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Modeling Of A Diffraction Grating Coupled Waveguide Based Biosensor For Microfluidic Applications

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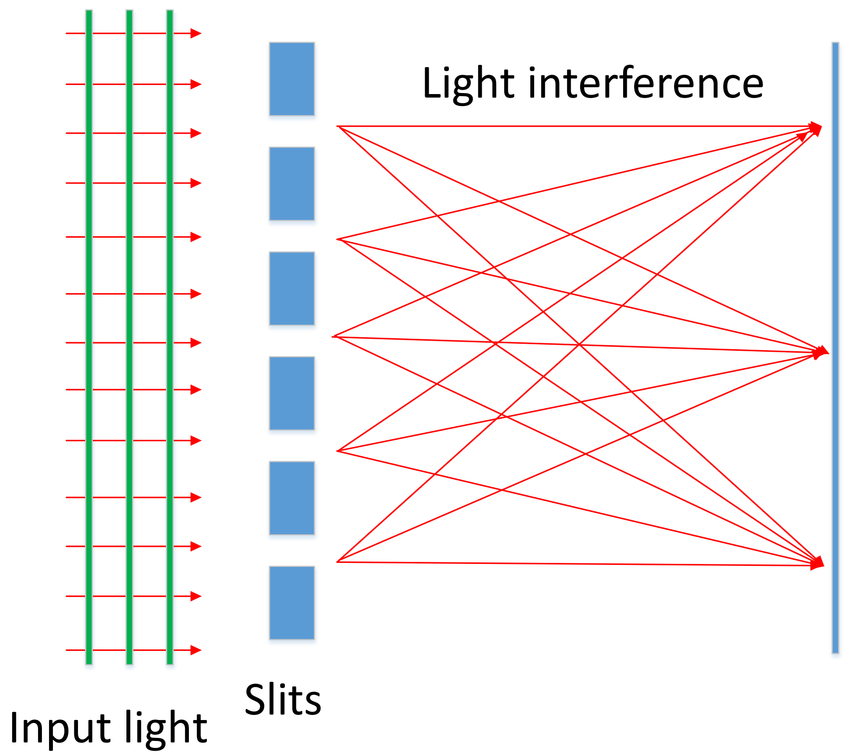
Outline

- Motivation
- Background
- Computational method
- Result
- Conclusion

Motivation

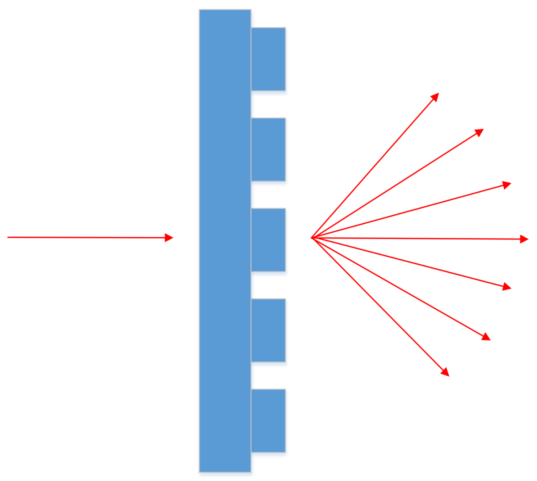
- Point-of-care diagnostics and lab-on-a-chip applications need low cost, accurate sensing
- Optical sensing techniques are well established
- A microfluidic diffraction grating coupled waveguide (MDGCW) biosensor
  - Label-free detection of a biological analyte
  - High sensitivity based on changes in refractive index
  - Designed for simplicity of fabrication and functionalization

Background



Principle of a classical optical grating

$$d(sin\varphi_t - sin\varphi_i) = m\lambda$$



Light incident onto a binary grating will be diffracted to several diffraction orders

$$d(n_t sin\varphi_t - n_i sin\varphi_i) = m\lambda$$

Computational methods

Wave Optics module is used.
The boundary mode analysis is used to run the simulation in which the propagation constant and electric field are solved.

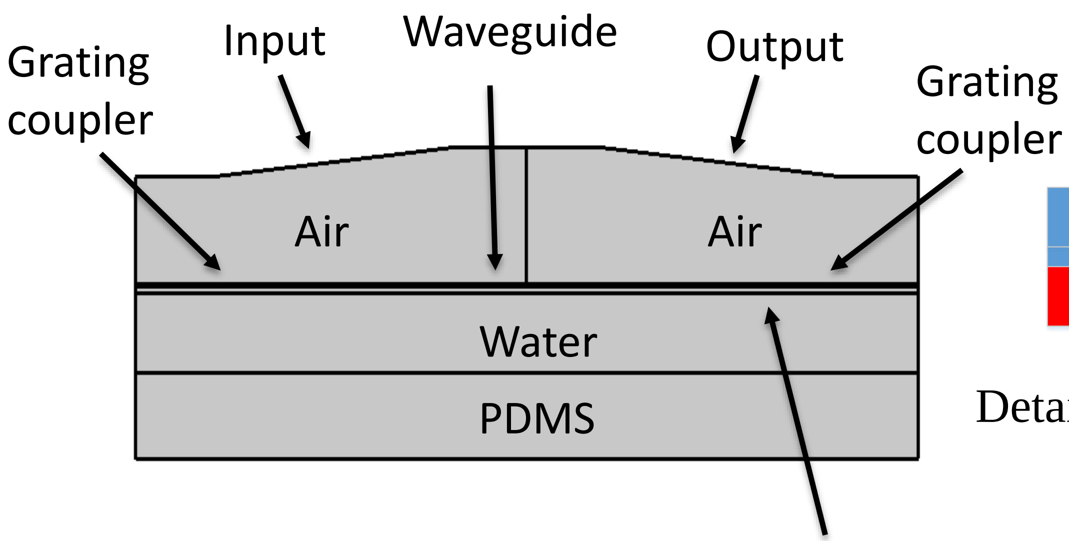
$$\nabla \times \mu_r^{-1}(\nabla \times E) - k_0^2 \left(\epsilon_r - \frac{j\sigma}{\omega \epsilon_0} \right) E = 0$$

$$\lambda = -j\beta - \delta_z$$

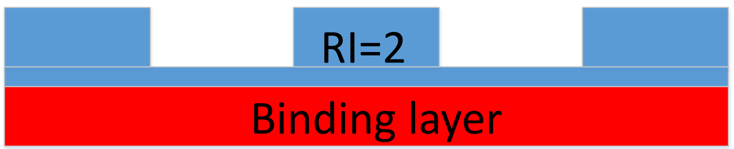
$$E(x, y, z) = \tilde{E}(x, y) e^{-ik_z z}$$

Boundary condition: Scattering boundary condition.

Model Geometry



Geometry of the microfluidic diffraction grating coupled waveguide based biosensor.



Details of the grating design and binding layer.

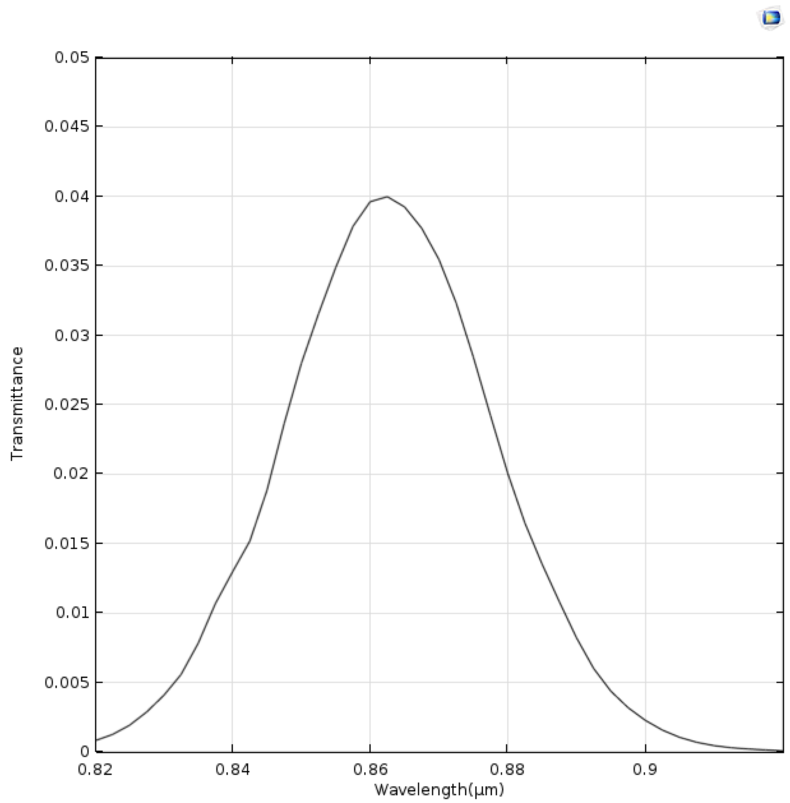
Characteristic Equations

$$n_{eff} = n_t sin\varphi t$$

$$n_{eff} = n_{top} * sin\varphi_i + m\frac{\lambda}{d}$$

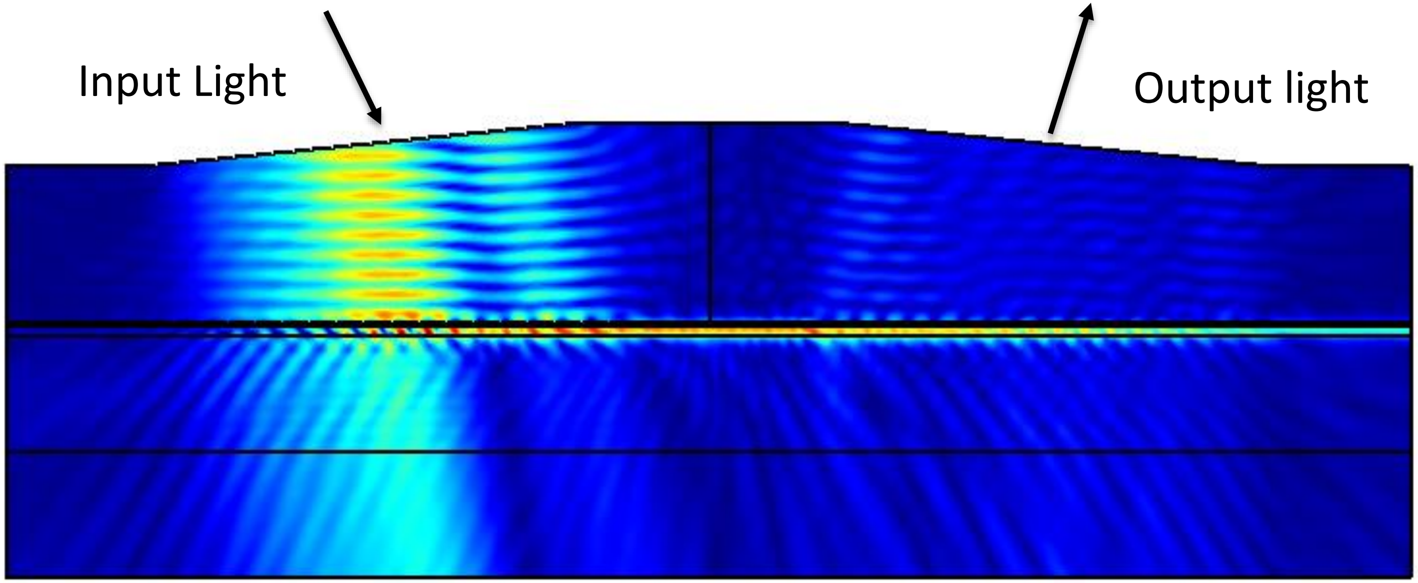
$$\Delta n_{eff} = n_{top} * sin\varphi_i + m\frac{\Delta\lambda}{d}$$

$$S = \frac{\Delta\lambda}{\Delta n}$$



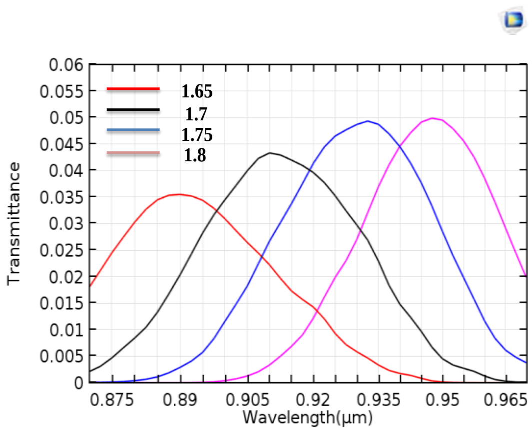
Transmission through the MDGCW structure

Results

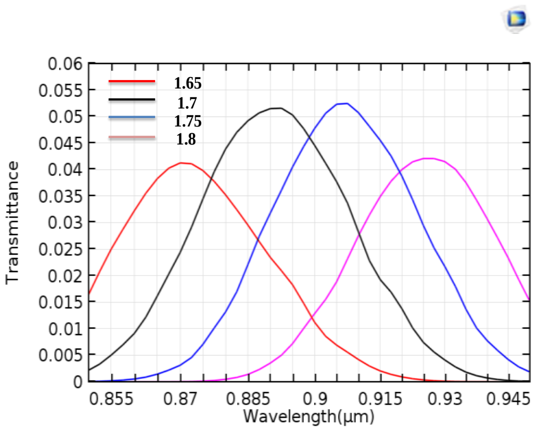


Electrical field distribution of the sensor

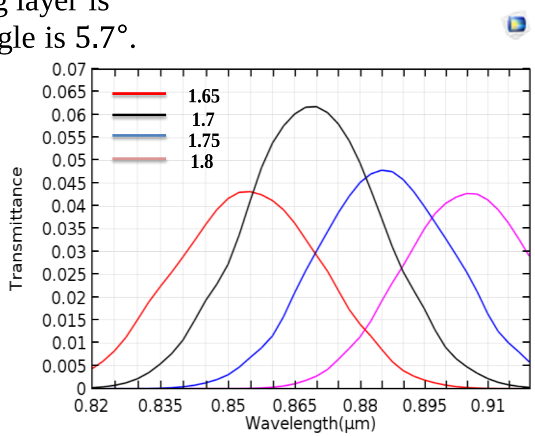
Results



Spectrum when binding layer is 0.2μm and coupling angle is 5.7°.

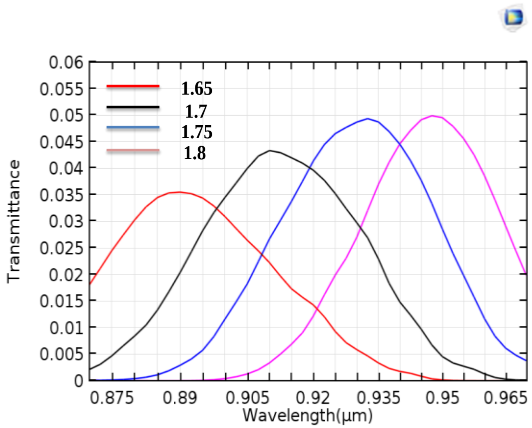


Spectrum when binding layer is 0.2μm and coupling angle is 7.9°.

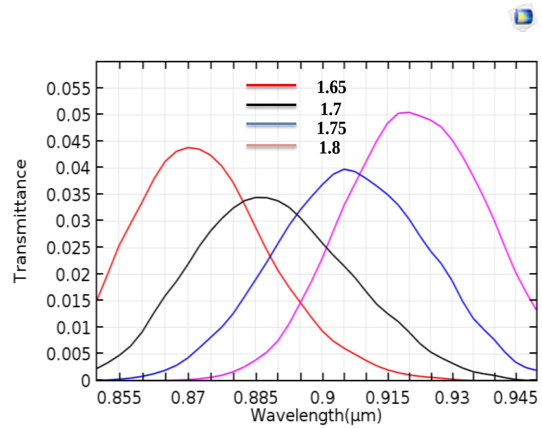


Spectrum when binding layer is 0.2μm and coupling angle is 10.1°.

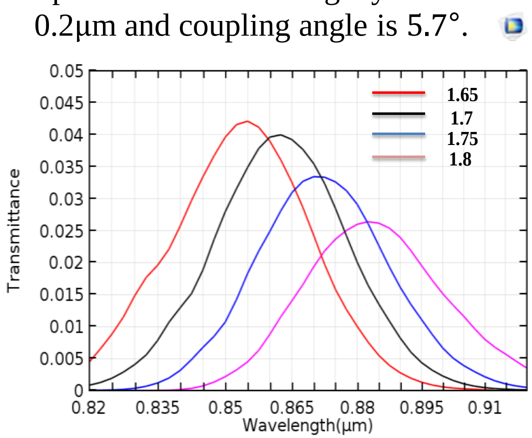
Results



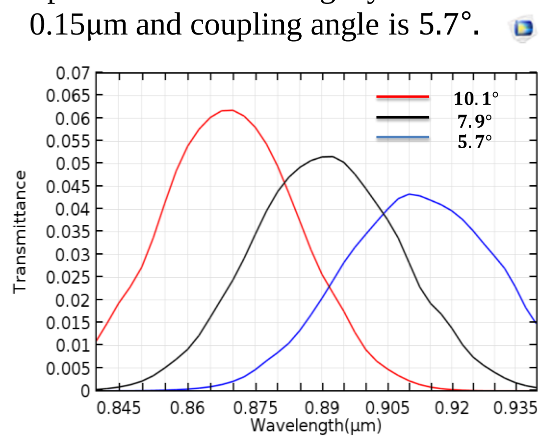
Spectrum when binding layer is 0.2µm and coupling angle is 5.7°.



Spectrum when binding layer is 0.15µm and coupling angle is 5.7°.



Spectrum when binding layer is 0.1µm and coupling angle is 5.7°.



Spectrum when binding layer is 0.2µm and the refractive index of the binding layer is 1.7

Conclusion and Future Work

- MDGCW biosensor has good sensitivity
- Additional simulation
- Fabrication and testing of the MDGCW design