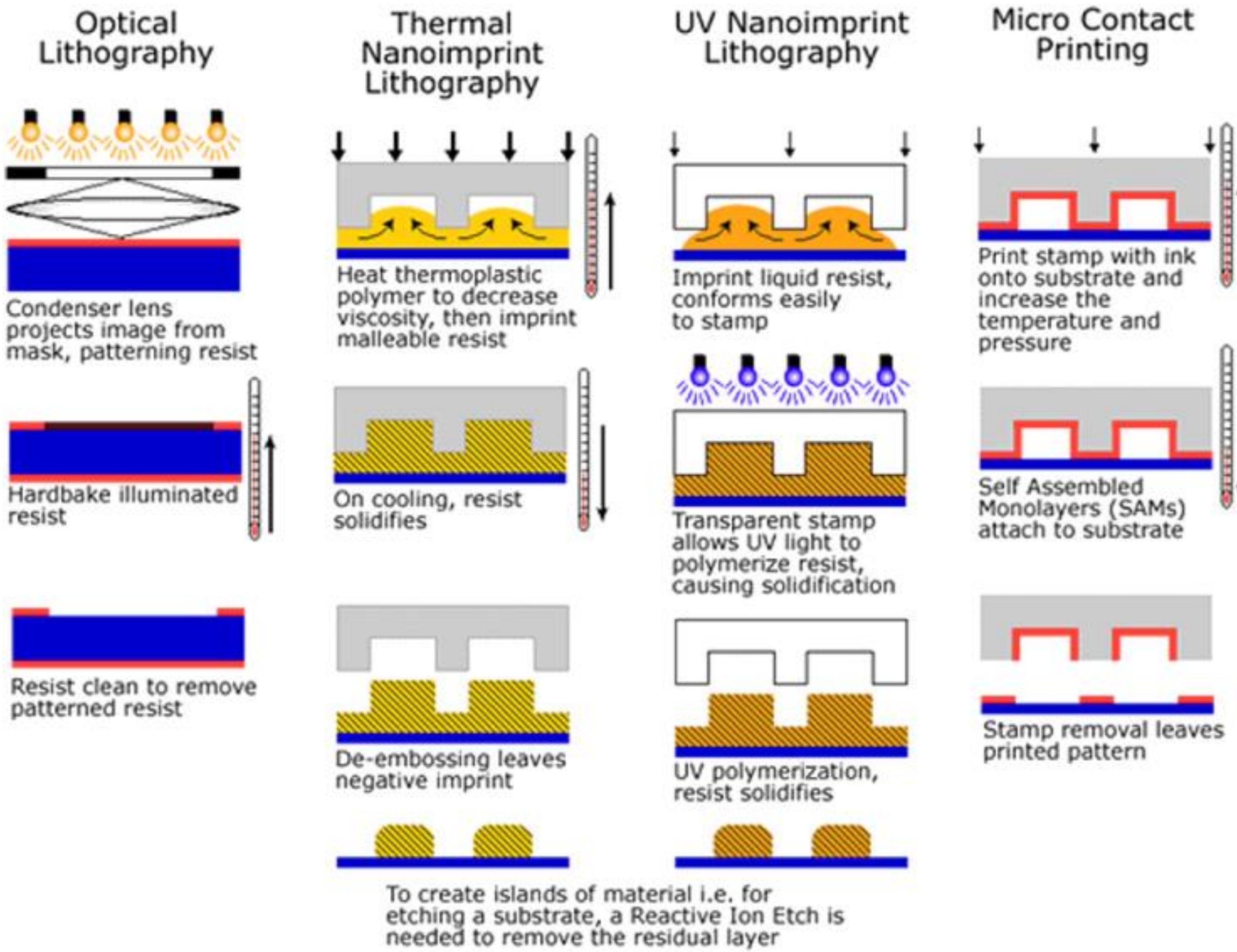
1. Orient substrate and treated template
2. Dispense drops of low viscosity UV curable low viscosity organosilicon monomer
3. Close gap and illuminate with UV (Room Temperature, Low Pressure)
4. Separate the template from the substrate
5. Halogen break-thru etch followed by oxygen etch



Step and Flash Imprinting Lithography (S-FIL^{TM})

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
Heat thermoplastic polymer to decrease viscosity, then imprint malleable resist
Imprint liquid resist, conforms easily to stamp
Print stamp with ink onto substrate and increase the temperature and pressure
Hardbake illuminated resist
On cooling, resist solidifies
Transparent stamp allows UV light to polymerize resist, causing solidification
Self Assembled Monolayers (SAMs) attach to substrate
Resist clean to remove patterned resist
De-embossing leaves negative imprint
UV polymerization, resist solidifies
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

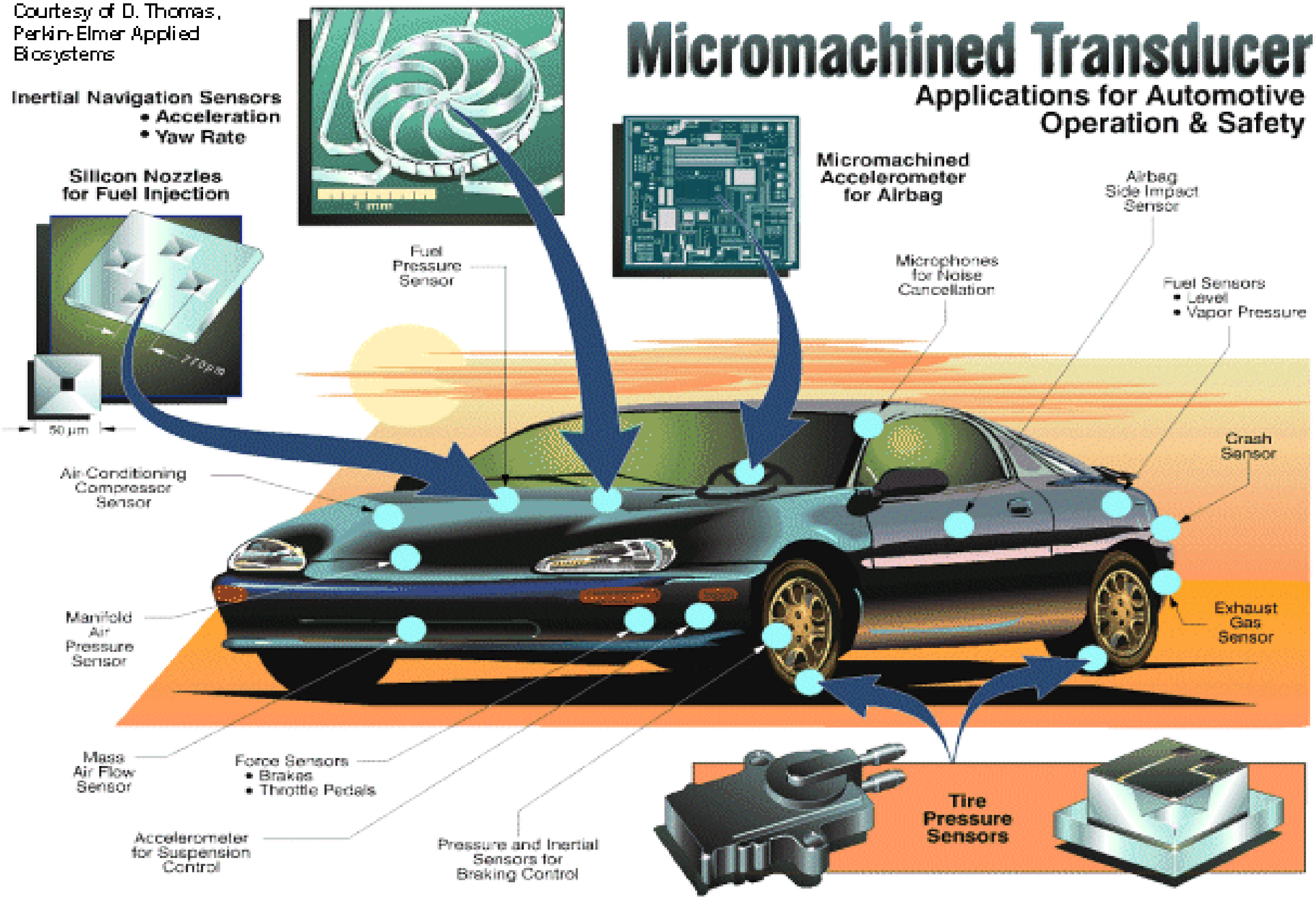
There are three basic building blocks in MEMS technology

- **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



MEMS Applications

• Micro-engines	✓ Micro-Reactors
	✓ Vibrating Wheel
• Inertial Sensors	✓ Virtual Reality Systems
• Accelerometers	✓ Airbag
	✓ Accelerometer
• Pressure Sensors	✓ Air Pressure Sensors
• Optical MEMS	✓ Pill Camera
• Fluidic MEMS	✓ Cartridges for Printers
• Bio-MEMS	✓ Blood Pressure Sensors
• MEMS Memory Units	✓ Flash Memory

Definitions

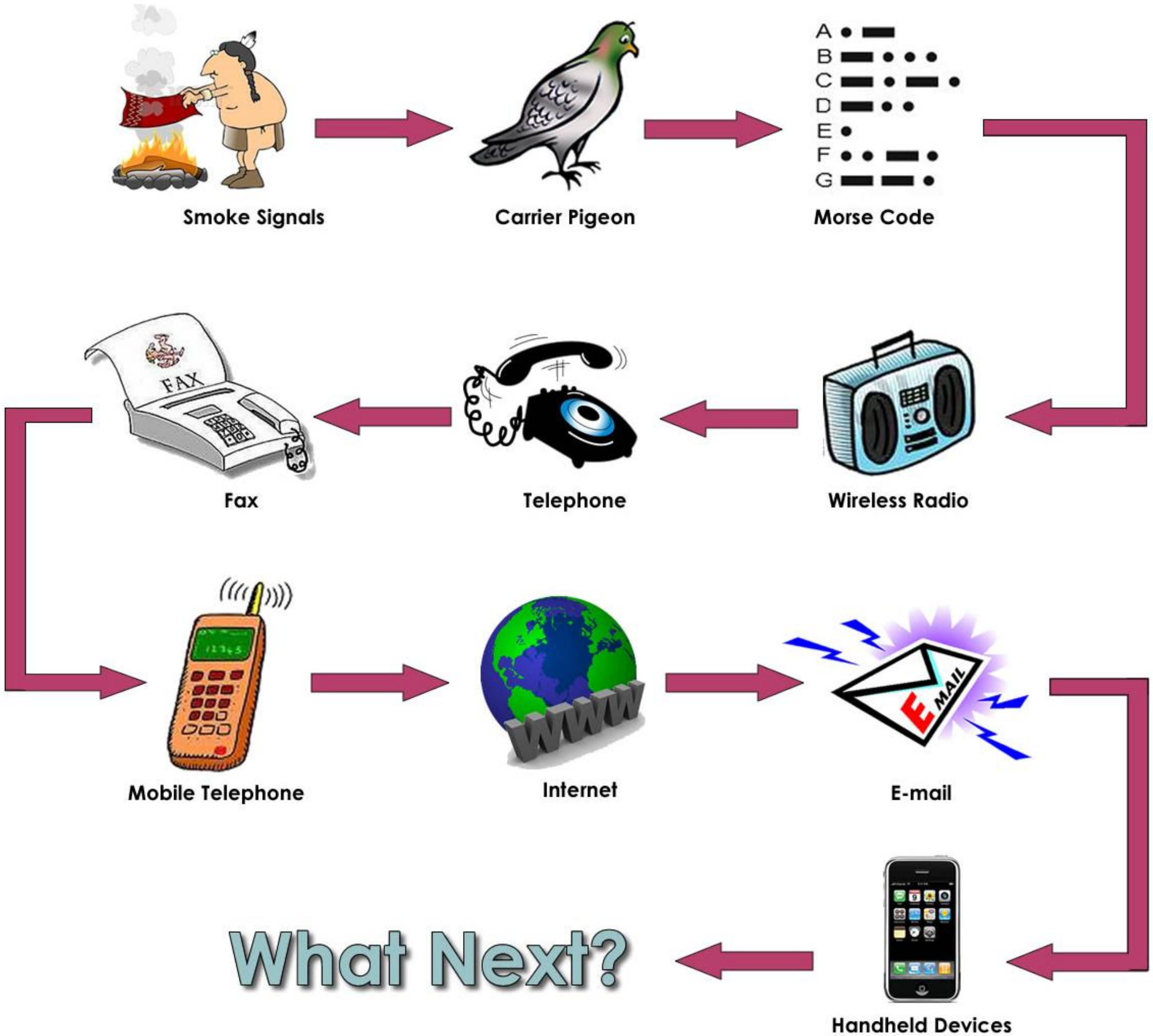
- **Measurand (Physical quantities)**:
  - Position, displacement
  - Temperature
  - Force
  - Pressure,…
  - Concentrations, chemicals,…,
- **Sensor**:
  - is a device that detects a change in a physical stimulus and turns it into a signal which can be measured or recorded
- **Signal conditioning:**
  - Amplifying, wave- shaping, filtering, rectifying,…
- **Transducer**
  - is a device that transfers power from one system to another in the same or in a different form.

Smart Phone Tough: Techno Sensitivity

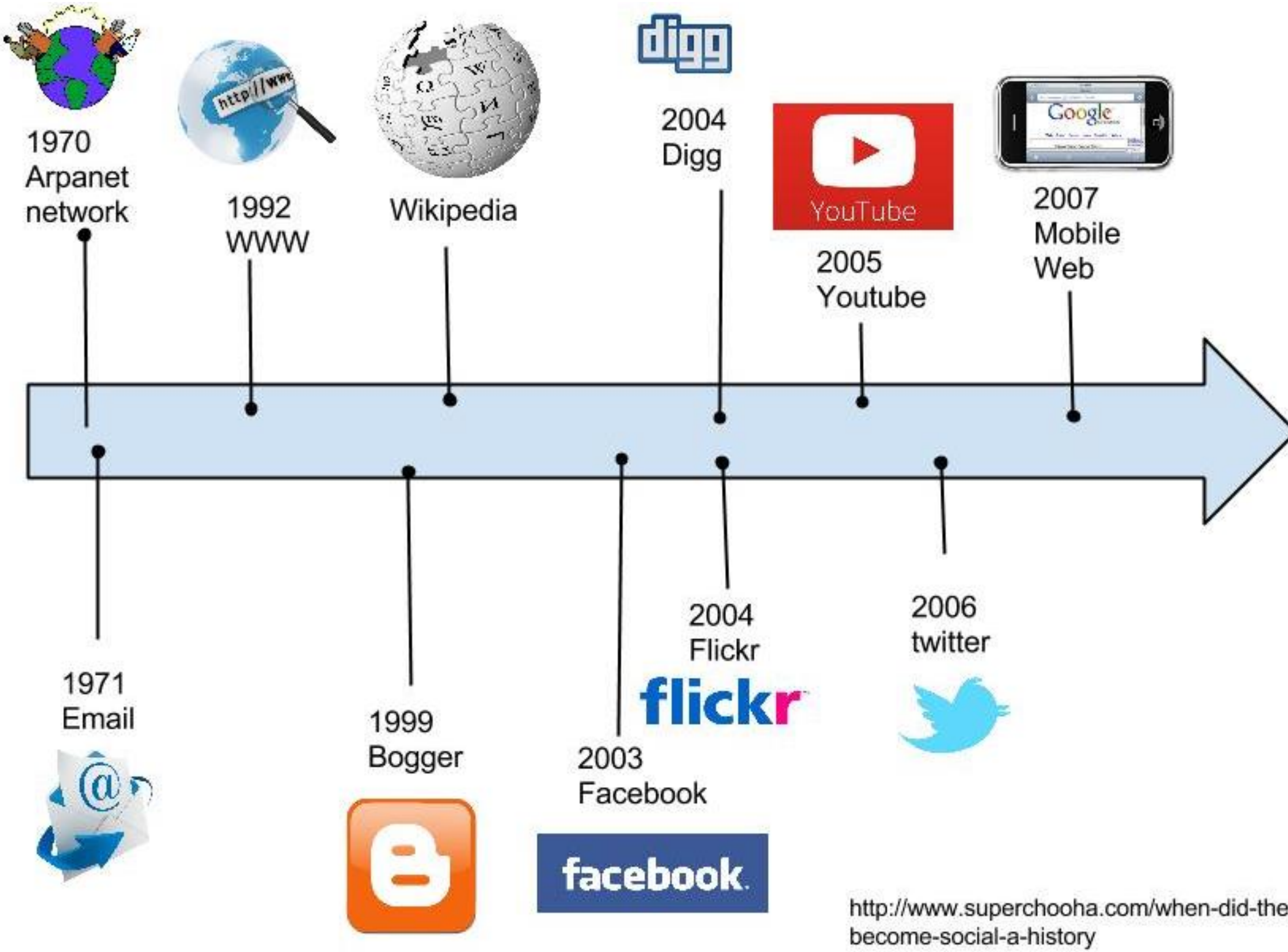
- The two key elements of a MEMS are:
  - MEMS sensor, the silicon mechanical element which senses the motion;
  - Interface chip, the IC which converts the motion measured by the sensor into an analog or digital signal.

Integrated circuit (IC)

CommunicationTimeline



The History of Internet

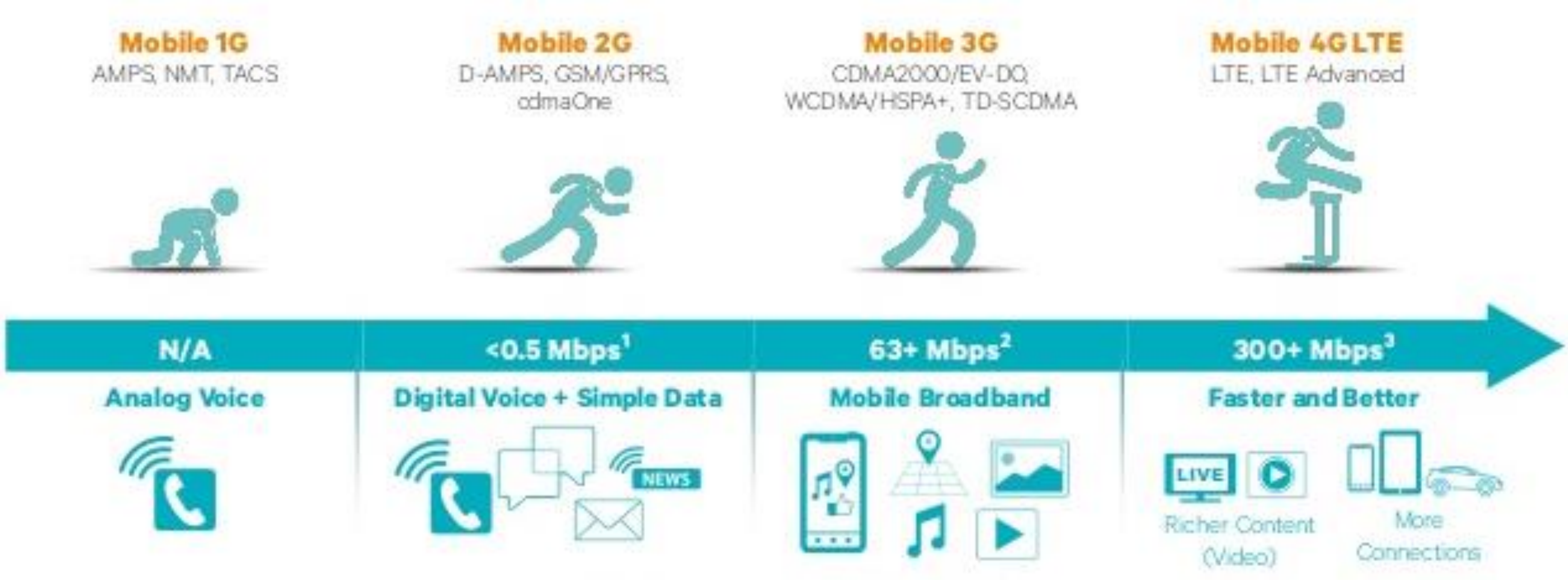


http://www.superchooha.com/when-did-the-web-become-social-a-history

The evolution of the cellphone


Evolution of the Mobile Phone
Motorola 8900X-2
Nokia 2146
Nokia 3210
Nokia 6210
Ericsson T39
Alcatel OT511
Samsung E250
Apple iPhone
BlackBerry Curve 8900
Samsung Galaxy S2
Samsung Galaxy S4
Samsung Galaxy S9

Mobile Technology



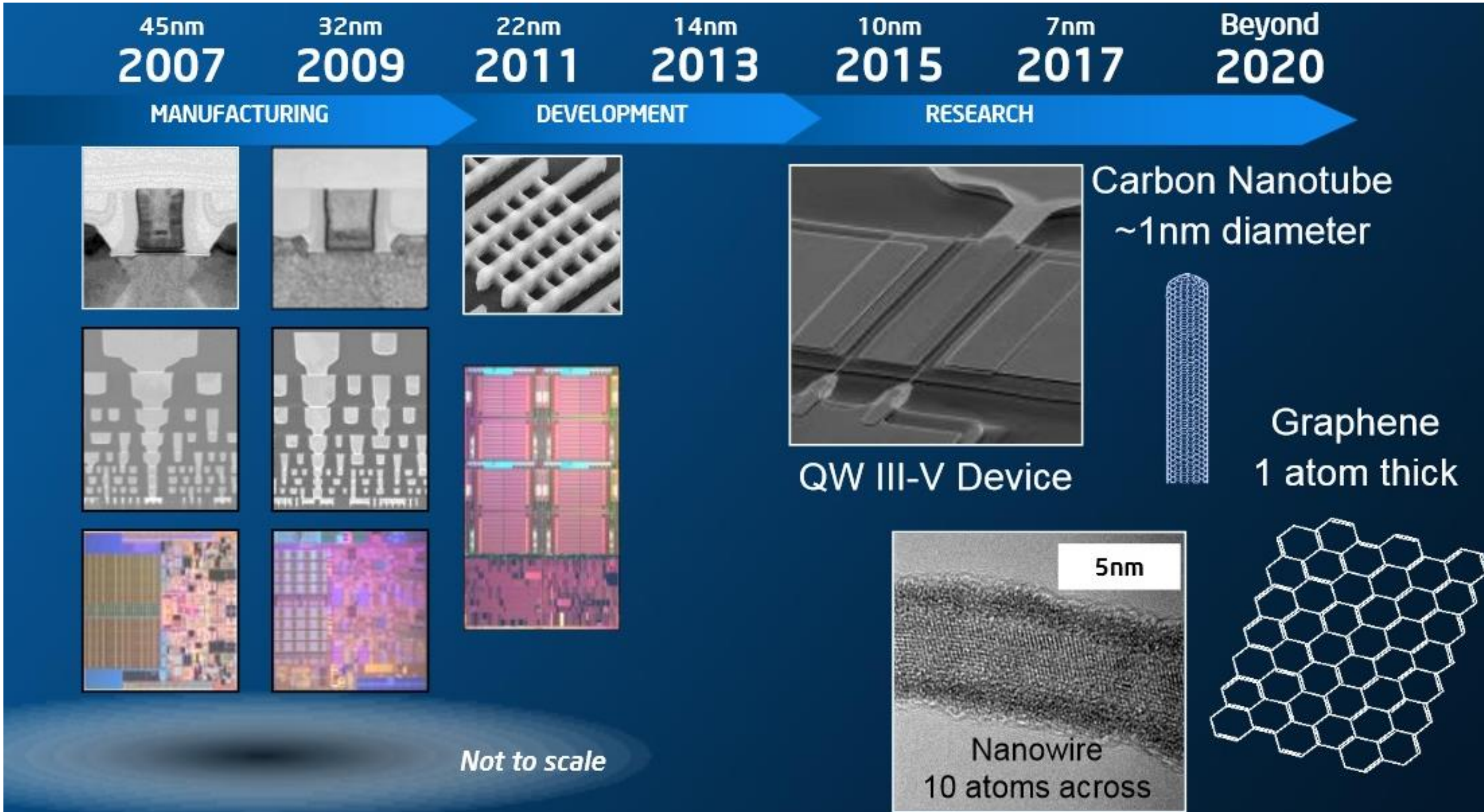
Comparison between 4G vs. 5G

The following basis differences between 4G and 5G are:

	4G (2000-10)	5G (2010-20)
Switching	Circuit/Packet	Circuit/Packet
Data Rate	Upto 20 Mbps	Upto 1 Gbps
Technology	Combination of broadband LAN/WAN/PAN	Combination of broadband LAN/WAN/PAN

Technology Generation

2014 2017 2020?

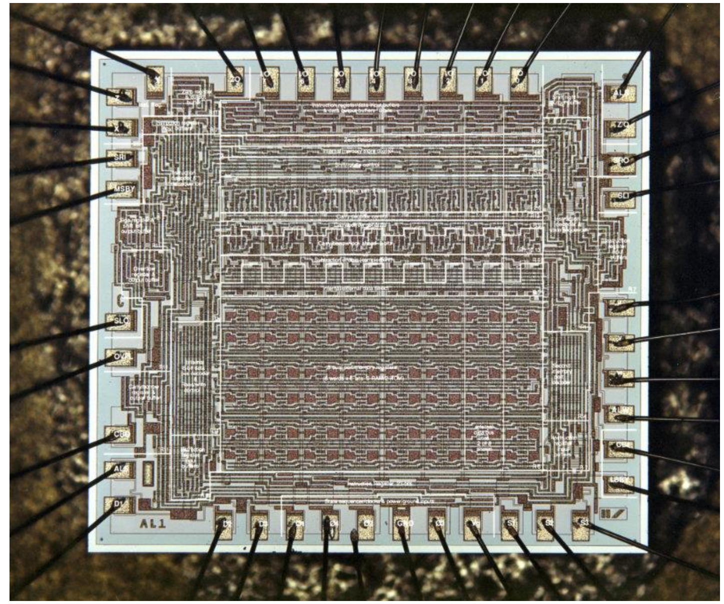


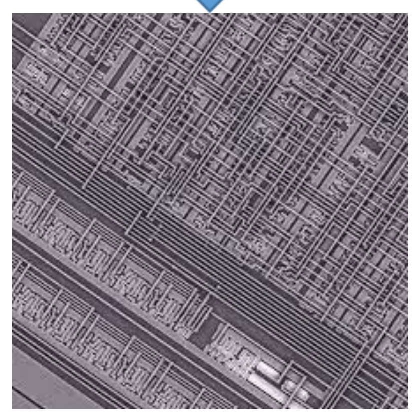
- Silicon lattice is ~ 0.5nm, hard to imagine good devices smaller than 10 lattices across – reached in 2020

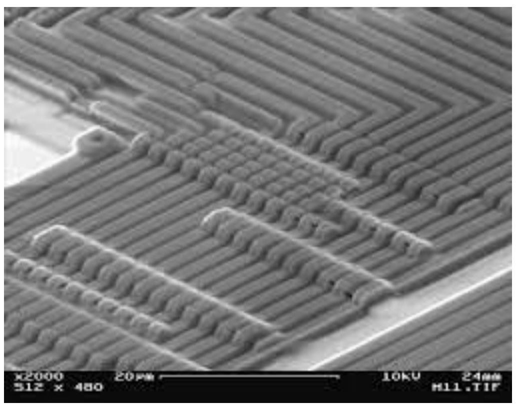
Metric Prefixes

Symbol	Name	Multiplication
p	pico	1×10^{-12}
n	nano	1×10^{-9}
µ	micro	1×10^{-6}
mm	milli	1×10^{-3}
m	meter	1
k	kilo	1×10^{3}
M	Mega	1×10^{6}
G	Giga	1×10^{9}
T	Tera	1×10^{12}
PETA	Peta	1×10^{15}
EXA	Exa	1×10^{18}


intel
Core™ i7



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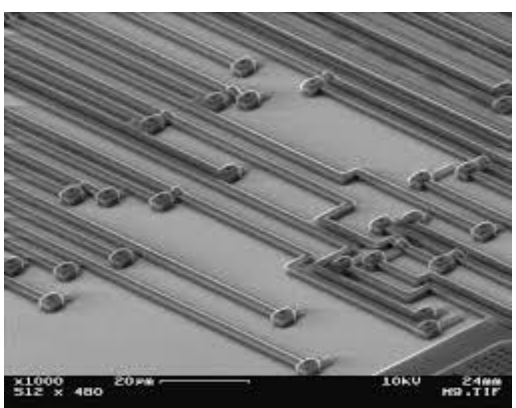
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Conclusion

- The medical, wireless technology, biotechnology, computer, automotive and aerospace industries are only a few that will benefit greatly from MEMS.

- This enabling technology promises to create entirely new categories of products

- MEMS will be the indispensable factor for advancing technology in the 21st century