The Loss Mechanism of Nanoporous Silicon Optical Waveguide for Biochemical Sensors

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Nanoporous silicon
- Large surface area
- Large range of porosities, and refractive indices

Optical waveguide, Biosensor
- Multilayer structure

Optical loss
- Propagation loss
- Coupling loss
Fabrication Procedure

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

- High current density $\rightarrow$ High porosity $\rightarrow$ Low refractive index $\rightarrow$ Cladding layer

- Low current density $\rightarrow$ Low porosity $\rightarrow$ High refractive index $\rightarrow$ Core layer
Laser Writing

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

  \[
  \text{Total loss} = -8.9\,\text{dB}
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  \[
  \text{Propagation loss} = -13\,\text{dB/cm} \quad (-6.3\,\text{dB})
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  \text{Coupling loss} = -2.6\,\text{dB}
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- 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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