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The Loss Mechanism of Nanoporous Silicon Optical Waveguide for Biochemical Sensors

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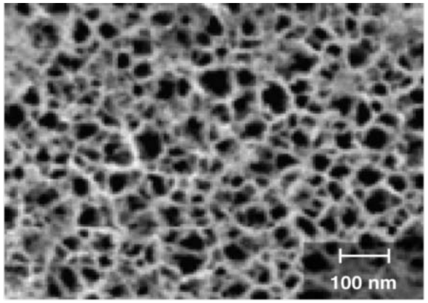
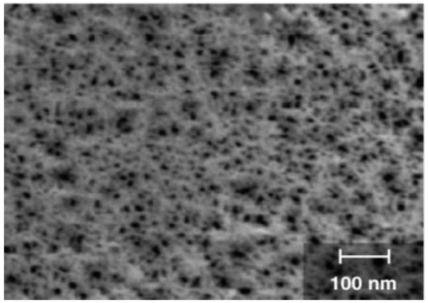
Introduction

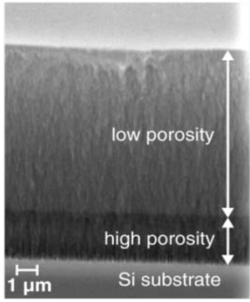
- Nanoporous silicon
  - Large surface area
  - Large range of porosities, and refractive indices
- Optical waveguide, Biosensor
  - Multilayer structure
- Optical loss
  - Propagation loss
  - Coupling loss

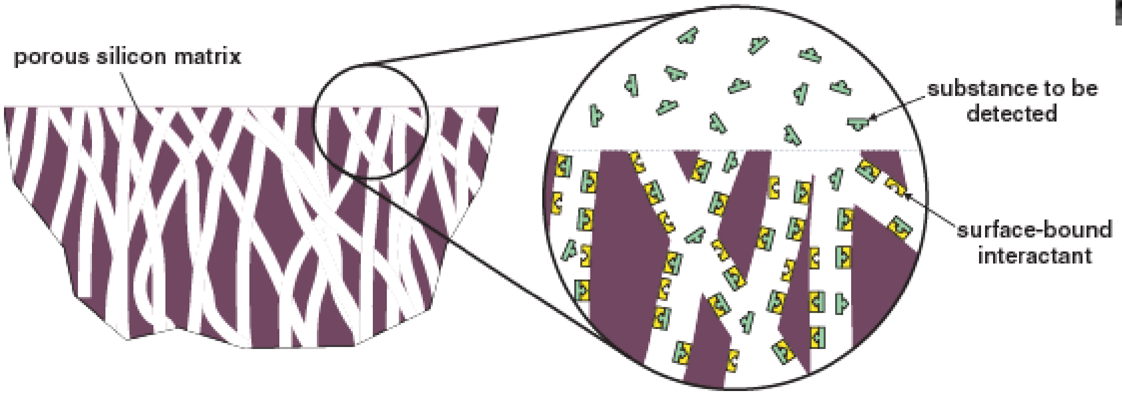
High porosity



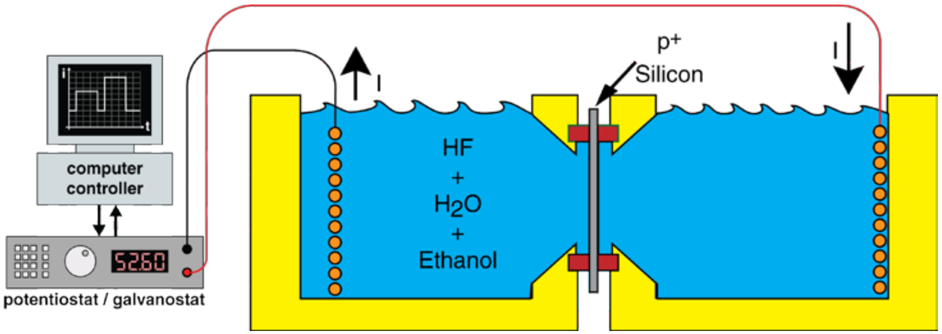


Low porosity





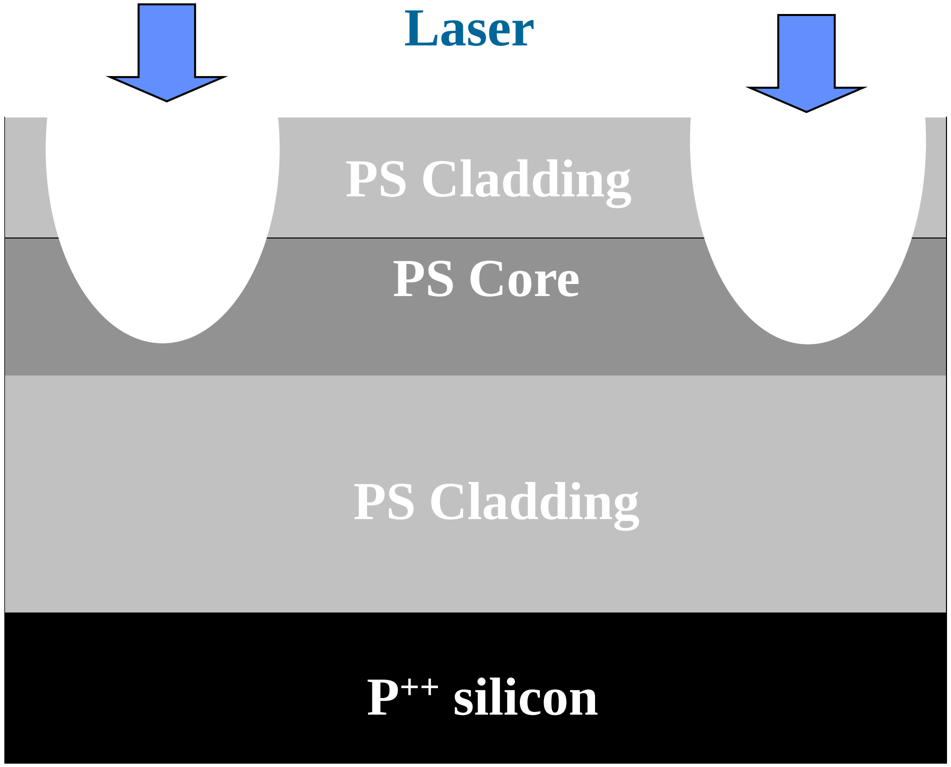
Fabrication Procedure



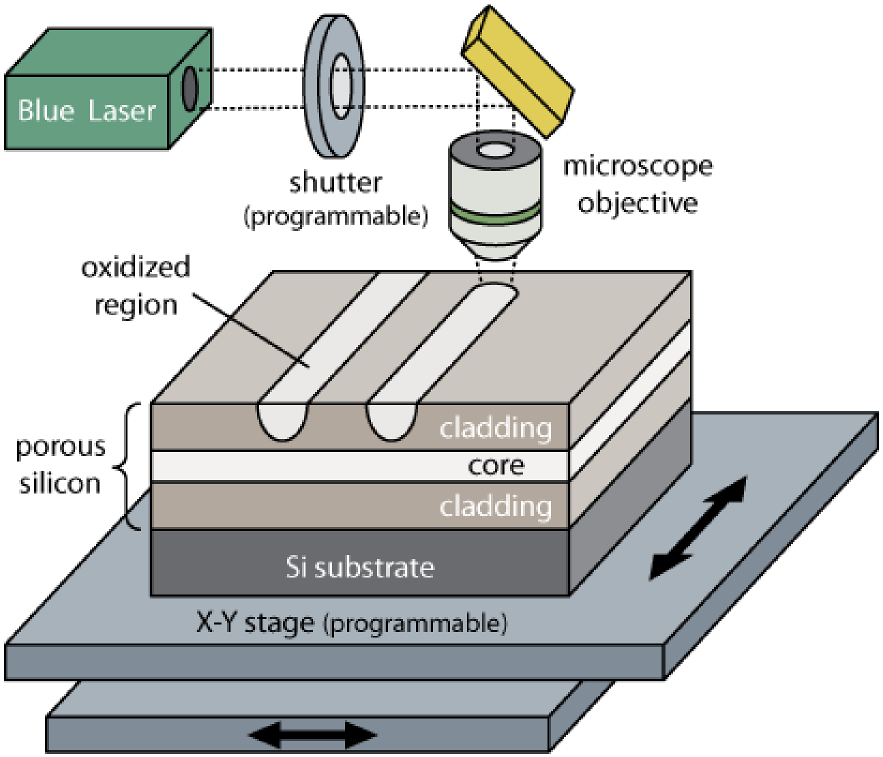
- **Electrochemical Etching**
  - p-type doped silicon wafer ($10^{20}\,\mathrm{cm}^{-3}$)
  - HF-Water-Ethanol = 1:1:2
  - Different current densities

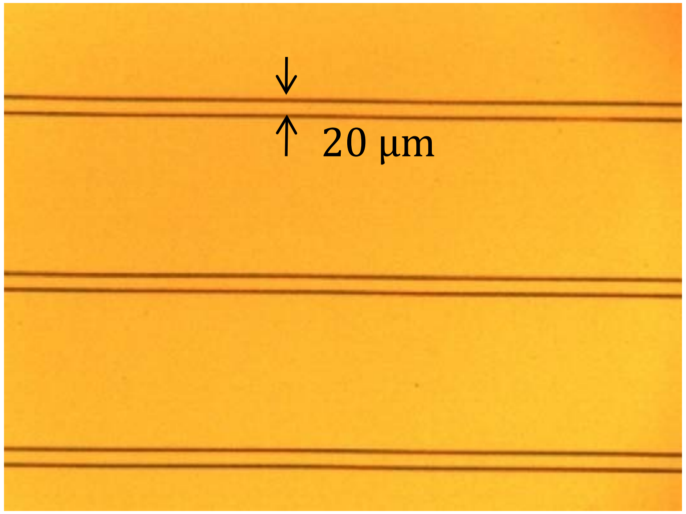
- High current density → High porosity
  → Low refractive index → Cladding layer

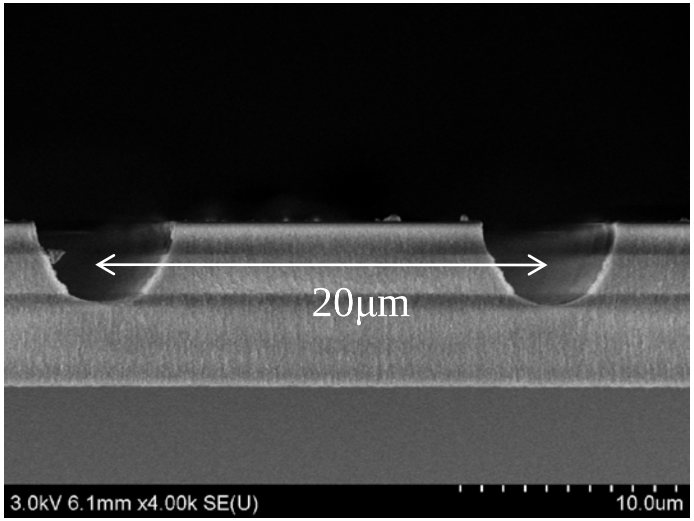
- Low current density → Low porosity
  → High refractive index → Core layer



Laser Writing







- 473nm blue laser
- Optimized parameters
  - 30mW laser power
  - 1mm/s speed running X-Y stage
  - 20 µm width waveguide

Measurements & Results

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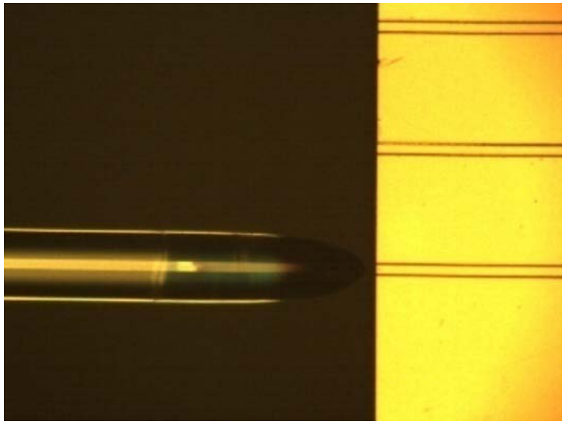
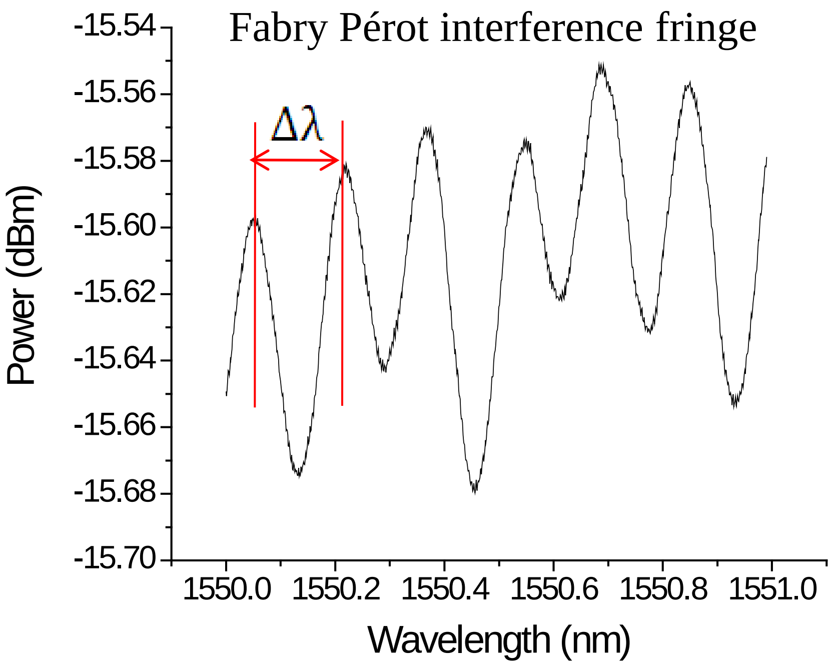
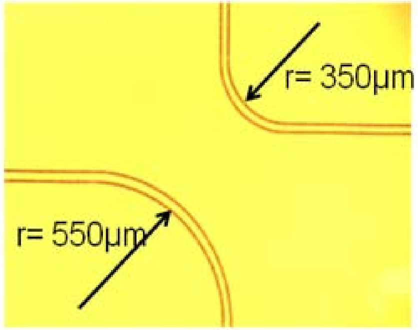
- Fiber coupling measurement
  - 1550nm wavelength
  - Input power : 0.879mW, Output power : 0.112mW
  - Total loss = -8.9dB

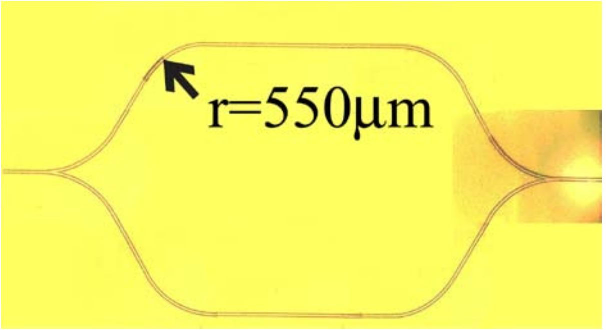


- Fabry Pérot measurement
  - Effective refractive index:1.552
  - Propagation loss: -13dB/cm
  - Coupling loss: -2.6dB



- Bent waveguides and
  Mach Zehnder interferometer





Conclusions

- Losses for nanoporous silicon waveguide

$$Total\ loss = -8.9dB$$

$$Propagation\ loss = -13dB/cm \qquad (-6.3dB)$$

$$Coupling\ loss = -2.6dB$$

- Propagation loss is the main loss.
- Lose analysis of porous silicon waveguide based on Fabry Pérot interferometry measurement was achieved.
- Optimized parameters to obtain low loss nanoporous silicon optical straight waveguide which can be used as biochemical sensors.
- Bent waveguide and Mach Zehnder interferometer was fabricated.

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