12 Photonic Crystals: Simulation Successes and some Remaining Challenges

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Abstract. A wide range of software now exists for the design and simulation of photonic crystals. The sophistication and high performance specifications of many photonic crystal devices mean that techniques must typically not only provide accurate vector results, or at least a reliable error estimate, but also be able to deal with multi-scale problems, intricate materials properties including non-linearity, arbitrary geometries and multi-physics effects. The design process also demands consideration of process variation and performance optimisation issues.

In this chapter we review some of the modelling and simulation activities that have formed the activities of Working Group 2 of the COST P11 Action on 'The physics of linear, non-linear and active photonic crystals' and place these achievements within some more general trends in electromagnetics modelling. It will be seen that although time-domain numerical techniques such as the finite difference time-domain (FDTD) and transmission line modelling (TLM) methods have come to the forefront in recent years, principally driven by their flexibility, other techniques still have significant roles to play in the design process and in efficient, accurate and thorough simulation investigations.

Key words: modelling methods; simulation; slow wave structures; photonic wire; second harmonic generation; membrane waveguides

12.1 Introduction

Significant attention and investment has been made in providing computer simulation packages for photonics devices and systems. The emergence of photonic crystals, photonic crystal fibres, all-optical signal processing, plasmonics, nano- and micro- resonators and photonic molecules, optical memory and device synthesis continue to further the requirements on simulation techniques. Techniques must typically not only provide accurate vector results, or at least a reliable error estimate, but also be able to deal with multi-scale problems, intricate materials properties and arbitrary geometries. The questions posed by the designers are largely common across the broad spectrum of computational electromagnetics, including: Will the model solve my problem? Are there any constraints? Can you deal with time-varying and non-linear problems? What size of problem is realistic? How accurate