Comparison of Simulation and Experimental Pulse Compression in Photonic Crystal Coupled Cavity Waveguides

Tim J. Karle[1], **Yew Jun Chai**[2], **Chris Morgan**[2], **Ian H. White**[2], **and Thomas F. Krauss**[1]
[1]University of St Andrews, St Andrews, UK.
[2]University of Cambridge, Cambridge, UK.

We observe compression of picosecond pulses in transmission through 2D photonic crystal (PhC) coupled cavity waveguides (CCWs). Such devices could impact upon future high-speed transmission systems. Continuous Wave characterisation of PhCs is commonplace, yet a full analysis of their dynamic performance has not yet been completed. Device performance is studied with the aid of both 2D eigenmode expansion (Fimmwave) and 2D Finite Difference Time Domain (FDTD-Fullwave) models. The observed spectral features are mirrored in the bandstructure, calculated for an infinite supercell. The finite length device (see Fig. 1), an L2in1 CCW demonstrates a significantly stronger dispersion than that calculated from the Ω-k plot of an infinitely long device. This highlights the importance of including finite length effects, apparent here from the signature of each individual cavity, into the simulation. Remarkable agreement between each 2D model and experiment is observed, giving high confidence in the large values of Group Velocity Dispersion (GVD) that we report. A maximum pulse width reduction of 40%, from 1.91 ps to 1.17 ps, is achieved from the 8 μm long planar PhC waveguide. The equivalent dispersion value is $> 10^6$ times larger than that of standard single mode fibre at the pulse centre wavelength of 1.55 μm.

The photonic crystals are etched into a GaAs/AlGaAs waveguide heterostructure, and the corresponding material and waveguide dispersion parameters are introduced into the 2D models. An effective index approach is then applied to retrieve the group index and hence the GVD for the L2in1. Losses remain a critical issue and limit the dynamic range of the pulse characterisation. We obtain sufficient signal level for autocorrelation measurements using Erbium Doped Fibre Amplifiers (EDFA). Careful choice of material and pulse duration is required to obtain a regime where non-linear processes are avoided, the effect of facet reflections minimised and the models remain valid.

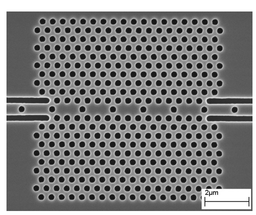

Figure 1: Device under test, an L2in1 Coupled Cavity Waveguide, with $a = 460$ nm.

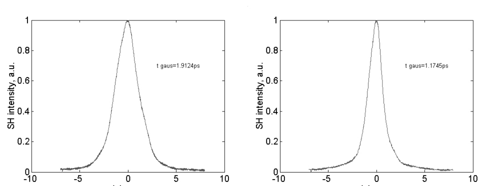

Figure 2: Autocorrelation of pulses transmitted through a) blank waveguide, b) L2in1 PhC waveguide.