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Report on the thesis of Hynek Nemec :

"Time –resolved TeraHertz spectroscopy applied to the investigation of magnetic material and photonic structures"

The present work is divided in two equal parts. The first one deals with Terahertz measurements while the second one deals with photonic band-gap structure in the Terahertz domain. These two domains are hot topics but are seldom studied together. However the combination of Terahertz and Photonic Band Gap (PBG) materials is of great interest. In the microwave regime, the quasi-optic treatment, well adapted to PBG, is not very practical due to large wavelengths, while in the near infrared domain, the size of the PBG is technologically very challenging. Terahertz offers just the right compromise. The reason for the surprisingly few common studies is certainly a consequence of the difficulties to obtain enough accurate measurements for efficient studies of complex PBG materials.

After an introductory chapter on generation and detection of Terahertz radiation, the first part concentrates on time domain Terahertz spectroscopy (TDTS) and its applications to precise determination of dielectric and magnetic material properties. Chapter 2 presents a clear overview of TDTS in both transmission and reflection modes and introduces shortly the two spectrometers used at the Institute of Physics in Prague and at the University of Savoy. The third chapter describes an independent determination of dielectric and magnetic properties in the Terahertz domains. While there are a lot of studies on dielectric determination, comparatively few measurements have been done on magnetic properties, and very few on the independent determination on dielectric and magnetic properties. These determinations require complex measurements (i.e. amplitude and phase) of both transmitted and reflected waves, or at least independent measurement of two values based on these waves. In fact, the thesis proposes three methods for the independent determination of dielectric and magnetic properties. The precision and drawbacks are carefully studied and checked on measurement of different materials. An evaluation of the pertinence of these methods for meta-materials where both permittivity and permeability measurements are of prime importance is performed on simulated measurements obtained with the simulation tools introduced in the second part of the thesis. All the studies of this chapter are made with great care and are very useful for PBG measurements.

In the second part of this thesis, chapter 4 introduces PBG concepts and particularly left-handed material. The main properties are clearly presented. Chapter 5 presents the simulation tools for PBG structures. After a few words on the plane wave expansion method, it focuses on transfer matrix methods (TMM). The 1D TMM is straightforward, so it is used as an introduction to 2D and 3D methods for PBG. Boundary condition is a very important point for simulation results. The author has made the choice to discuss the boundary conditions within the different calculations done. Although, this allows precise description of the conditions used, it scatters the information through the last chapters. A brief introduction in chapter 5 would be welcome. Chapter 6 presents the application to a grating coupler and compares two different simulations to experimental results. This allows checking of the simulation method and interesting comparisons between simulations and experimental results. The last chapter deals with 1D tunable PDG. The tunability is obtained through temperature adjustment of one defect. Careful simulations allow tunability optimization and relative values up to 60% is obtained.

This thesis is well written. The extended French abstract is also very clear and in good French. State of the art results are obtained in chapter 3, 6 and 7 as indicated by several publications in international peer-reviewed journals. In light of the high quality of the research work presented, I wholeheartedly support the award of a PhD for this thesis.

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