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<td>Mohammad Tollabi Mazraehno</td>
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Cleaning techniques

- Clean room/ Clean room apparel
- Types and sources of contamination
- Substrates for microoptics
- Cleaning methods: wet and dry

- Standard wet cleaning- RCA
- Ultrasonic cleaning
- Plasma Ashing
- Cleaning after the fabrication?
Photoresist

- Photoresists Type (Positive, Negative)
- Photoresists Structure (Resin, Solvent, Photoactive compound)
- Photoresists processing
- Chemistry of photoresist
- Optical processes in photoresist (Dill parameters)
- Backing processes
- Performances of photoresist
Spin Coating

- Equipment Schematic
- Basic Physics/ model of the process
- Common Spin Coating Defects

![Equipment Schematic](image)

Viscous Force: $-\eta \frac{\partial^2 v}{\partial z^2} = \rho \omega^2 r$

Centrifugal Force

![Viscous Force and Centrifugal Force](images)
Extreme ultraviolet lithography

- Double patterning
- Maskless lithography
- X-ray lithography
- Ion-projection Lithography (IPL)
- Charged-particle lithography
- Neutral Particle Lithography
- Nanoimprint lithography
- Scanning probe lithography
- Atomic Force Microscopic Nanolithography
- Magnetolithography

Nanosphere lithography
Double Patterning

double exposure lithography (DEL)

double patterning lithography (DPL),

depending on whether the resist is developed once or twice

- Dual-tone photoresist
- Dual-Tone Development
- Self-aligned spacer
- Double/Multiple exposure
- Double Expose, Double Etch (mesas)
- Double Expose, Double Etch (trenches)
- Multiple patterning - the ultimate resolution
AFM (Atomic Force Microscope)

Scanning Probe Microscopy "Family Tree" (SPM)

- How AFM works
- Kind of forces involved in the afm
- Different types of operation (contact; non contact; tapping)
- The use of AFM in Microoptics

Linewidth variability

Sidewall roughness and profiles

Standard tip
Integrated Optics

Integrated optical circuits (IOC’s) are the direct optical analogues of the electronic integrated circuits now in use. In a IOC, lasers, lenses, beam splitters, modulators, etc., should be produced in compact, low power consuming, easily connectable packages. Although nowadays one is still a long way from truly monolithic integrated optics, some devices are already available and the fabrication of hybrid circuits is possible, combining some discrete optical components with integrated devices.

The basis of integrated optic devices is the optical planar (or slab) waveguide.

- Advantages (small size, low power consumption; Efficiency and reliability of batch fabrication...)
- Waveguide
- Optical components ( interferometer, prisma coupling, grating coupling,...)
- Photonic crystal

An example of one of the basic IO components is the Y-coupler (also called Y-junction), whose main application is in beamsplitters or interferometric modulators.

![Y-coupler with single-mode stripe waveguide](image-url)
Diamond machining of micro-optical components and structures

- Methods employed in producing microstructure optics:
  - Diamond Turning (DT)
  - Diamond milling
  - Diamond shaping
  - Raster cutting
  - Slow Slide Servo (SSS) and Fast Tool Servo (FTS)

- Requirements for microoptics
**Precision Cutting**

Fraunhofer-Institute for Production Technology (IPT), Aachen

- **Turning**
- **Thin-film turning**
- **Endmill cutting**
- **Fly-cutting**

- **Fast-Tool turning**
- **Plunge-cutting**
- **Ball-endmill cutting**
- **Planing**

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- **Endmill Ø 300 µm**
- **Ball-endmill R 0.8 mm**
- **Fly-cutting tool width 120 µm**
- **Tool for contour-machining R 0.5 mm**
- **Tool for plunge-cutting (sharp pointed)**
- **Tool for contour-machining R 2.5 µm**

- **200 µm**
- **20 µm**
- **50 µm**

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100 µm
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