FALAPHEL – Preliminary PIC Measurements

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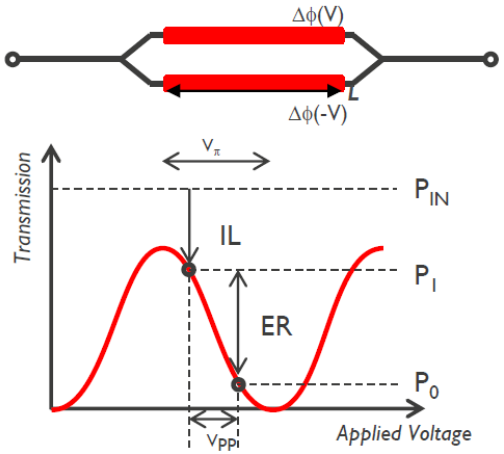
Outline

- Overview Falaphel PIC
- Characterization setup @ Scuola Sant'Anna
- MZMs and RMs preliminary measurements
- Future works

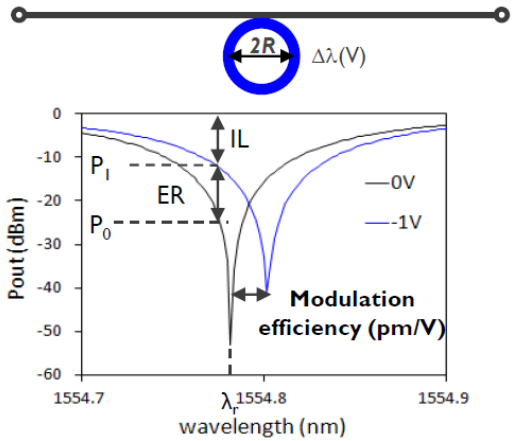
Falaphel PIC – Overview

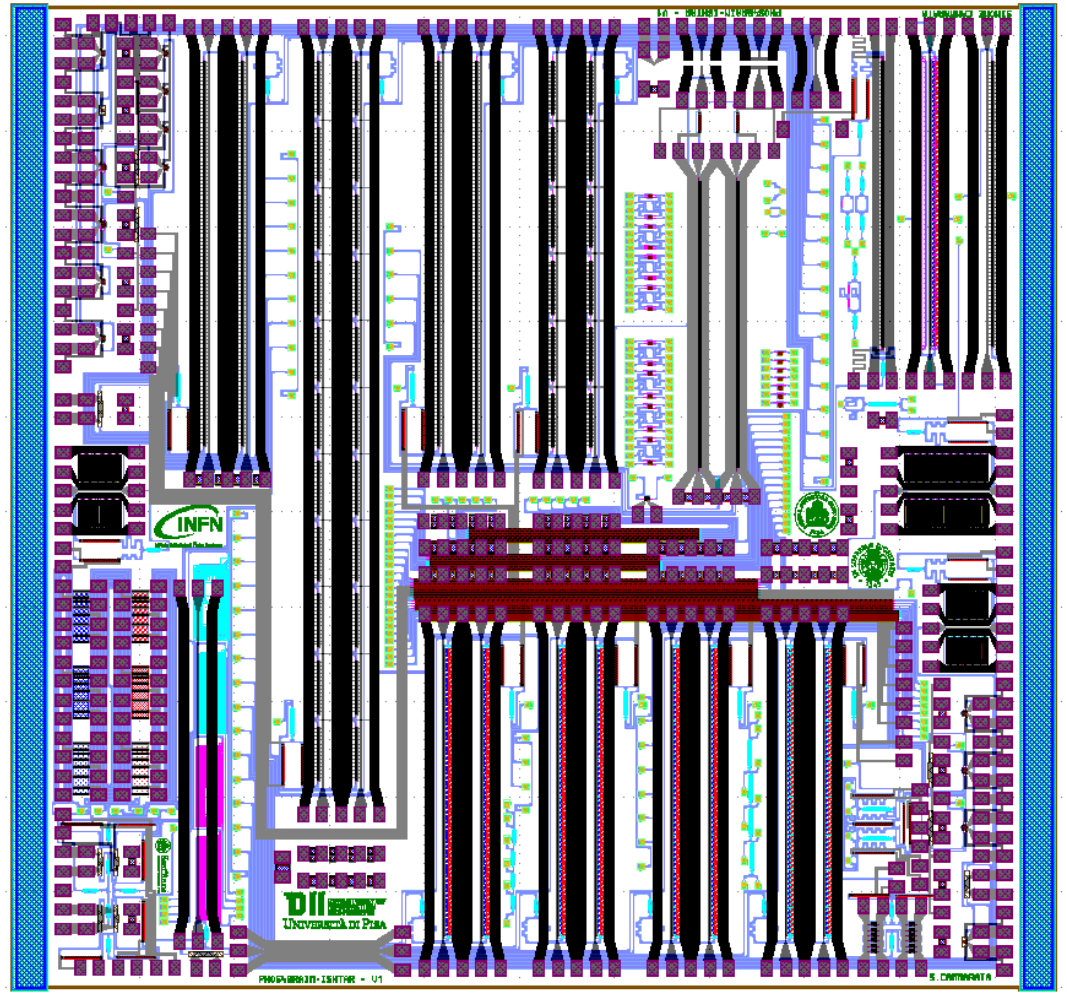
- PIC designed in Imec's iSiPP50G technology
- Electro-optic modulators for optical communication in high energy physics, e.g., Mach-Zehnder modulators (MZMs), ring modulators (RMs), electro-absorption modulators (EAMs), etc.
- Submitted in June 2020 and delivered end of December 2021

Si Mach-Zehnder Modulator



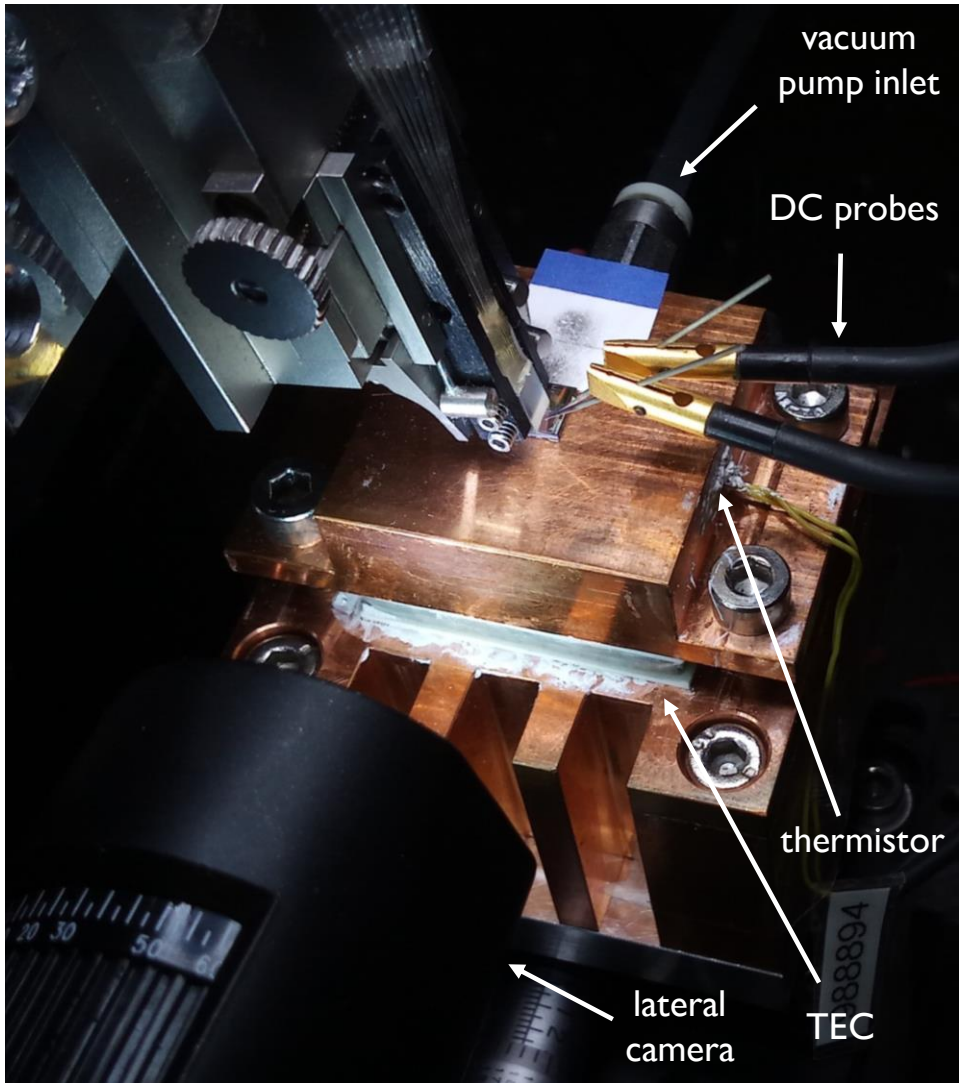
Si Ring Modulator

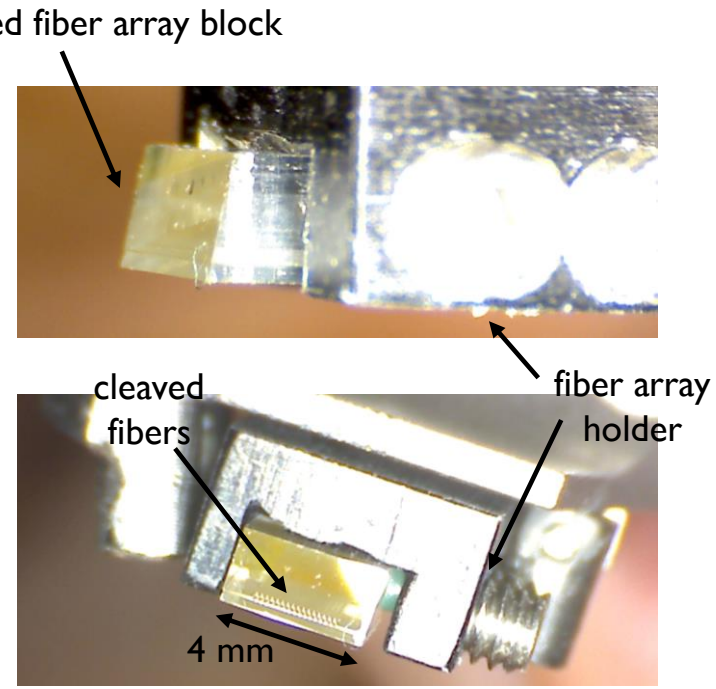


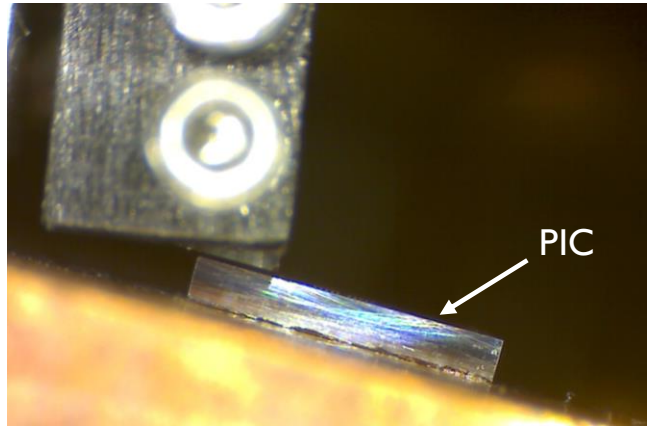


Characterization Setup @ SSSA

- Bare photonic die mounted on a mechanical stage equipped with thermo-electric cooler
- 16 channels vertical fiber array used to couple light via grating couplers
- Fiber array angle and position optimized to locate the grating response peak near 1550 nm

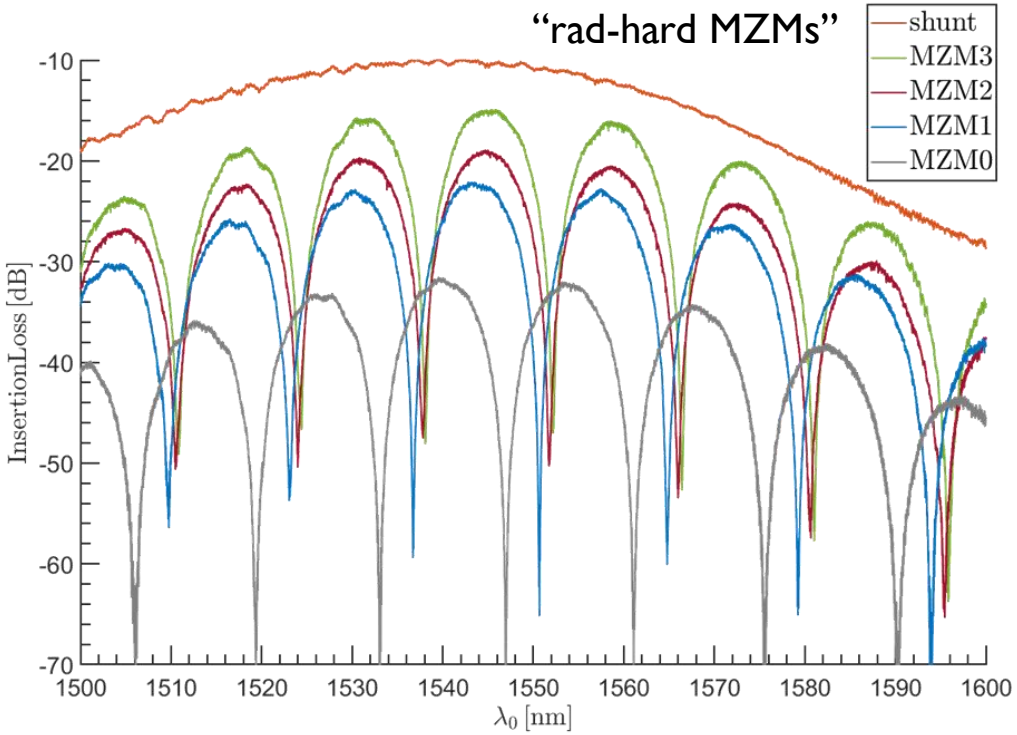


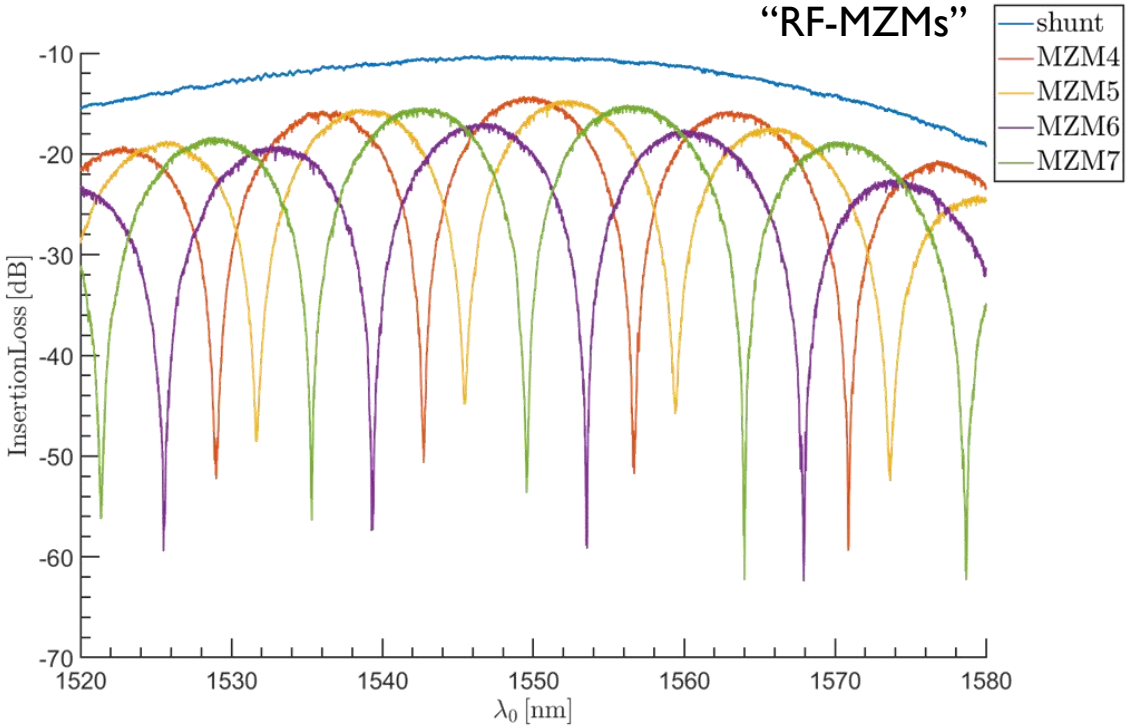




MZMs – Insertion Losses

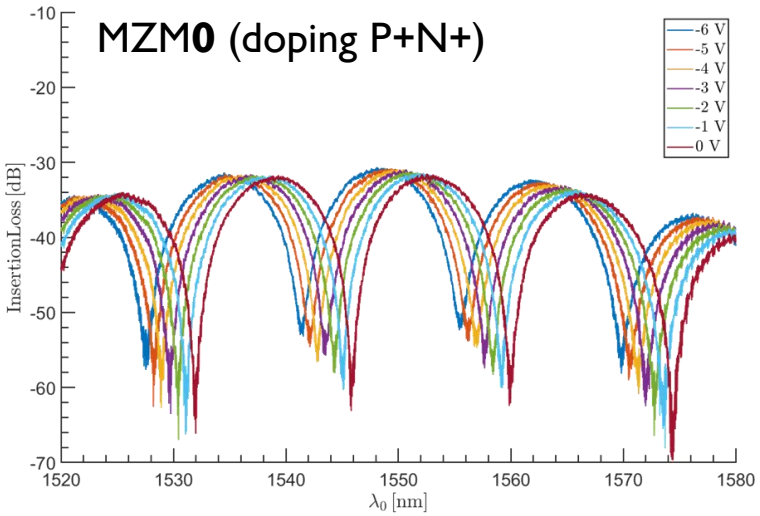
- Insertion losses for MZMs (including splitters and heaters) with different doping patterns:
  - MZM0 (doping P+N+): ~ 4 dB
  - MZM1 (doping P+N): ~ 8 dB
  - MZM2 (doping P+PN): ~ 9.5 dB
  - MZM3 (doping PN): ~ 16 dB

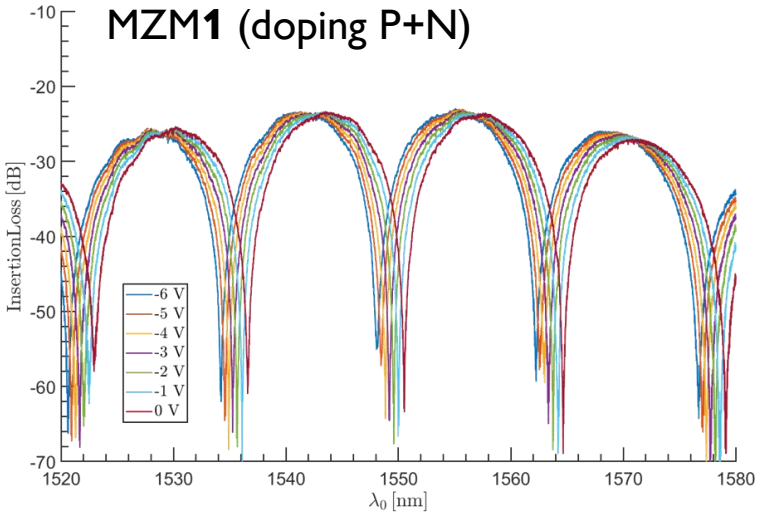


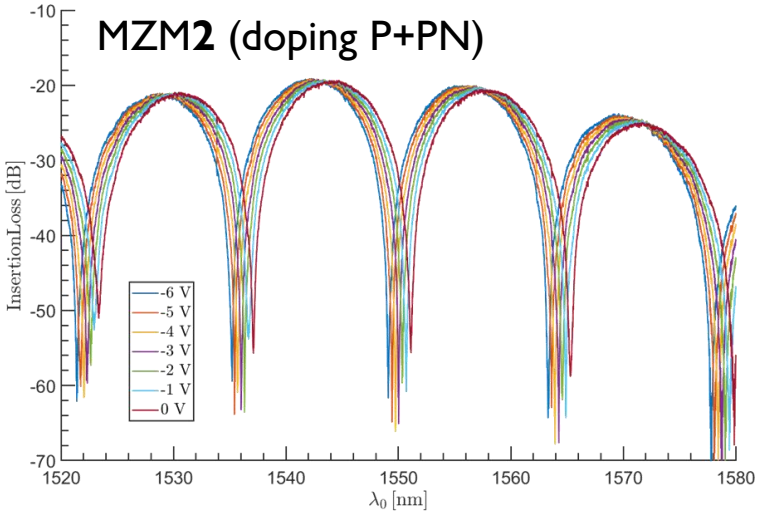


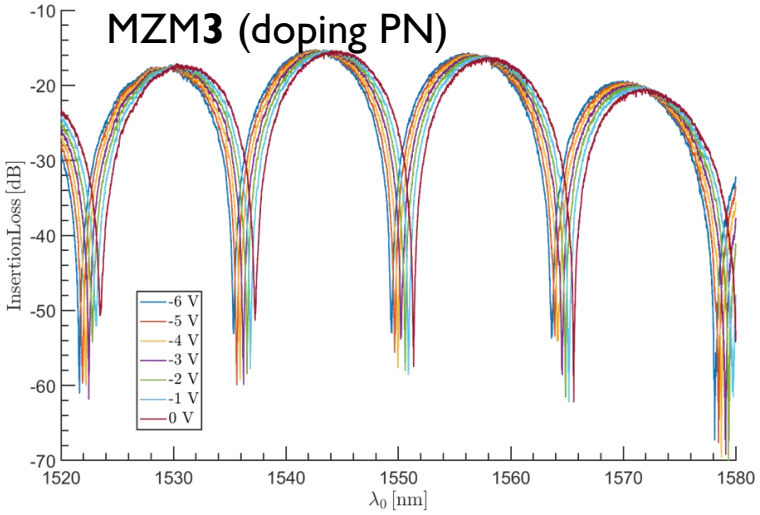
MZMs – DC Electro-Optic Spectrum

- Modulation response of MZMs with different doping patterns
- Higher-doped samples show better modulation performances, as expected
- Accurate performance metrics (e.g., V_π) to be post processed soon…



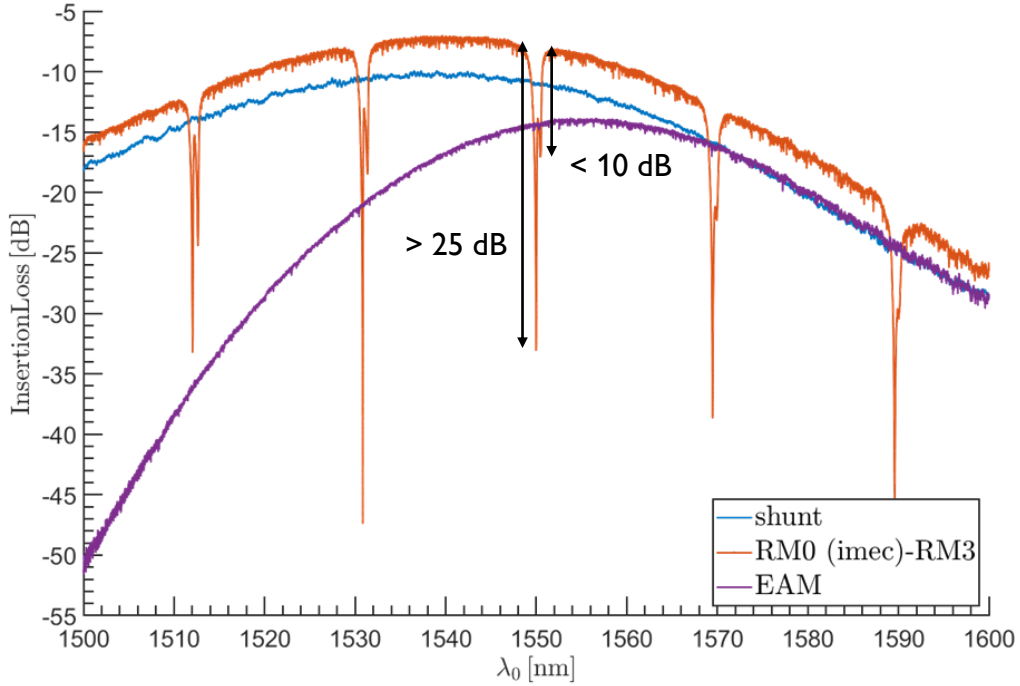


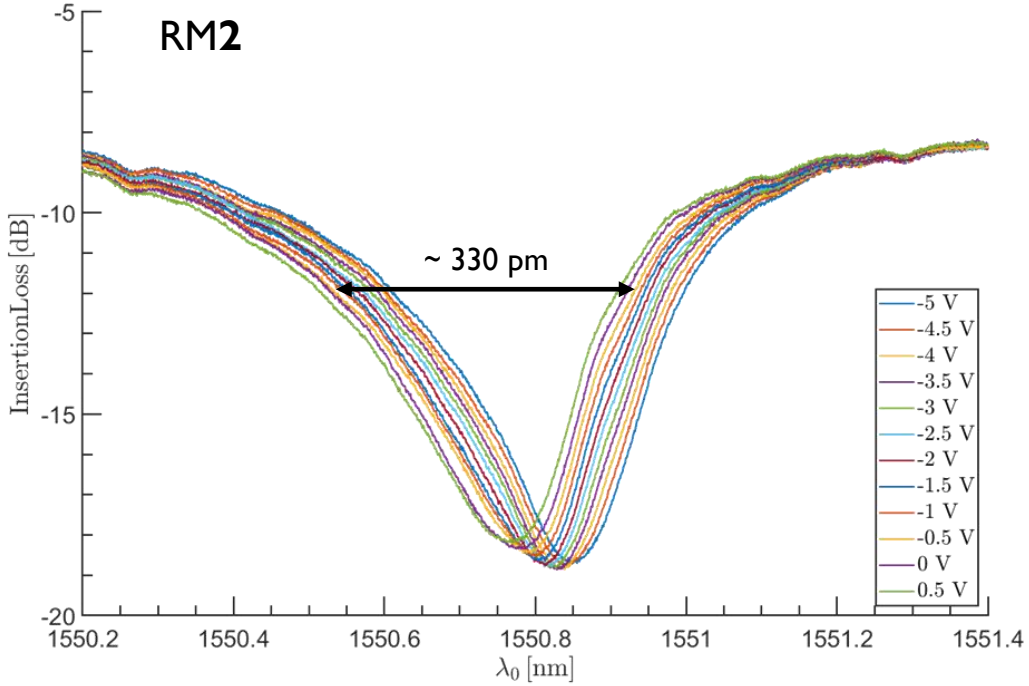




RMs – Preliminary Measurements

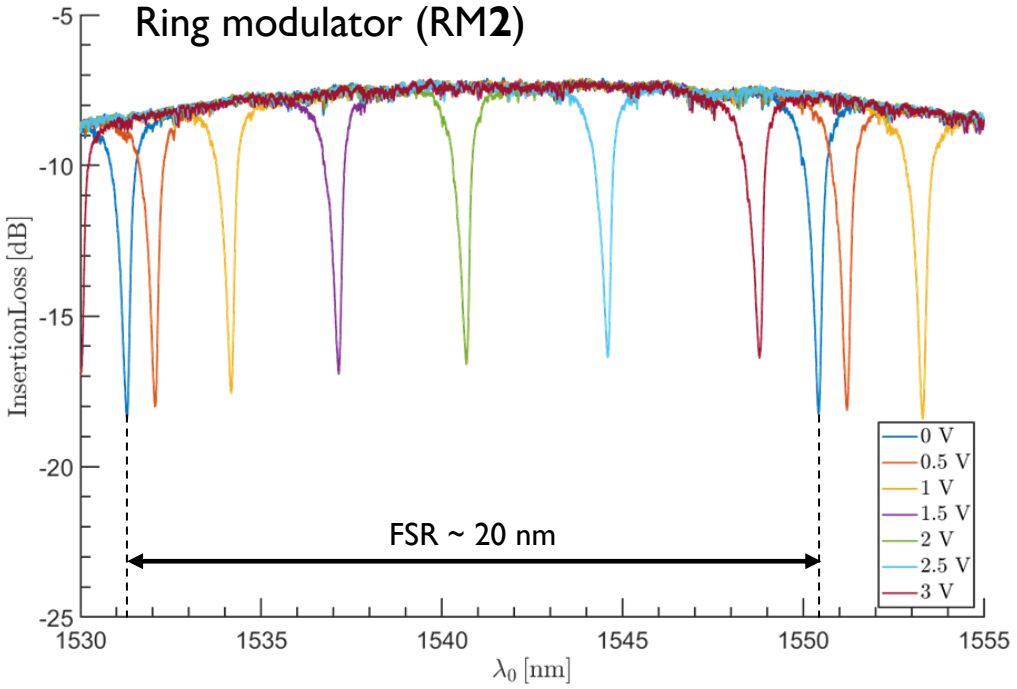
- *Custom* all-pass RMs are slightly out of critical coupling (over-coupling is supposed), while Imec's building block RM clearly on critical coupling
- *Custom* add-drop RMs present deeper static extiction ratios than all-pass RMs but tiny modulation response (15-20 pm/V)
- Accurate performance metrics to be post processed soon…

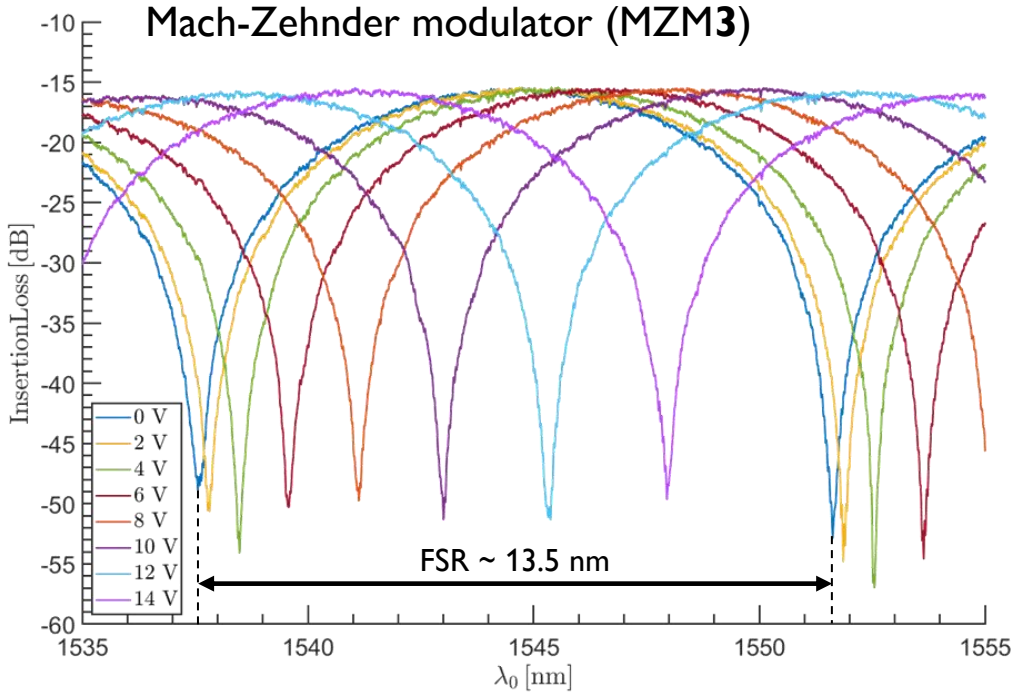




Heaters – Electro-Optic Characterization

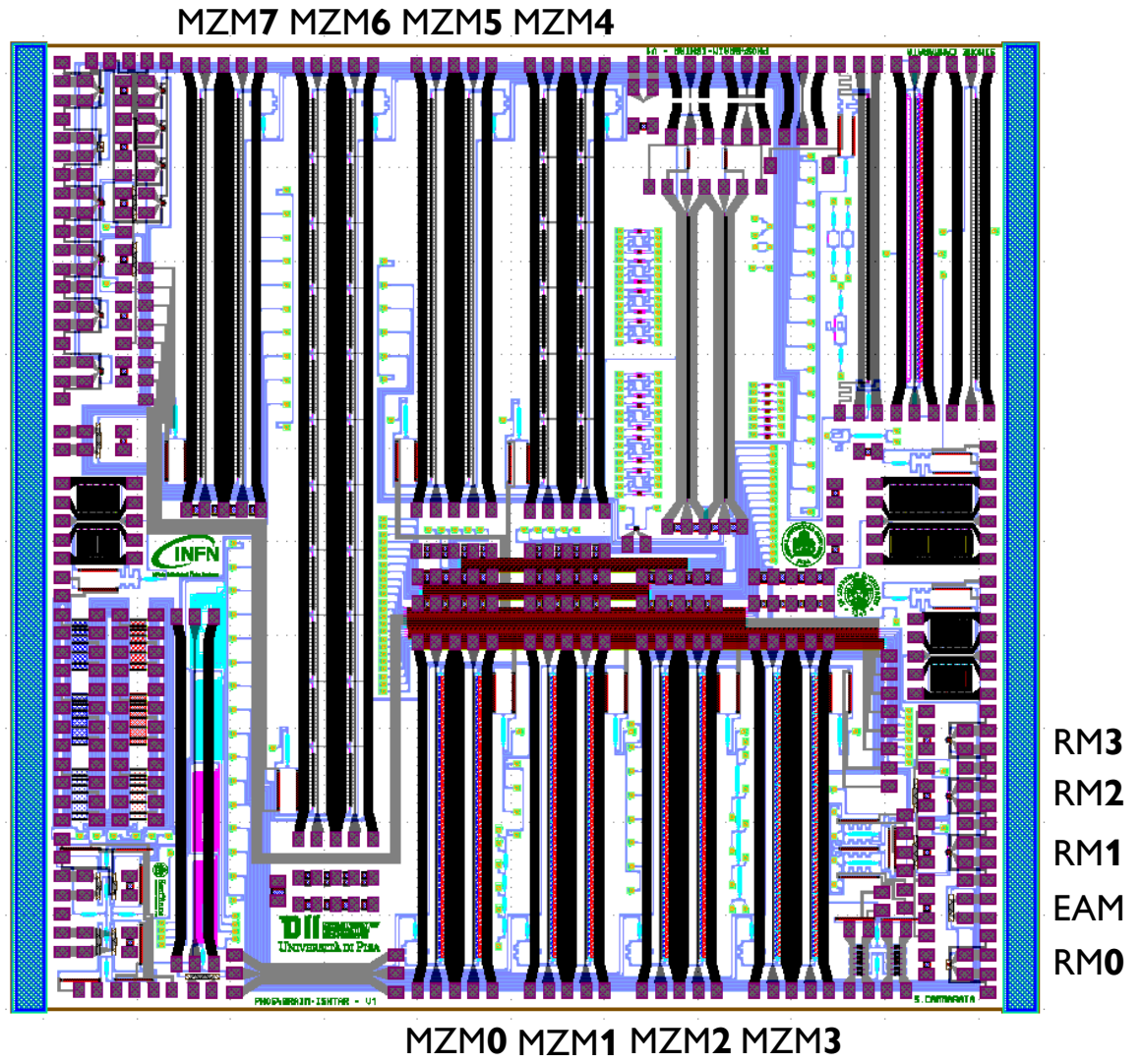
- Electro-optic characterization of heating elements for RMs and MZMs. Each modulator type has (almost) the same heater strcture throughout the chip.
- Ring modulator (RM2, **tungsten** heater): V_{FSR} ~ 3.3 V with P_{FSR} ~ 100 mW
- Mach-Zehnder modulator (MZM3, **doped-Si** heater): V_{π} ~ 11.5 V with P_{π} ~ 25 mW





Future Activities

- Electro-optic DC characterization of each device
- Characterization of test structures (sheet resistances, ring resonators, waveguides, etc.)
- Samples packaging @ CamGraPhIC
- RF **fully-electrical** test of modulating structures (ongoing activity)
- RF **electro-optical** characterization
- Build setups and automated mesurement routines for irradiation campaings



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Thanks for the attention

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