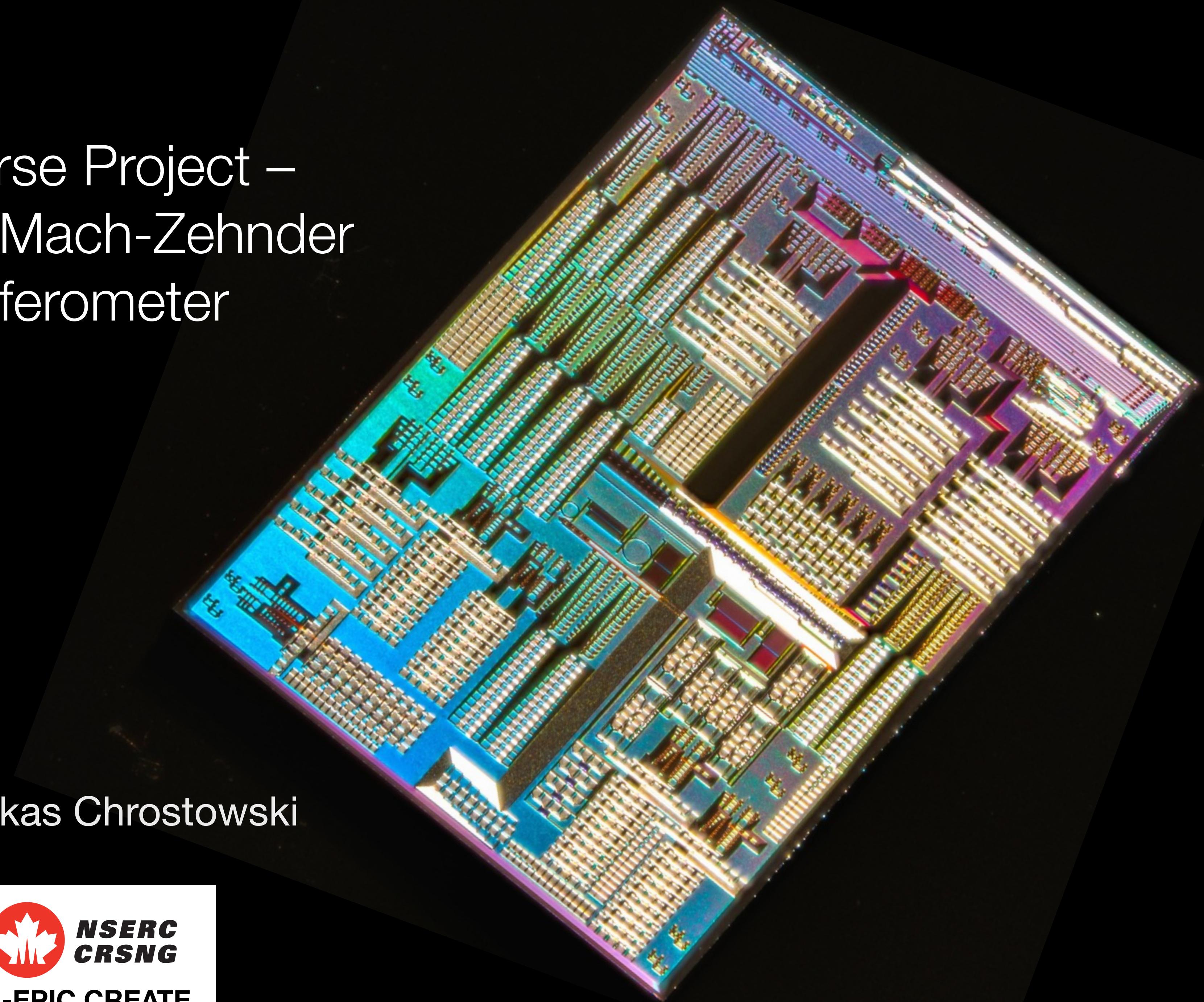


Course Project – The Mach-Zehnder Interferometer



Dr. Lukas Chrostowski

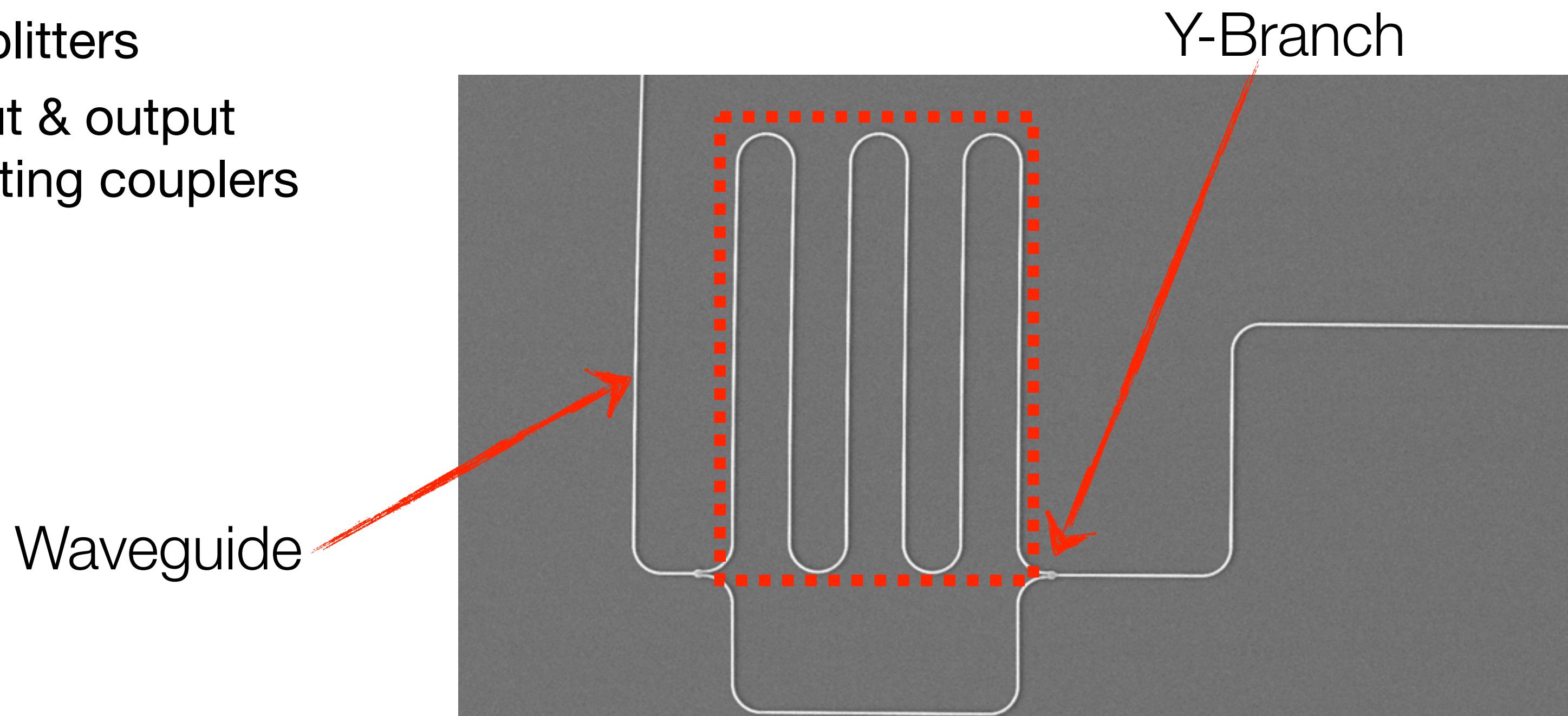


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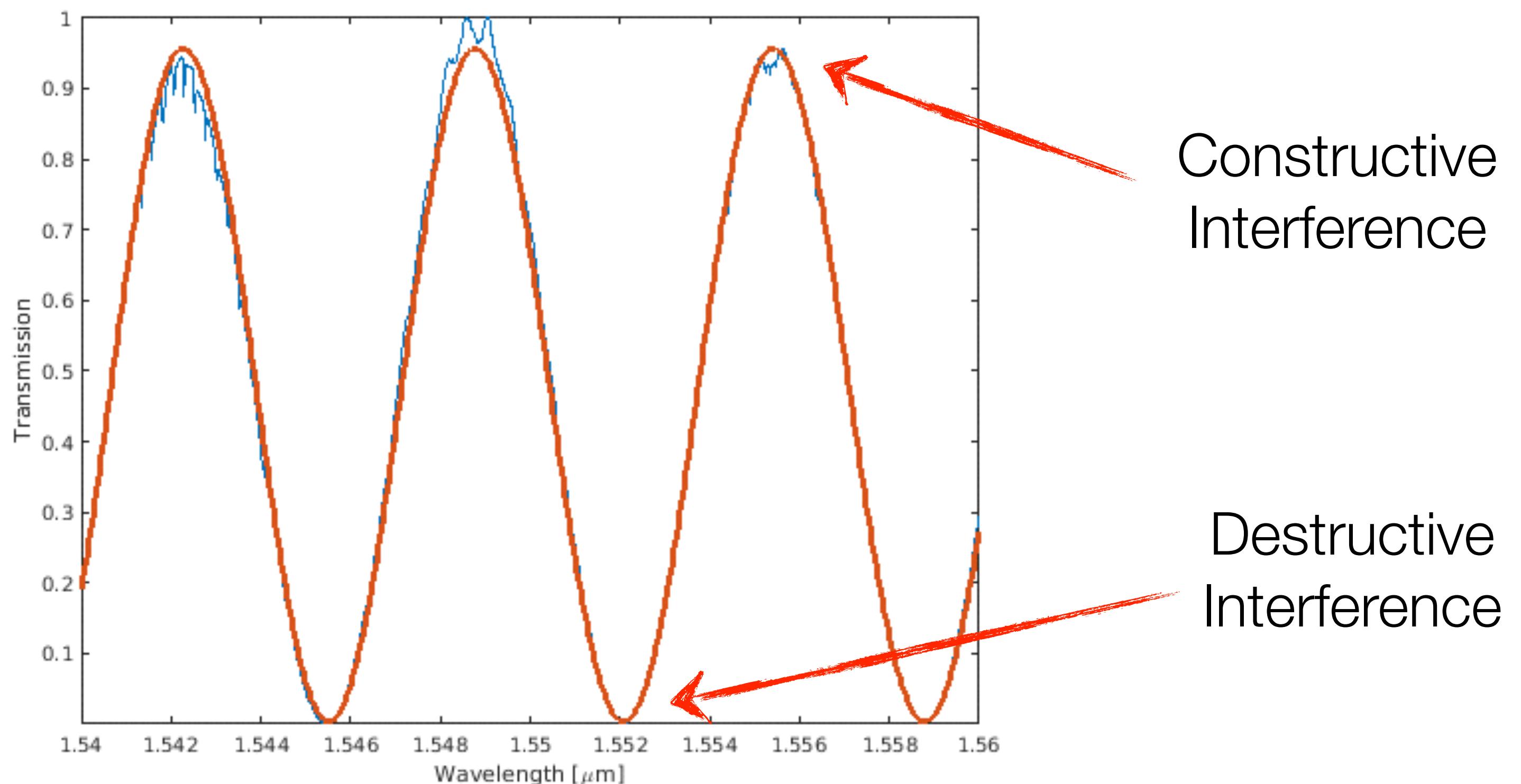
Course Project

- Modelling and design of a fundamental building block in photonic circuits
 - The **Mach-Zehnder Interferometer (MZI)**
 - Used for optical switches (on-off modulation, routing signals) and filters
- We will use components:
 - Waveguides
 - Y-Branch splitters
 - Optical input & output via fibre grating couplers



Interference

- Task – Design an imbalanced interferometer, in order to observe constructive and destructive interference
- As a function of wavelength, observe oscillations:



Constructive
Interference

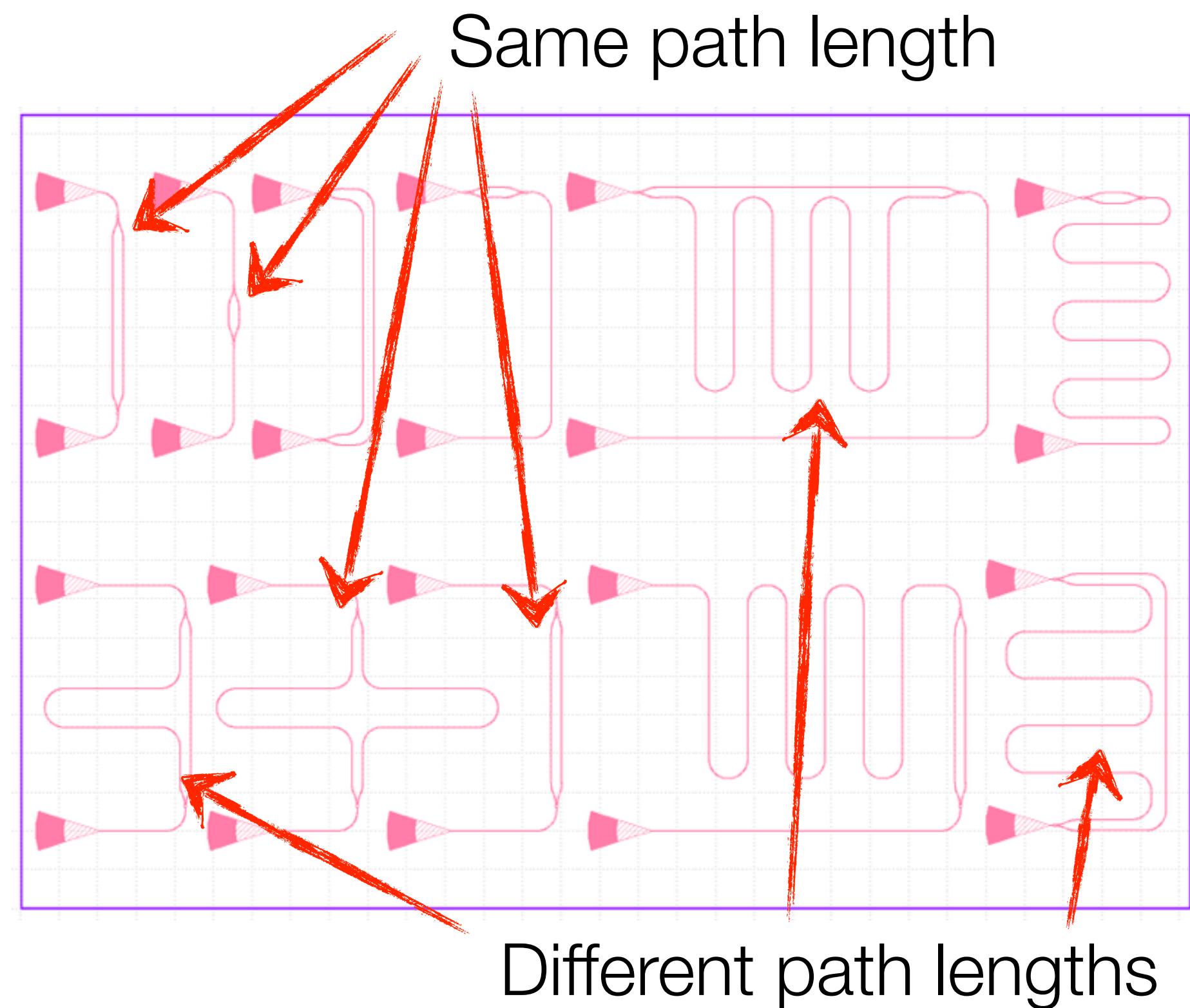
Destructive
Interference

Why choose to design an MZI in this course?

- Simple to model and design:
 - Interferometer – simple equations describing the interference of light
 - Single-mode waveguide – numerical calculations to find the speed of light
- Simple for experimentation:
 - Easy to create a layout
 - Automated measurements of your circuit at many wavelength points
- Compare experiments vs. simulations:
 - Extract waveguide parameters from experimental data
 - Get insight into the “real-world” and how manufacturing affects your circuit performance
- This first experience exposes you to the tools and techniques used to design more complicated devices and systems

Design Variations

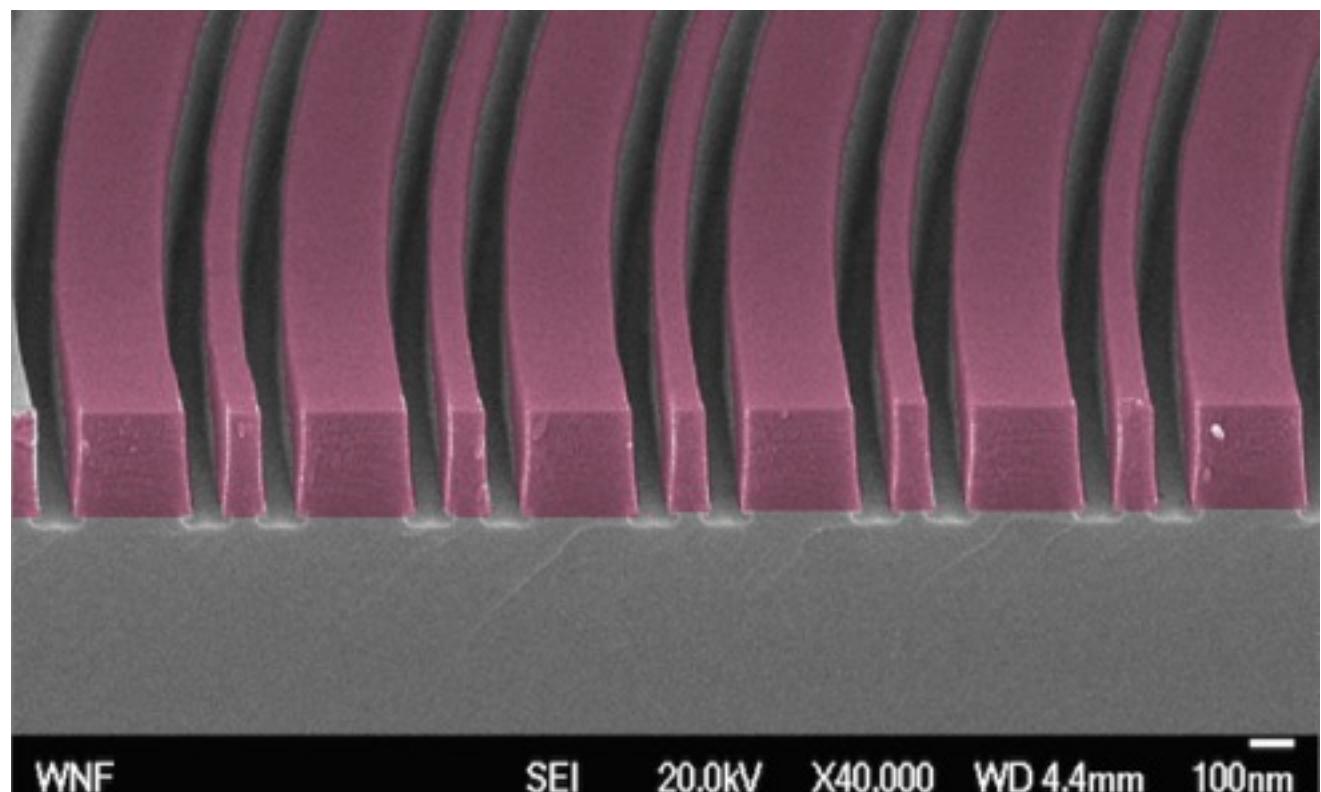
- You are allocated space on the chip for many circuits
- Consider different interferometer designs:
 - MZI with different imbalances (path length difference ΔL)
 - MZI with different waveguide designs
- Repeated copies of the same design:
 - To test for manufacturing variability
- Practice efficient and effective layout techniques



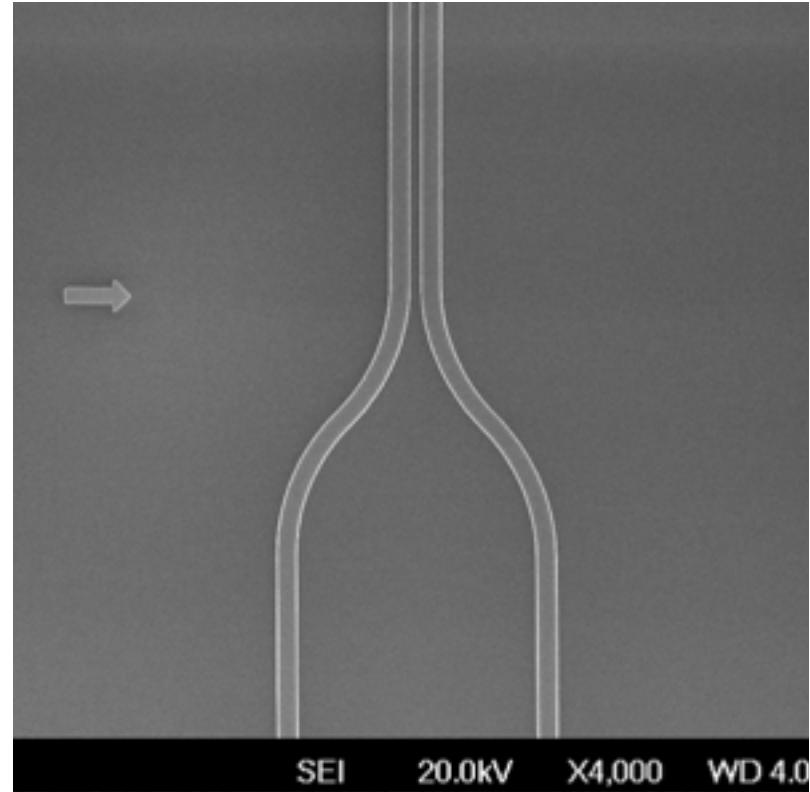
What makes a successful design?

- Success = “functional”, qualitatively as expected
 - Very exciting to see experimental data appear like you expect!
 - It means you have succeeded to implement your design
- Success = agreement between simulations and experiments
 - You have good insight into how your design operates, and how manufacturing/experimentation affect your results.
 - This means that you have validated your modelling and design methods. You can confidently proceed with more complex designs in the future.
- Personal objective – get the most out this opportunity to make an MZI circuit.

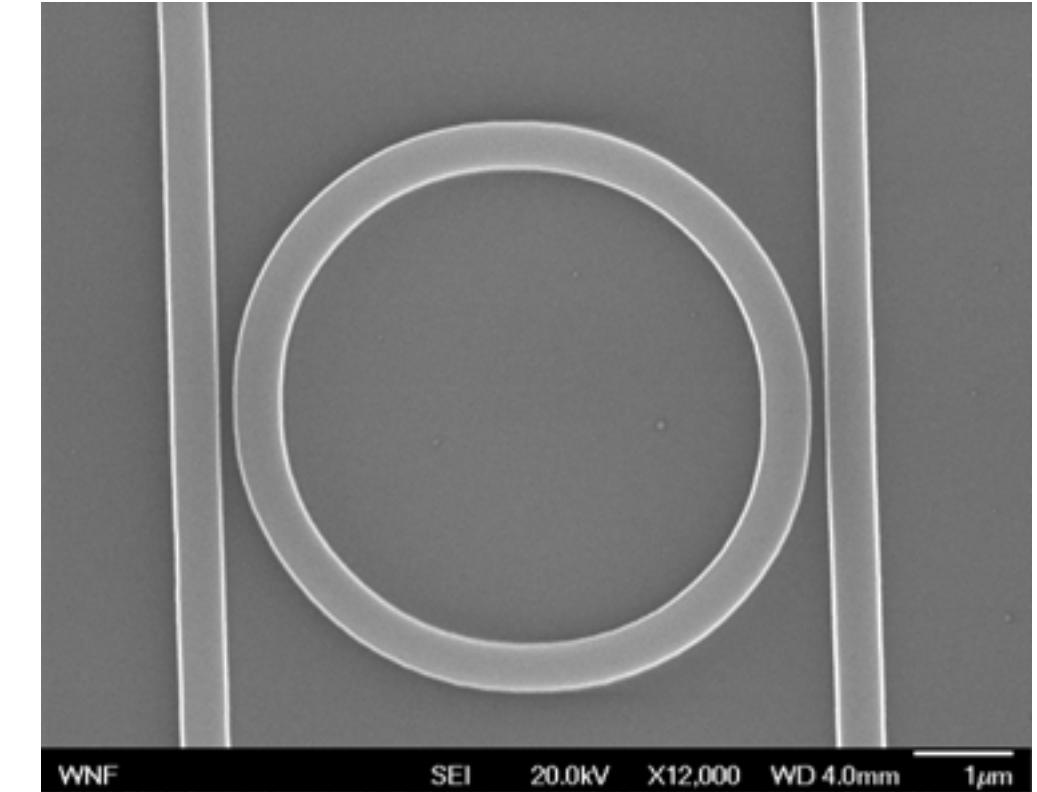
“Advanced” Design Projects



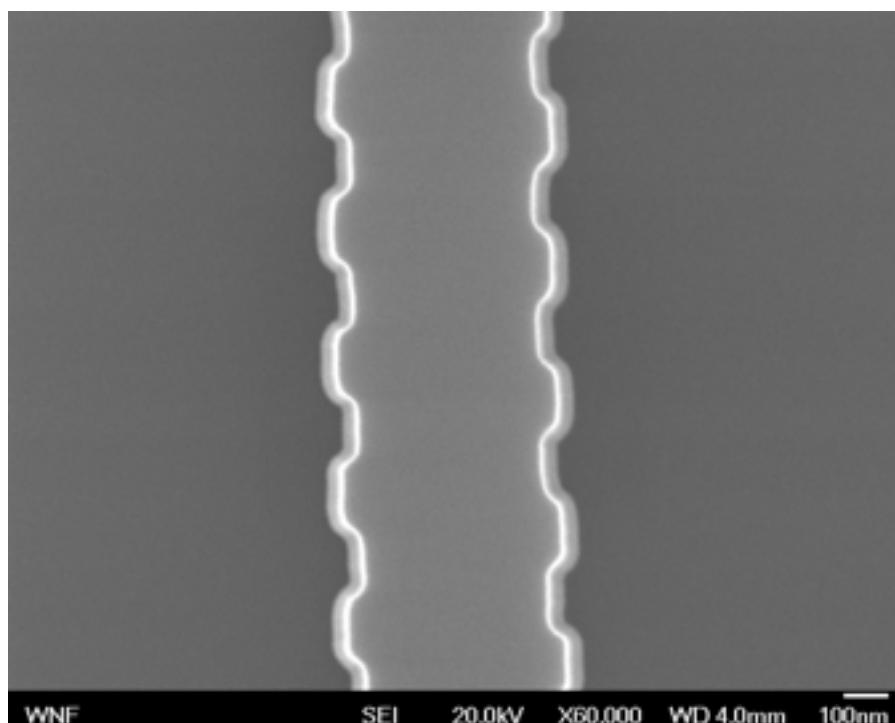
Fibre Grating Coupler



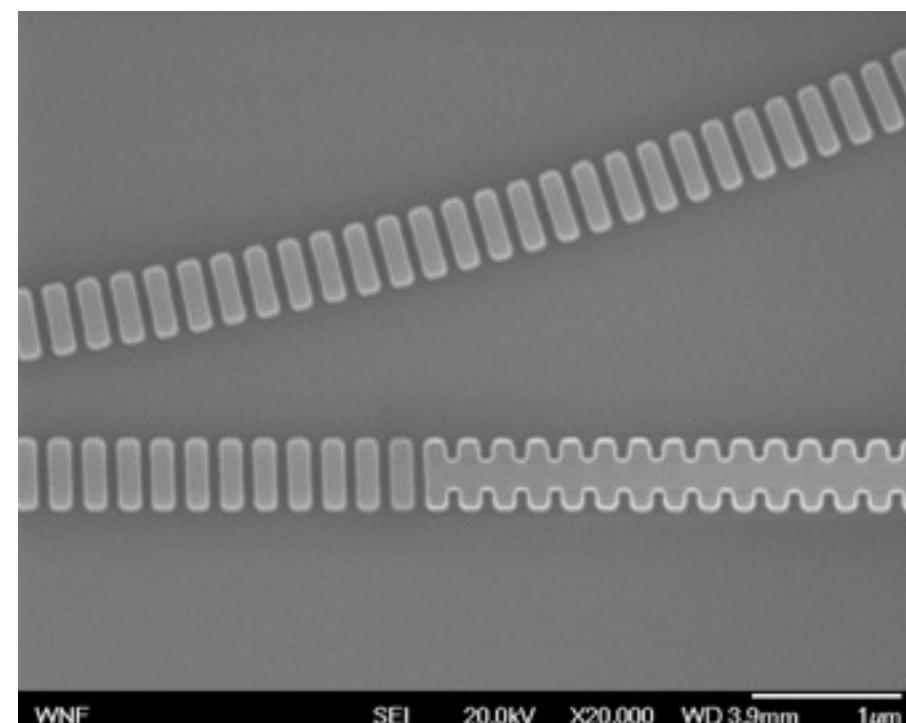
Directional Coupler



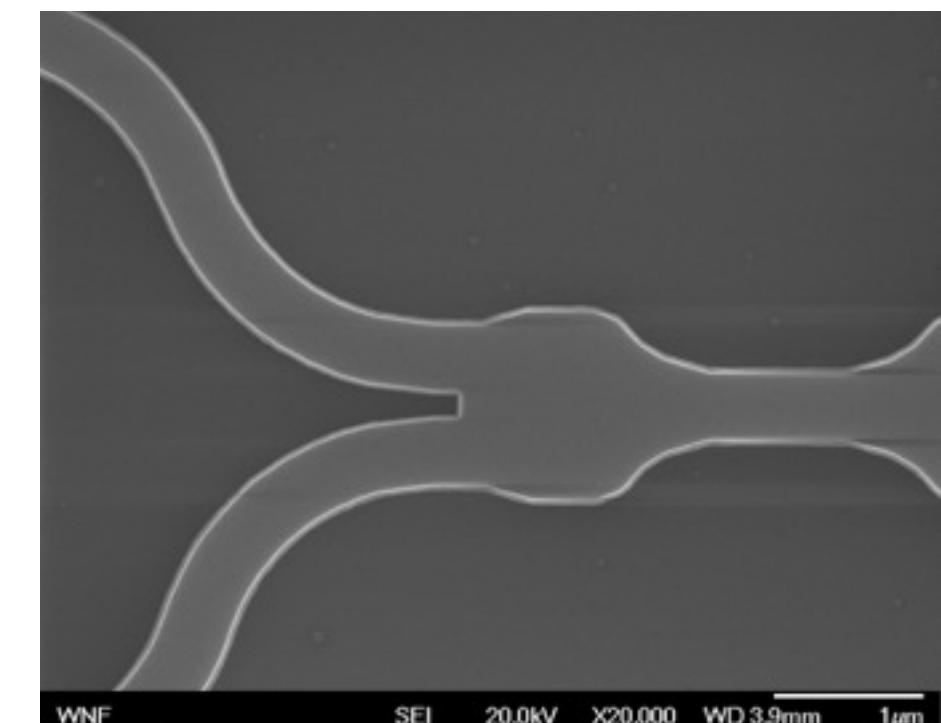
Ring Resonator



Bragg grating

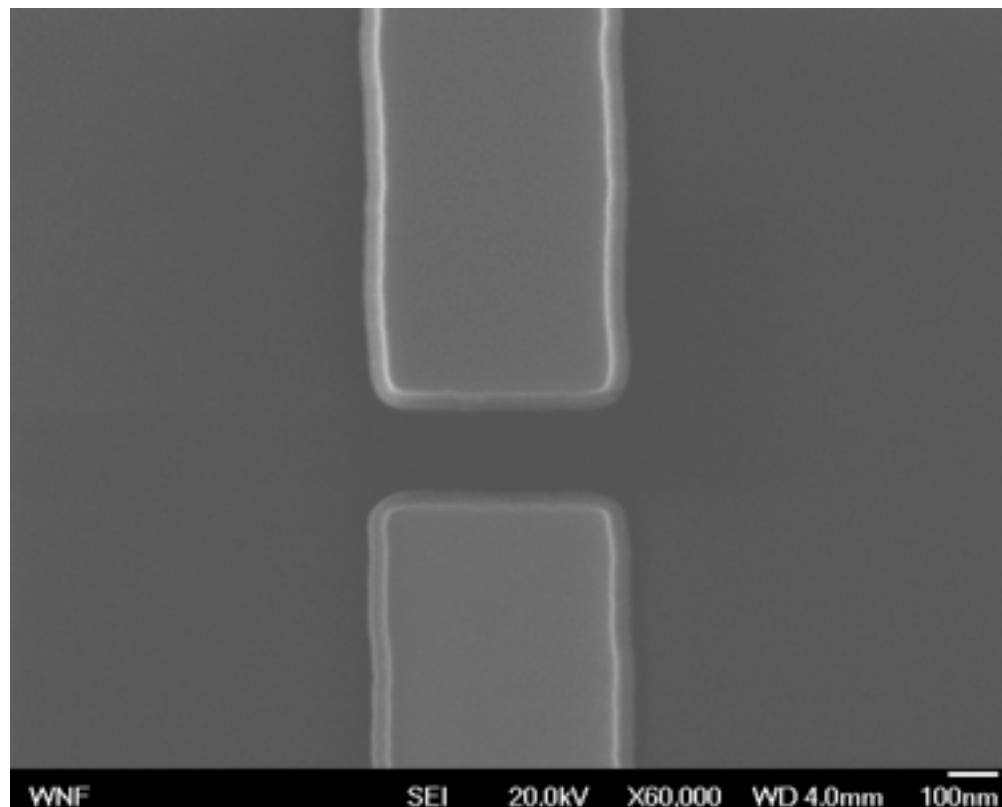


Sub-wavelength
structures

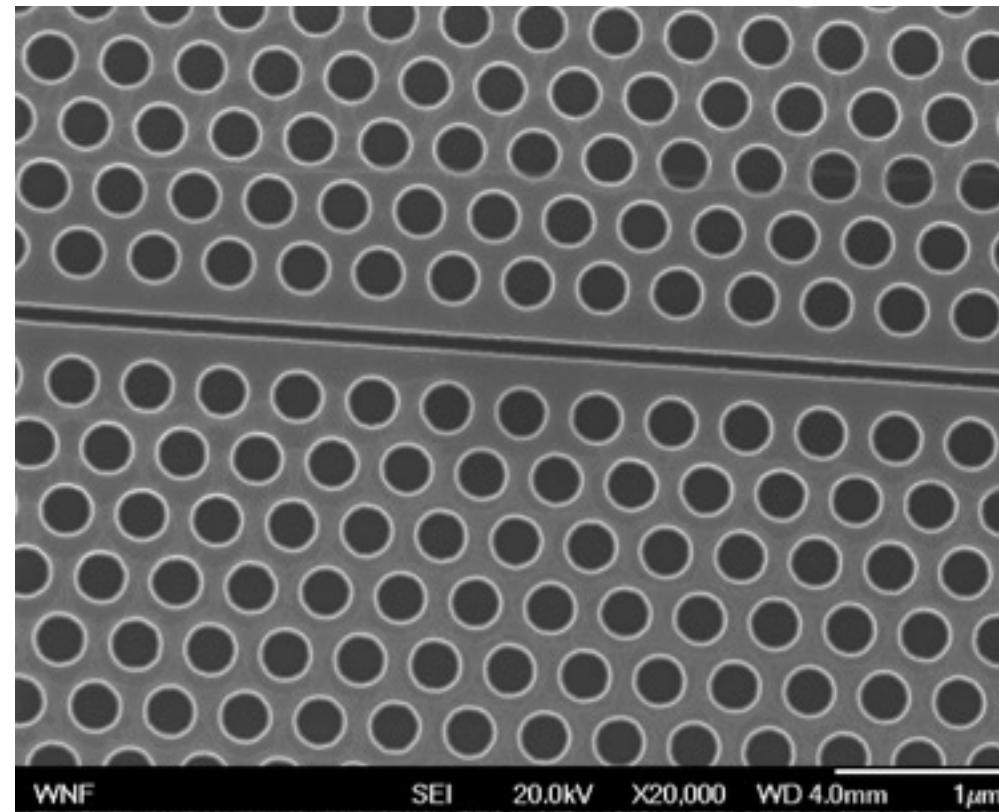


Splitters, MMIs

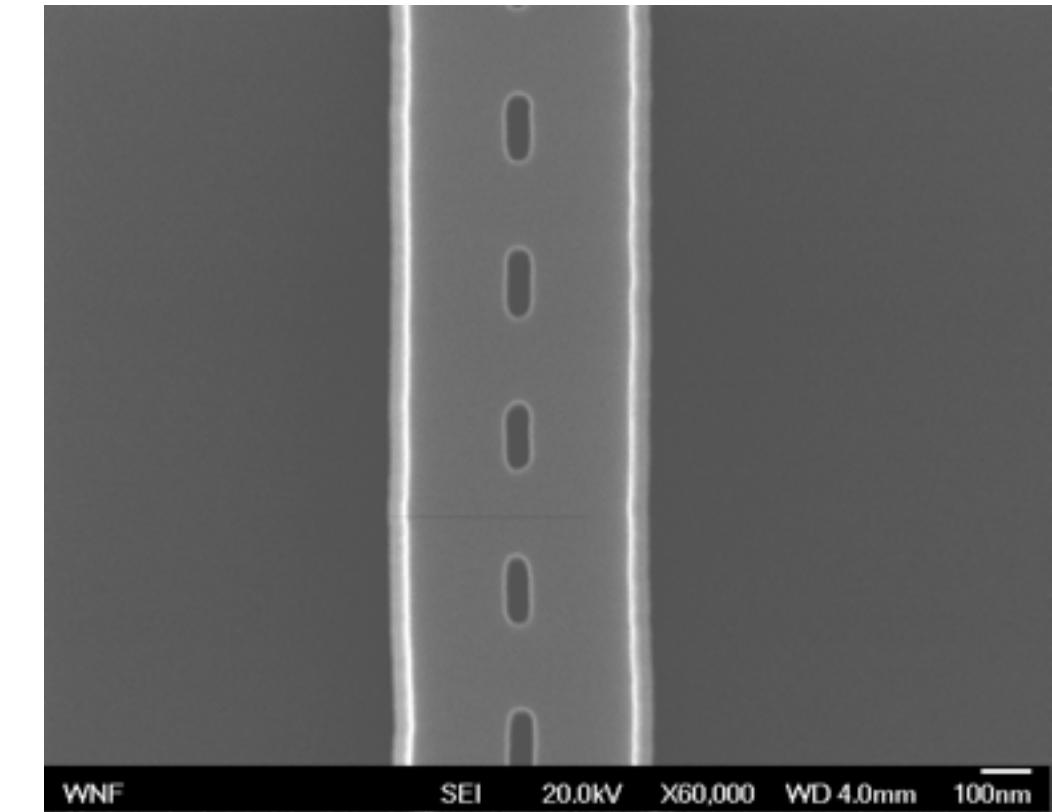
“Advanced” Design Projects



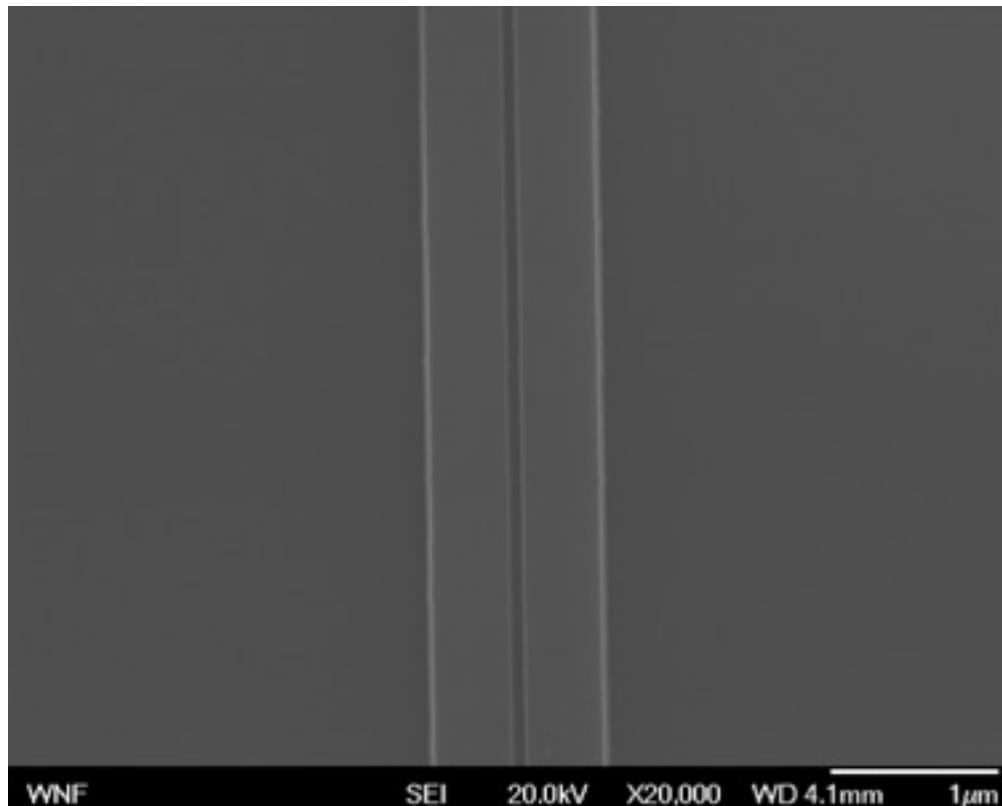
Broken Waveguides



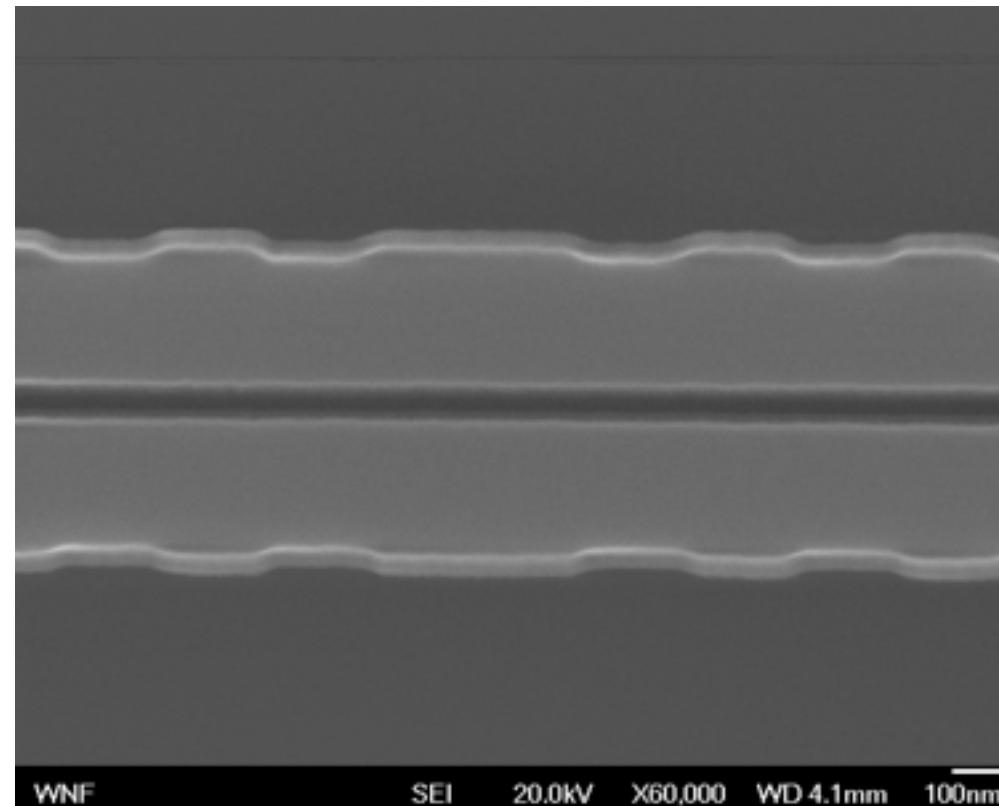
Photonic Crystals



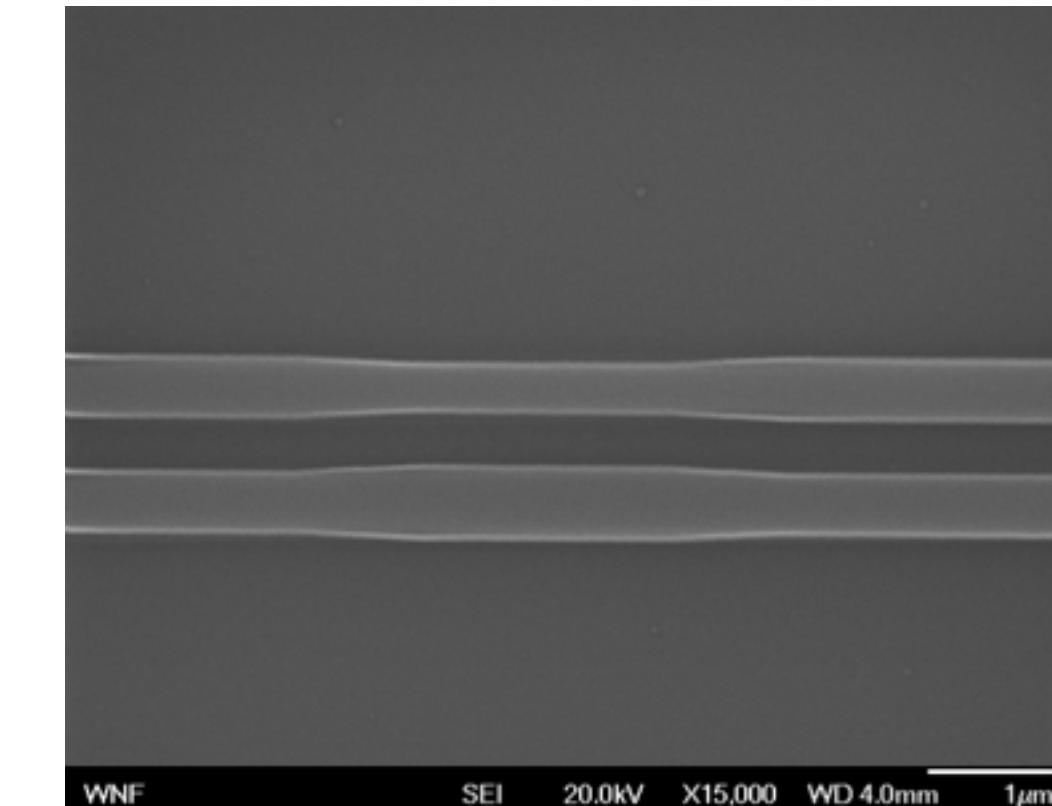
1D Photonic Crystals



Slot Waveguides

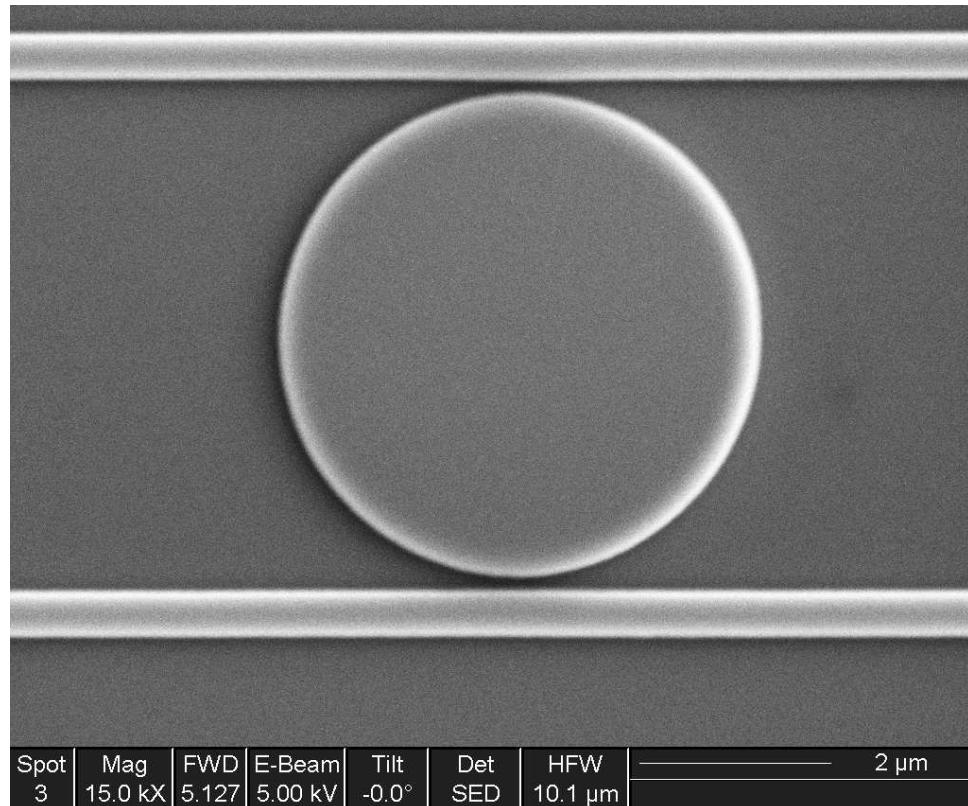


Slot Waveguide
Bragg gratings

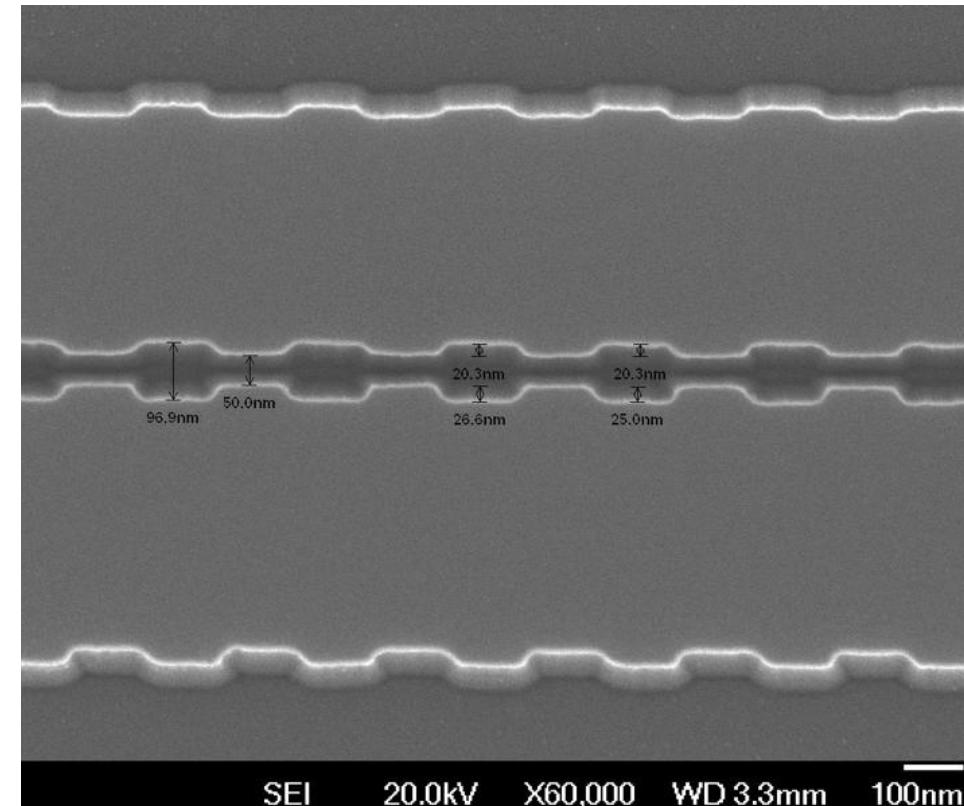


Broad-band
Directional Couplers

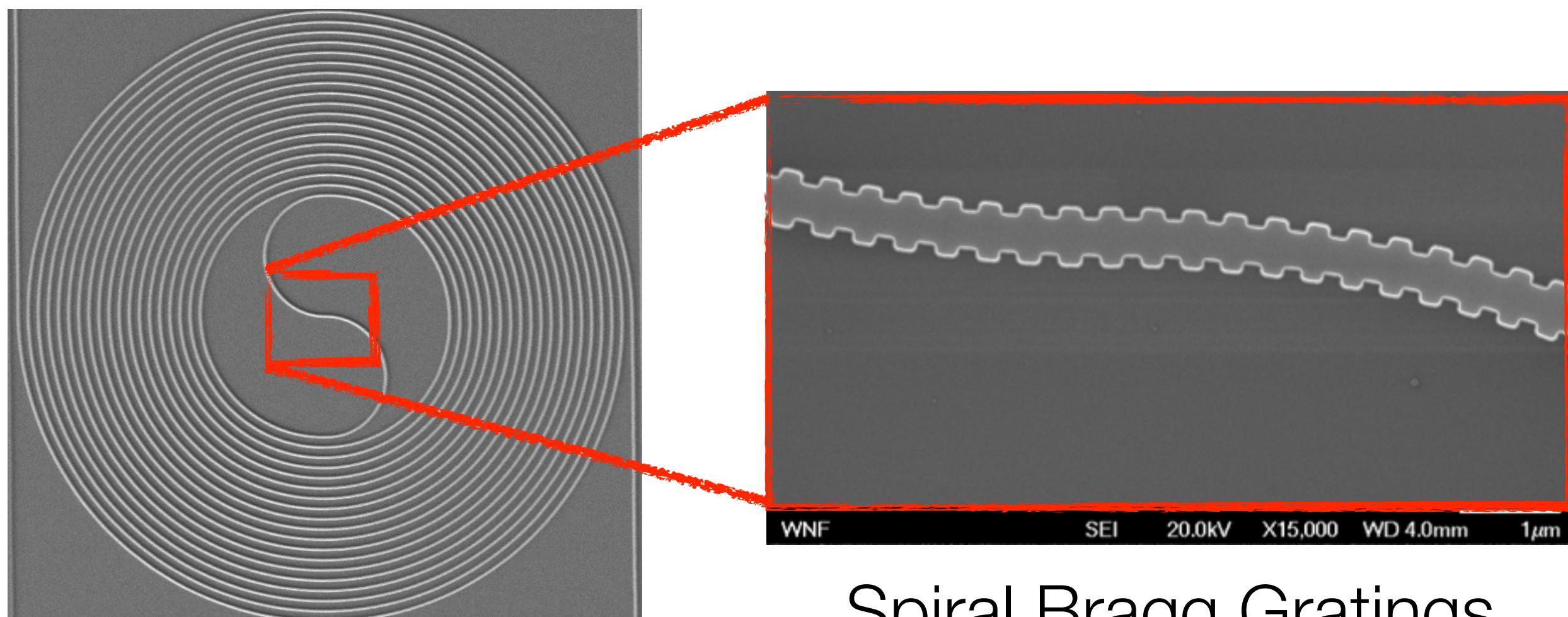
“Advanced” Design Projects



Disk Resonators



Contra-Directional
Grating Couplers



Spiral Bragg Gratings

“Advanced” Design Projects

- Feel free to design more complicated things, but:
 - Keep in mind you only have up to 3 weeks of design time
 - Consider doing the design cycle several times to gradually develop more complex designs.
 - We typically carry out EBeam fabrication runs every two months
 - Please include at least one MZI so you can complete the course requirements
- For inspiration of other design ideas:
 - check the library to see what has been done before
 - journal and conference papers
 - post your interest and questions in the Discussion Forum