Non-linear effects in silicon photonic devices: modelling and experiments

Marco Novarese[1]

Supervisor: Mariangela Gioannini[1]

[1]Department of Electronics and Telecommunication, Politecnico di Torino, Italy

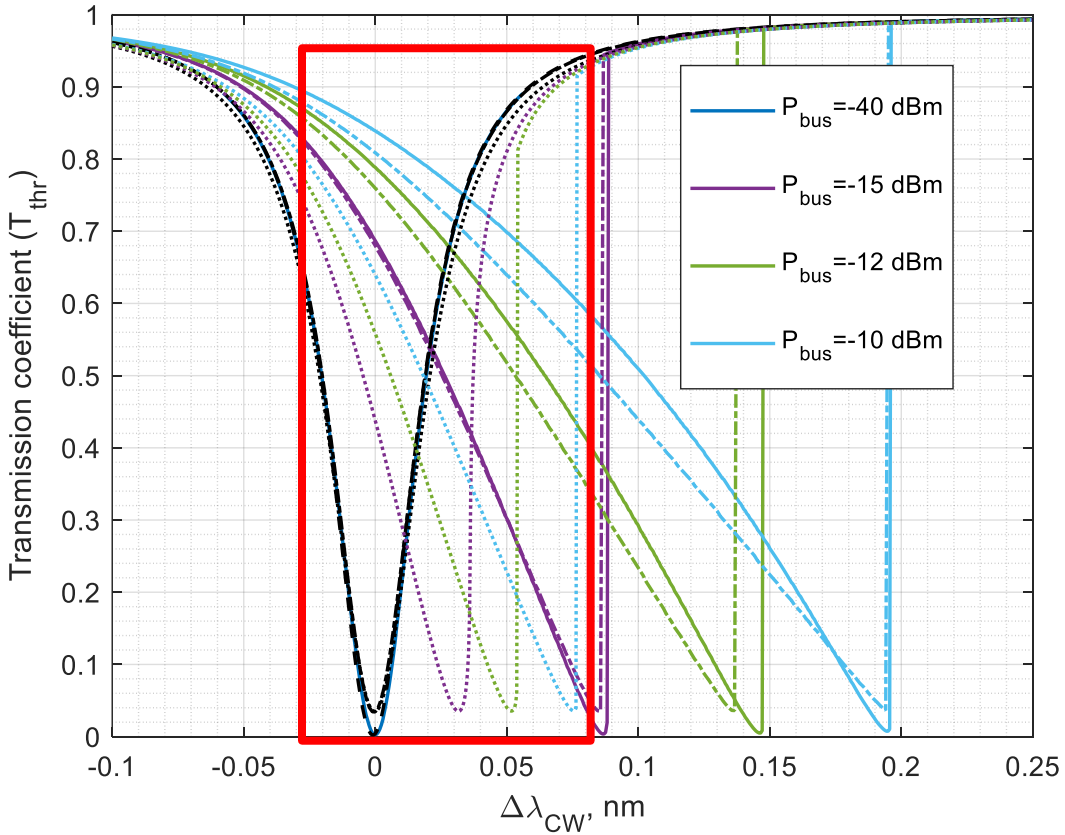
marco.novarese@polito.it
mariangela.gioannini@polito.it

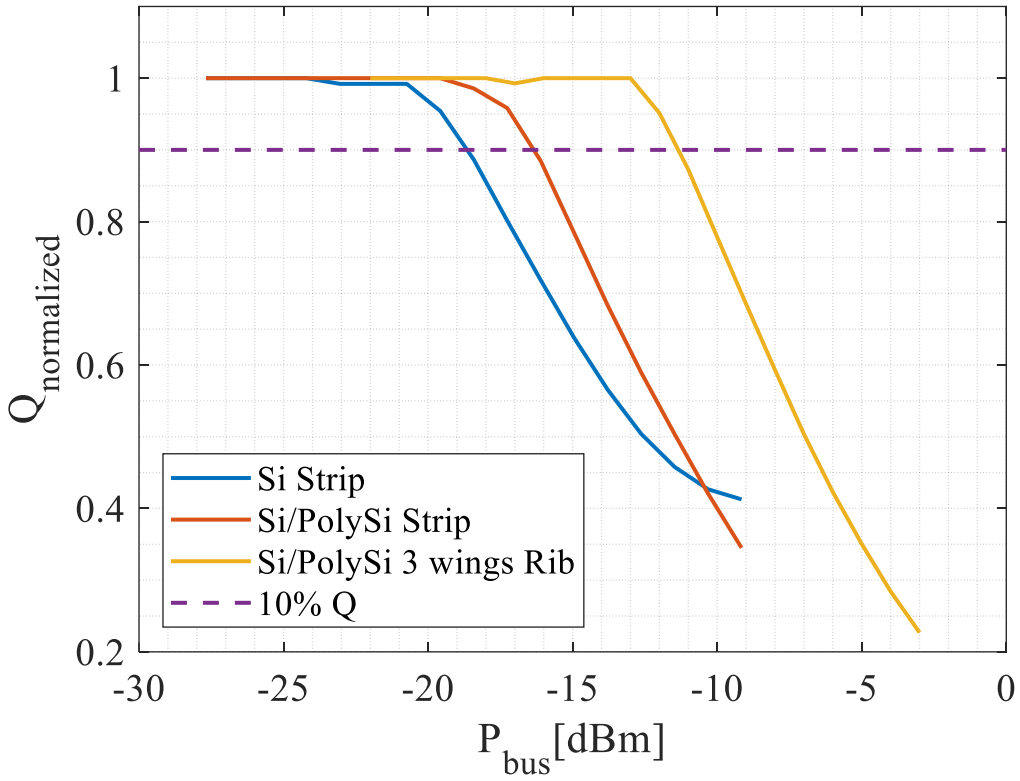
Politecnico di Torino
Department of Electronics and Telecommunications

DET

PHOTONEXT

Modelling results

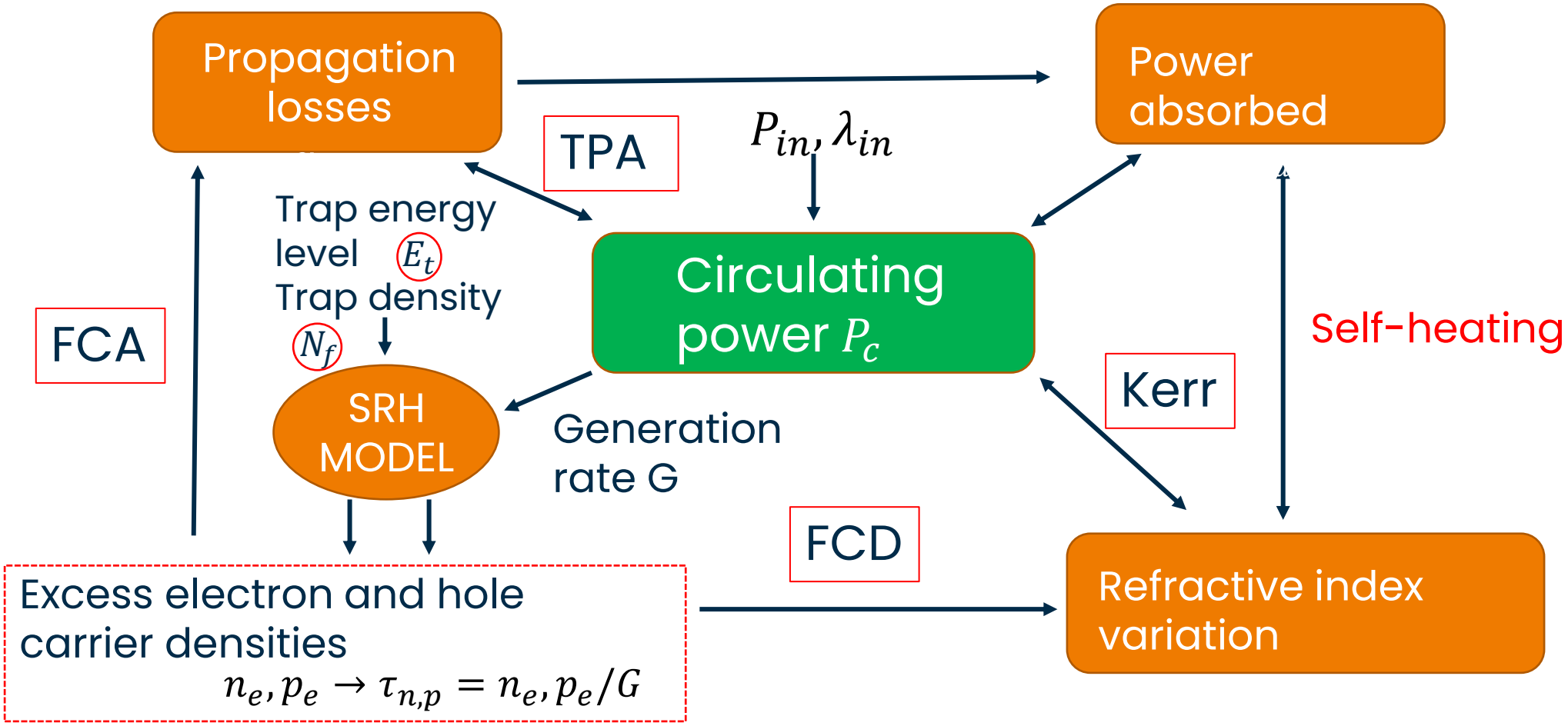




Transmission spectra of the 3 MRRs at different bus input power:

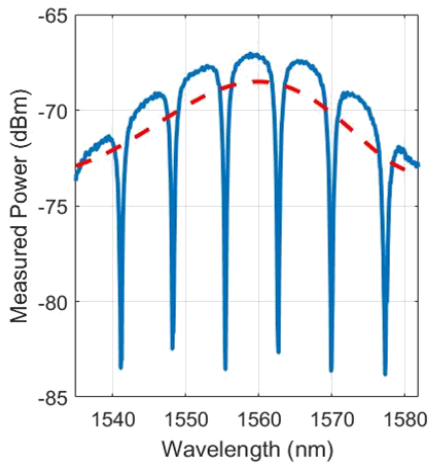
- Si strip (continuos)
- Si/PolySi strip (dash-dotted)
- Si/PolySi 3 wings Rib guide (dotted)

Si non linear model

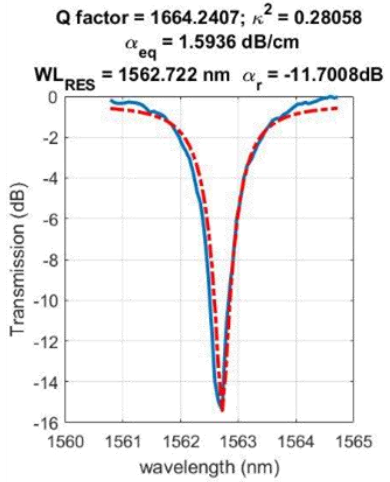


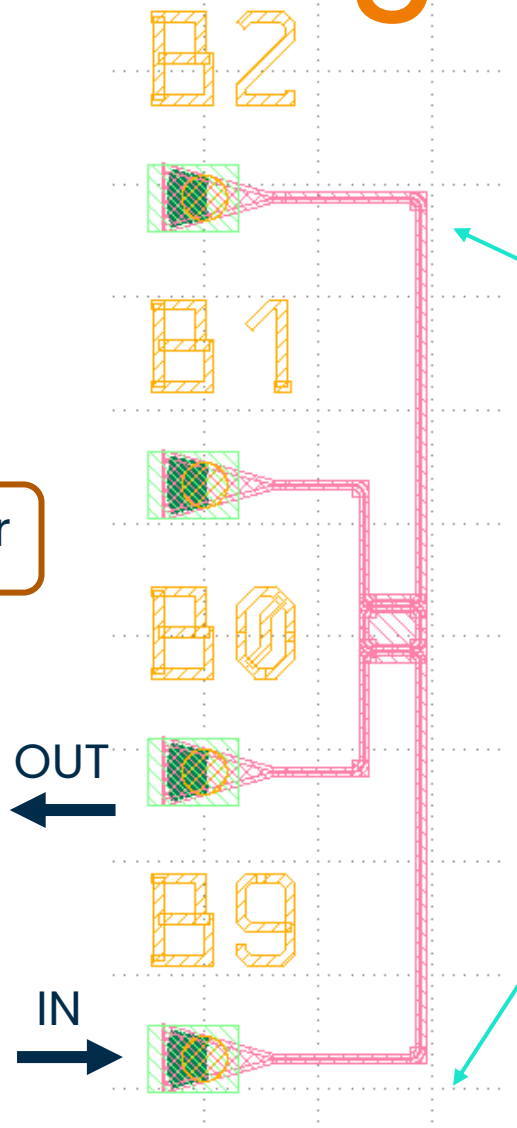
Si ring resonator

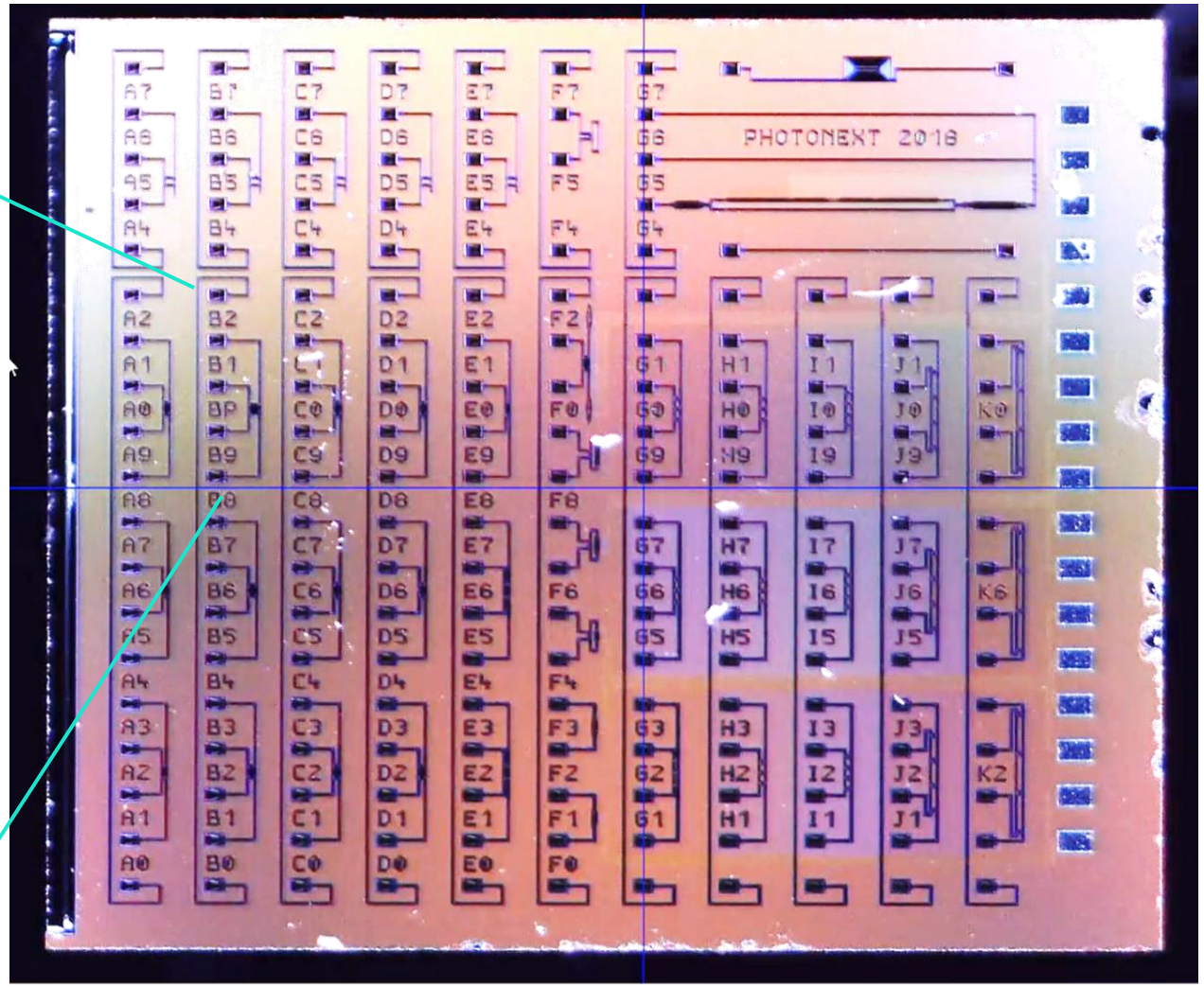
Low power spectrum



Extract ring parameter

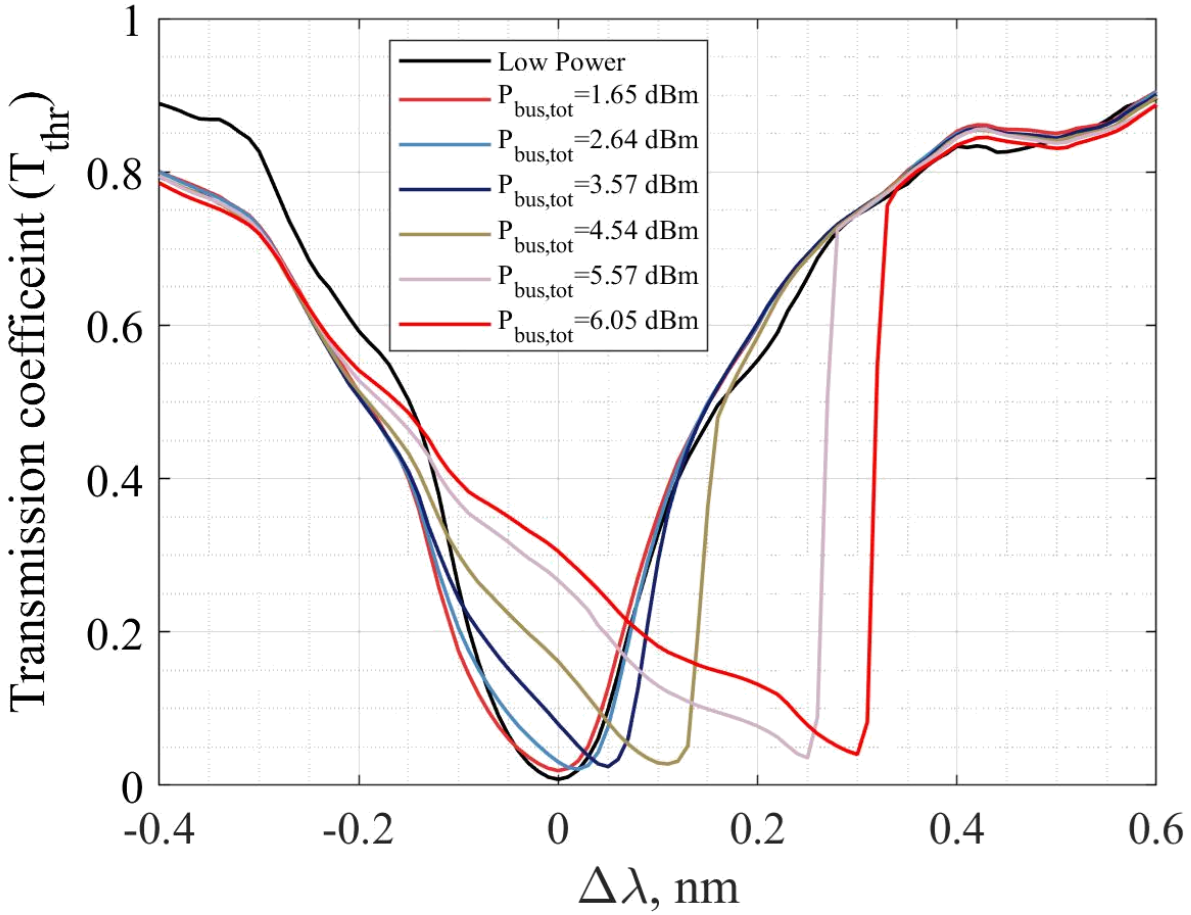




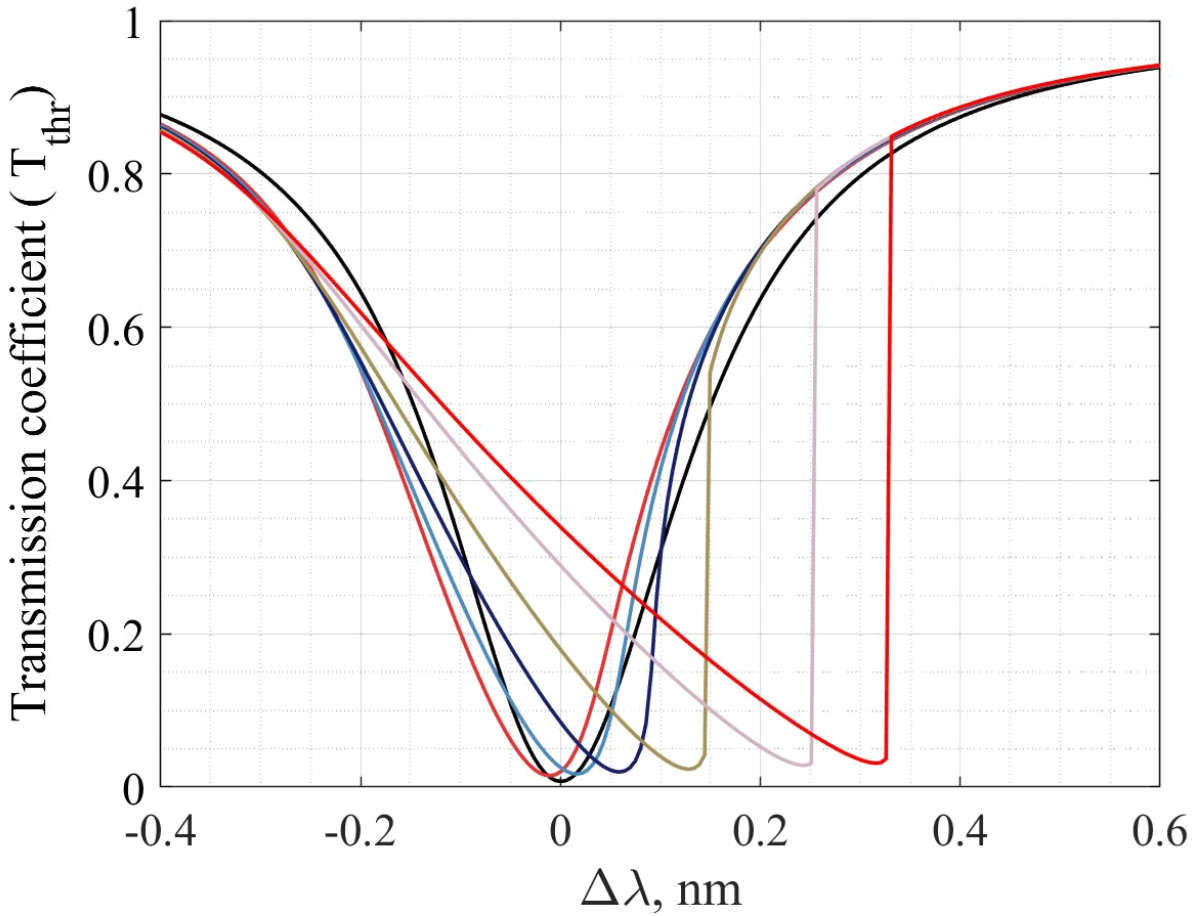


Experiment vs model

Experiment

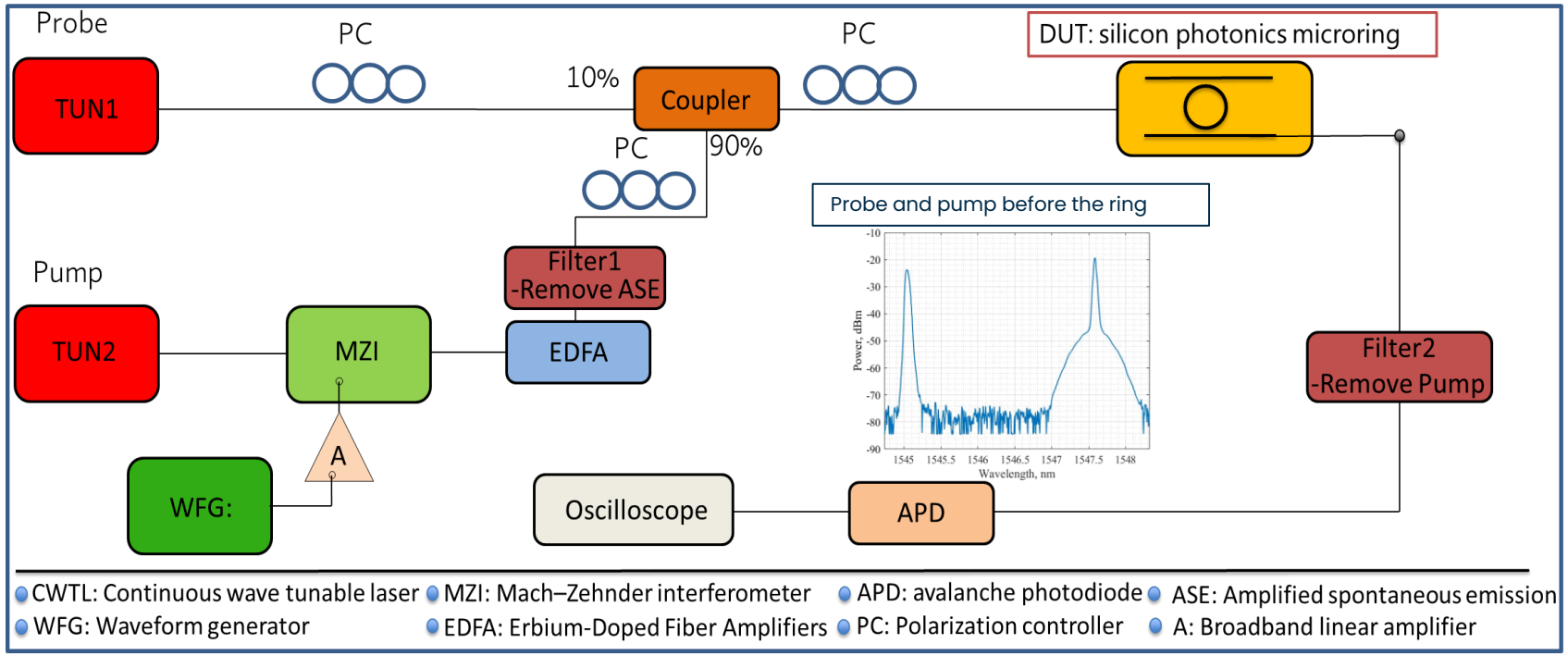


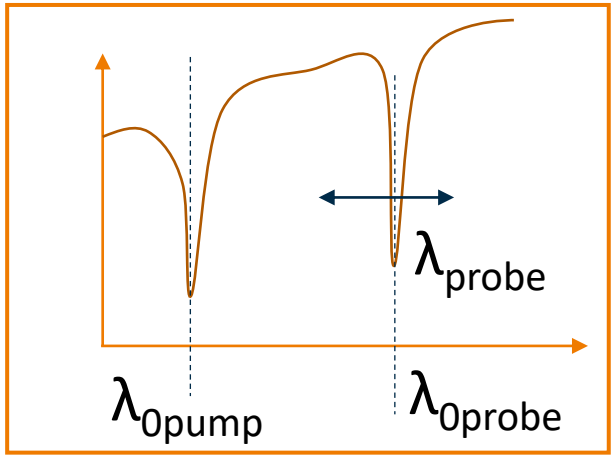
Model

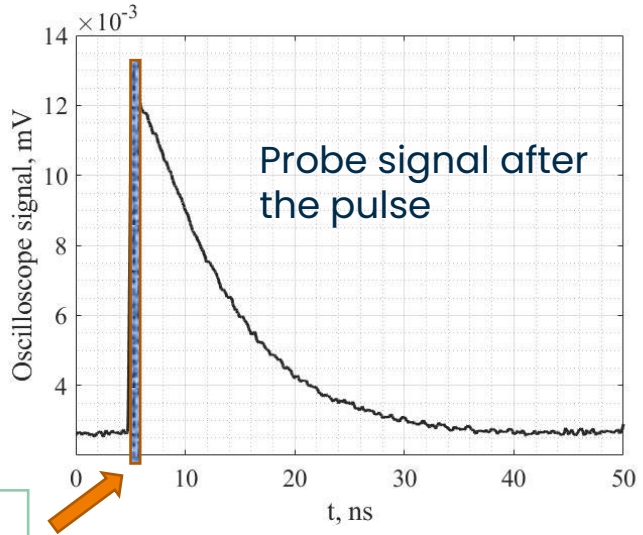


Marco Novarese, Sebastian Romero-García, Don Adams, Jock Bovington, Mariangela Gioannini, "Study of nonlinear effects and self-heating in a silicon microring resonator including a Shockley-Read-Hall model for carrier recombination," Opt. Express 30, 14341-14357, 2022.

Pump-probe setup



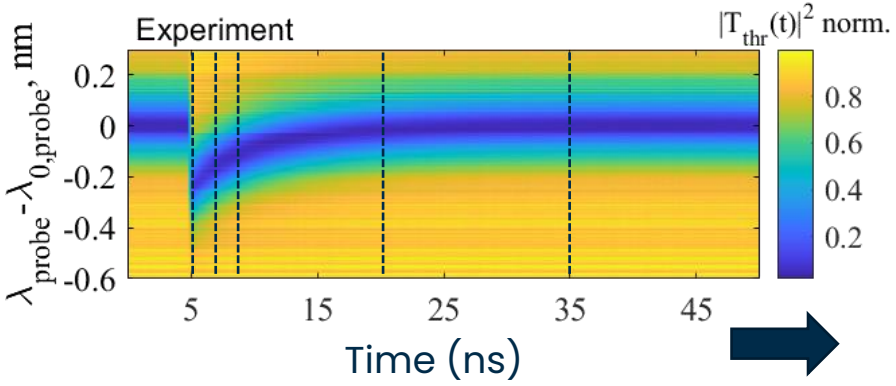




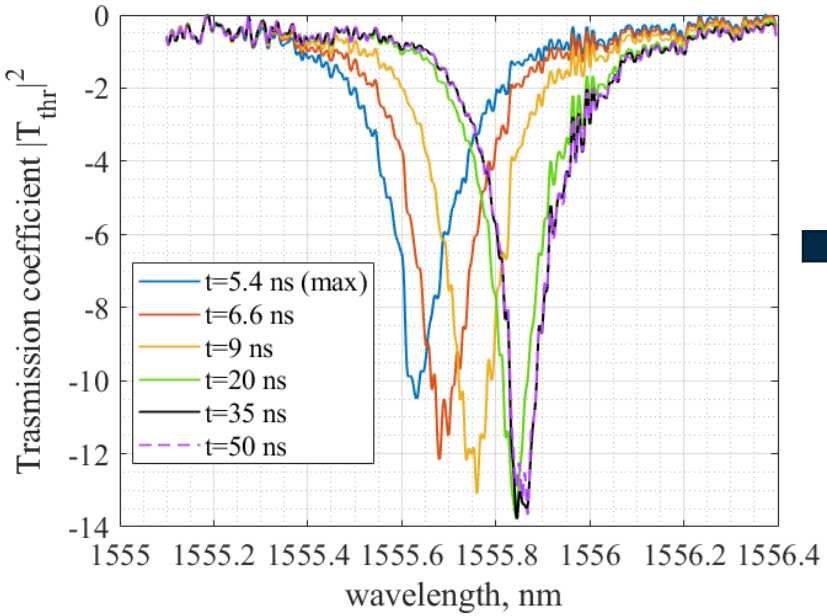
$Pump\ pulse\ width = 100ps$

Pump-probe experimental results

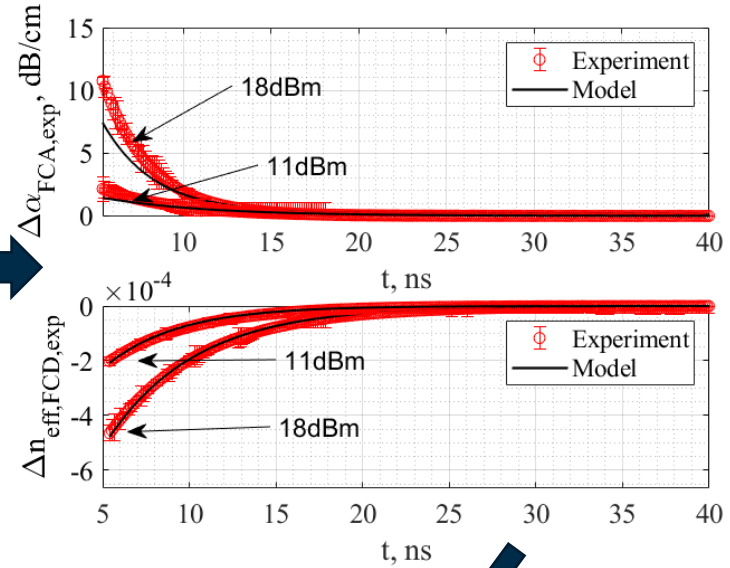
Map of probe signals (at different wavelengths) vs time



Time resolved transmission spectra



Recovery of absorption and refractive index variation



Electro-absorption/refraction relations in silicon

$$\Delta\alpha_{FCA} = \Gamma(8.8 \cdot 10^{-21} n_e^{1.167} + 5.84 \cdot 10^{-20} p_e^{1.109})$$

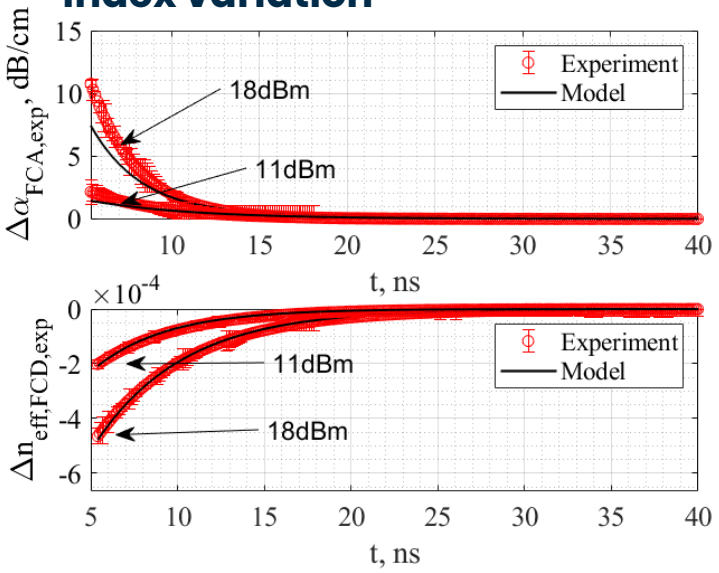
$$\Delta n_{eff,FCD} = -\Gamma(5.4 \cdot 10^{-22} n_e^{1.011} + 1.53 \cdot 10^{-18} p_e^{0.838})$$

Nedeljkovic, M., Soref, R., and Mashanovich, G. Z., *IEEE Photonics Journal*, 3(6):1171–1180,2011.

Extraction of electrons and holes free carrier densities

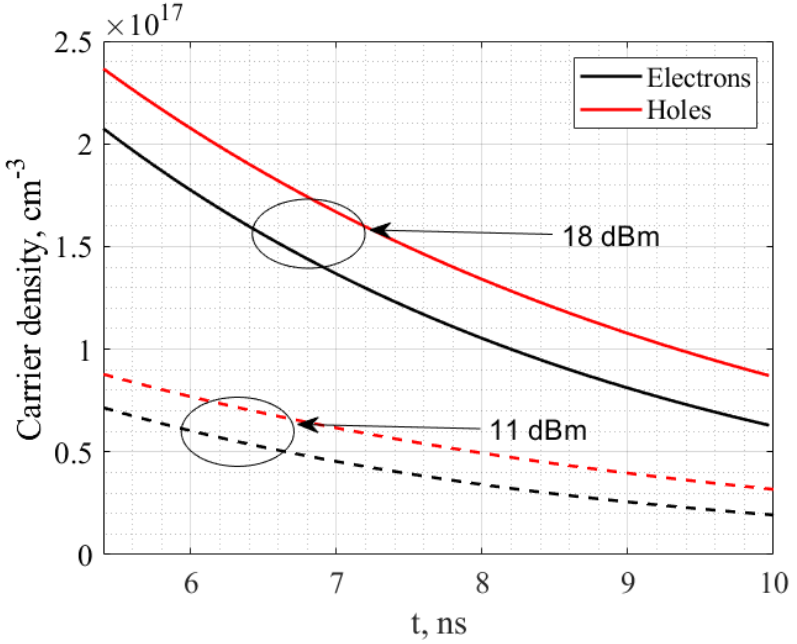
Initial free carrier lifetimes extraction

Recovery of absorption and refractive index variation



$$\Delta\alpha_{FCA} = \Gamma(8.8 \cdot 10^{-21} n_e^{1.167} + 5.84 \cdot 10^{-20} p_e^{1.109})$$
$$\Delta n_{eff,FCD} = -\Gamma(5.4 \cdot 10^{-22} n_e^{1.011} + 1.53 \cdot 10^{-18} p_e^{0.838})$$

Electrons and holes carrier density in the ring



- The initial free carrier lifetimes of electrons and holes can be calculated by fitting the first ns with a single exponential.
- Good matching with the theory.

$\tau[ns]$	Experiment	Theory
$\tau_{n,18dBm}$	3.6	2.7
$\tau_{p,18dBm}$	4.35	5
$\tau_{n,11dBm}$	1.15	0.83
$\tau_{p,11dBm}$	6.5	6.4

[1] Marco Novarese et al., *Opt. Express* vol. 30, 14341- 14357 (2022).