Optical Interconnect Fabrication

ECE6450

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Outline

- Introduction
- Fabrication of optical interconnects
- Conclusion

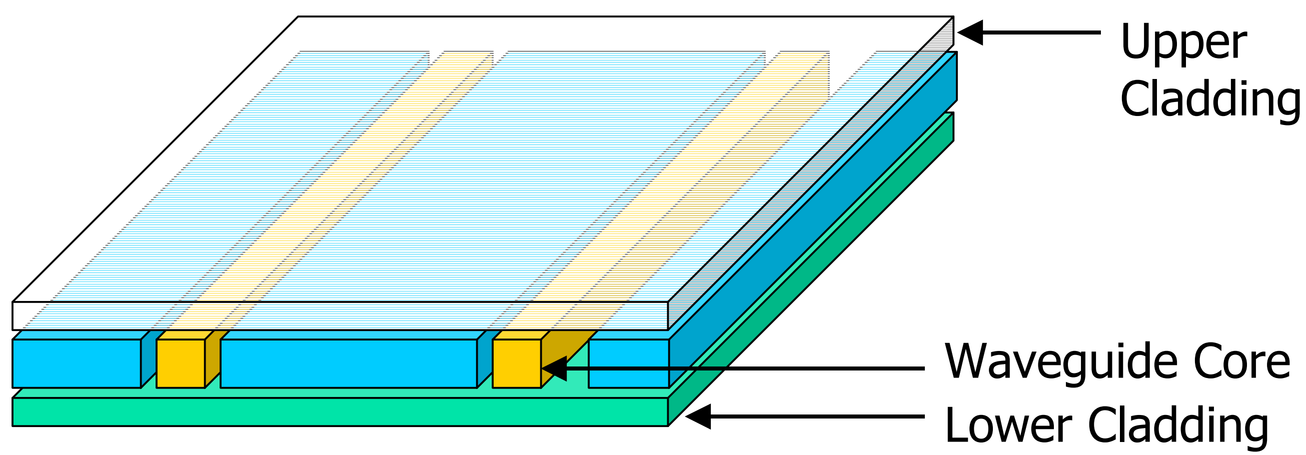
Introduction –
Why Optical Interconnect ?

- In integrated circuits, device delays are dominated by interconnection delays
- RC time constant does not scale down with device scaling, remains unchanged.
- Clock distribution in gigascale integration is now a growing concern
- Optical interconnects have the potential to solve these problems!

Introduction –
What is Optical Interconnect ?

- An optical interconnect is a **waveguide** fabricated in integrated circuits. Waveguides can be be made of different materials. We focus on polyer waveguides.
- For free-space optical interconnects, light propagates in free space

Basic Waveguide Structure



Characteristics of Optical Interconnects

Compared to electrical interconnects, optical interconnect benefits are:

- Immunity to Electromagnetic Interference (no crosstalk)
- Propagation speed dependent only on medium, independent of capacitance, inductance, and resistance.
- Free-space propagation – needs no propagation medium

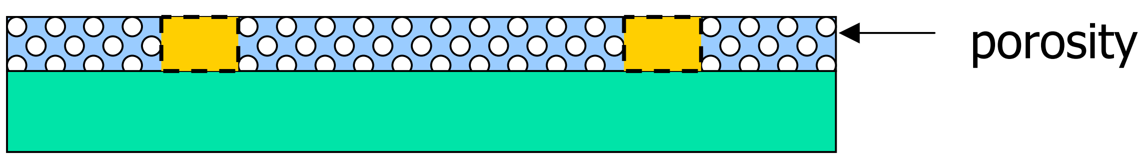
Methods of Fabrication of Waveguides

- Reactive Ion Etching (RIE)
- Micro-molding
- Laser and E-beam writing

Focus on a new proposed method

Nanoporous Spin-on Waveguide*

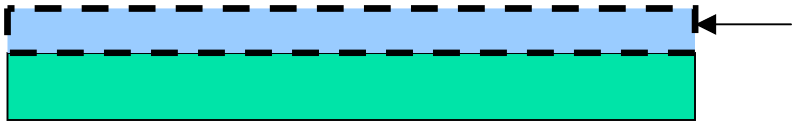
- We need a core and a cladding region to form a waveguide
- We create the lower-indexed cladding region by introducing porosities to the waveguide layer to lower its index of refraction
- The pores are created by adding a sacrificial polymer to a commercially available spin-on film, and thermally decomposing the sacrificial polymer within the film to form nano-size pores (~3-9 nm)



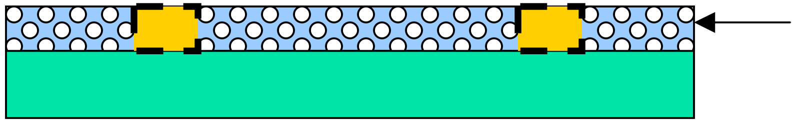
*** Padovani, A, "Templated Nanoporous Spin-on Glass for High Density Interconnect Applications"**

Nanoporous Waveguide Fabrication

The basic idea:

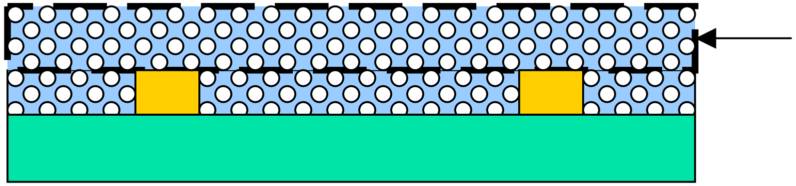


Spin coat onto substrate

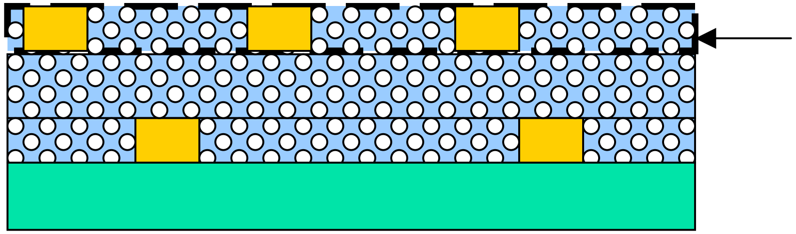


Heat up the sample. The sacrificial material decomposes, leaving nano-size porosities.

Nanoporous Waveguide Fabrication

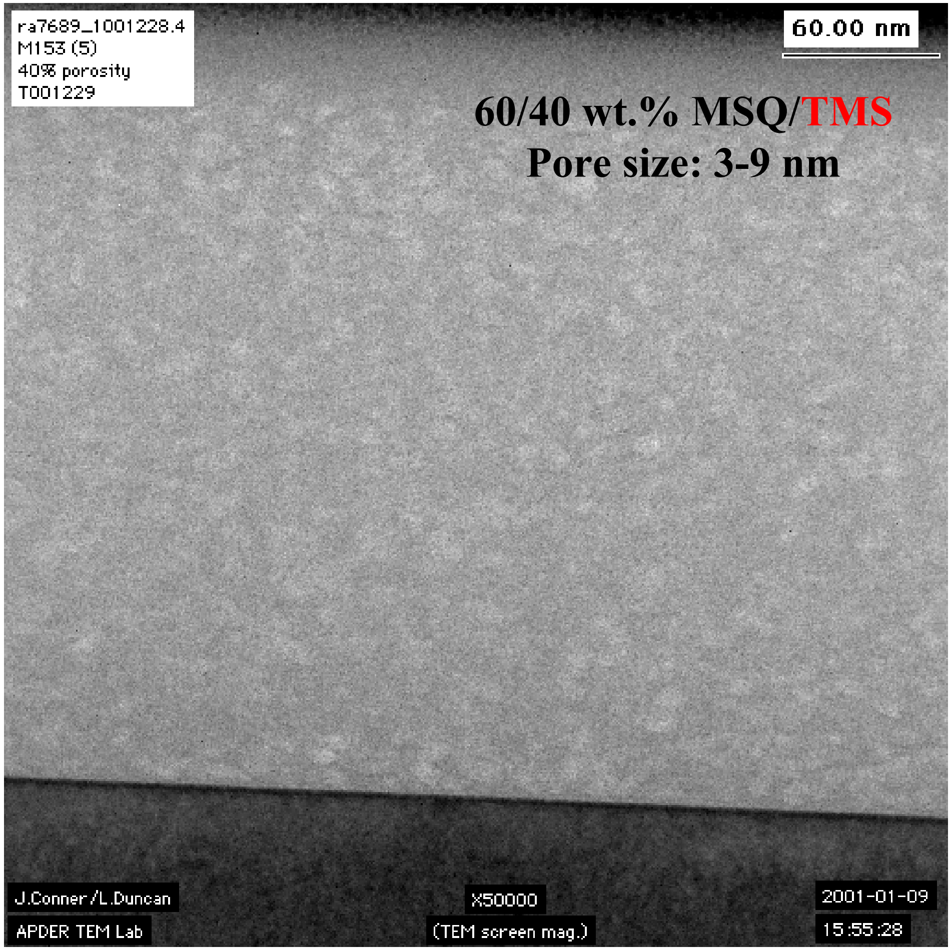


Spin coat another layer on top of the core layer and form porosities.



Multiple layers of waveguides

Transmission Electron Microscope(TEM) Image of Film After Decomposing



* Lighter color regions correspond to the porosities

Advantages Of Nanoporous Waveguides

- Material used as both waveguide core and cladding, and also used as an insulator for electrical components
- Low-k material (2.3-2.6 depending on weight (wt.) % of sacrificial polymer)
- Dielectric constant (electrical property) and index of refraction (optical property) are inversely related to wt. % of sacrificial material
- Size of porosities on the order of a few nm, much smaller than the wavelength of the wavelength of light, so light sees the material as homogeneous. Ideal for waveguide application

Challenges Of Nanoporous Waveguides

- Due to the intrinsic strain of the films, the layer thickness limited at less than 600 nm. Films thicker than 600 nm will crack upon processing
- Waveguide material not photosensitive. Difficult to define the cladding region.

Conclusion

- Nanoporous materials can be used as both core and cladding of a waveguide, and act as an insulator for electrical components
- Introduce a lower index of refraction by decomposing the sacrificial material and forming nanopores.
- Dimension of the porosities are much smaller than the wavelength of light and the the light sees the material as homogeneous
- Work to be done to make the waveguide material photosensitive.

Questions?