By applying a bias to the graphene across the aluminum oxide, the graphene can be charged and its Fermi level can be modulated. To find the distribution of the electric field in the waveguide a finite difference eigenmode solver was used. The horizontal electric field forms the majority of the energy in the mode. The interaction of the light with the graphene is strongest when the electric field is parallel to the graphene because it is treated as a surface conductivity. We operate the ring in quasi TE-mode and in this way the graphene on top of the waveguide has more influence than the graphene on the side of the waveguide. Applying a voltage bias to the graphene changes its optical properties; however the overall distribution of the light in the waveguide changes very little. We approximate the optical energy distribution in the waveguide to be constant with changing Fermi level of graphene. Voltage bias does change the effective refractive index and these effects are captured in the next section as perturbations. We obtain the unperturbed effective refractive index, $n_{eff,0}$, from the eigenmode solver when the Fermi level is 0.1 eV. This Fermi level was chosen because the optical behavior of graphene is relatively constant there.

3 The numerical model

Table 2: Simulation parameters.

Symbol	Value	Definition
Q_0	6E4	Intrinsic quality factor
Q_e	6E4	External quality factor
P_{pump}	25 mW	Input power
λ_0	1550 nm	Resonant wavelength
δ	$-0.000055\omega_0$	Frequency detuning
τ_{car}	100 ps	Free carrier lifetime
n_0	2.265479	Unperturbed effective refractive index
β_{2Si}	7.5E − 12 m/W	TPA coefficient for silicon
n_{2Si}	4.5E − 18 m^2/W	Kerr coefficient for silicon
Γ	10 meV	Graphene relaxation rate
W_{sat}	0.14 pJ	Saturation cavity energy
σ_{FCA}	1.45E − 21 m^2	Free carrier absorption coefficient
σ_e	8.8E − 28 m^3	Electron dispersion coefficient
σ_h	1.35E −	


0
5
10
15
Tim