Object: Report of Premysl Ciompa master's thesis “Modeling of passive and active optical structures”

The work and master’s manuscript of Premysl Ciompa set in the very active area of photonics and (spin-)Vecsel devices with the issue of finding the optical eigenmodes of complex optical cavity and structures. In particular, it has consisted in understanding and development numerical models of Rigorous Coupled Wave Analyses (RCWA) of optical eigenmodes of passive and active devices represented by VECSELs and involving local dipole sources 1D lateral grating designed as photonic devices. The interest to study and develop that kind of object is particularly obvious in the goal to optimize the output emission of lasers in mind to select only a low number of selected modes, e.g. transversally non-degenerate. The present contribution has consisted, in particular, to the modelling of the light coherent and incoherent propagation in devices with 1D lateral periodicity combining RCWA, S-matrix approach and 1D-Fourier transform analyses to describe the lateral geometrical devices. In more details, the rigorous coupled wave algorithm (RCWA) is used here for the modelling of periodic gratings and models of active dipole layers are based upon $4 \times 4$ matrix formalism suitable for modelling of spin-polarized light emitting diodes (spin-LEDs) and vertical-cavity surface-emitting lasers (spin-VCSELs). To enable the combination of these two approaches a new formalism for modelling of incoherent propagation in periodic structures based on coherence/Mueller matrices is introduced and it is demonstrated on the structure of flexible diffraction components that include thick layers. Models of active dipole layers are then expressed using the same formalism that enables the integration of both periodic and active layers in the same model.
Compared to the state-of-the art in the field, the originality of this work/manuscript lies in several points:

i) The development of a new formalism for modelling of incoherent propagation in grating structures that solves the problem of combining models of active structures with RCWA due to the treatment of incoherent processes by averaging over random phase factor.

ii) The application of the developed formalism to models of flexible diffractive components including incoherent propagation in the thick capping layer and the comparison with the coherent and partially coherent models.

iii) The expressing of the models of active structures in terms of coherence matrix based formalism making them compatible with RCWA together with the demonstrating the validity of the coherence matrix based approach on a simple LED structure and comparing it with the method of averaging over random phase factor. This makes the ensemble of the approach very relevant also for future numerical investigations coupled to future experiments. Indeed, the results of this thesis makes possible to target future prospects like checking models validity by comparing results of our models with the actual experimental data measured on the flexible diffractive gratings by Mueller matrix ellipsometry in order to combine RCWA with the models of active structures by the use of the formalism developed here. Also it will be possible to use the present models of incoherent propagation in grating structures for modelling of flexible diffractive optics components, such as security holograms and generalize the developed formalism of incoherent propagation for 2D periodic structures describing arrays of quantum dots or photonic crystals and model actual spin-VCSEL structures in order to understand the underlying processes and to design spin-lasers for future experimental situations and applications.

To end up, I would say that the present manuscript is very well written (the English is very correct) and also very well presented with the necessary physical and mathematical developments for a self-consistent understanding. The development of those modelling tools, like proposed here, becomes more and more mandatory to describe optimized complex structures involving non-translational invariance and help to design the experimental developments.
Moreover, we feel that Mr. Premysl Ciompa is strongly motivated to carry on and enlarge those investigations, in a short future, in the frame of an international cotutelle thesis between the technical university of Ostrava and the University of Paris-Saclay Palaiseau France. Undoubtedly, Mr. Premysl Ciompa is also strongly motivated for a carrier of scientific researcher.

For the ensemble of that reasons, I judge the present work and contribution as well as manuscript content, format and style, with grade 1 along the Technical Ostrava University’s rule. Also, I strongly support the Master thesis defense of Mr. Premysyl Ciompa in the University of Ostrava in June 2018 along the scientific themes presented in the manuscript.

Sincerely,

Dr. Henri JAFFRES
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