Report on the doctoral thesis „Coherent Light Sources with Spin-Polarized Current” by Tibor Fördös

The doctoral thesis presented by Tibor Fördös deals with the modelling and the measurement of semiconductor vertical cavity surface-emitting spin lasers in the presence of local anisotropies which influence the polarization state of light.

Parts of the doctoral thesis have been published by Tibor Fördös in three high-quality, peer-reviewed, international journals whereat Tibor Fördös is first author of all three publications. Tibor Fördös has additionally published three conference proceedings, has been invited to three international conferences, and has presented his results additionally at several other international scientific events. The thesis is subdivided into six chapters plus summary and appendices. The content of the chapters is summarized in the following:

Chapter 1 provides a brief introduction into spin electronics and semiconductor spin-lasers and describes the goal and motivation of the thesis.

Chapter 2 gives a general overview about the basic principles of spin vertical cavity surface-emitting lasers, the optical selection rules, pumping mechanisms, the phenomenological “bucket model”, the design of VCSEL, linear birefringence, circular gain dichroism, possible causes for anisotropies, and the measurement of linear birefringence in optically-pumped structures. Such a chapter naturally can’t give a complete overview over the field but this chapter is a little bit less readable and excellent compared to the following chapters, i.e., some explanations and references are missing, there are several typing errors, and some (minor) details are not presented with the desirable precision.

Chapter 3 focuses on ellipsometry of multilayer semiconductor lasers. The derivation of the wave equation from the Maxwell equations is in general dispensable but introduces in this case reasonably into the necessary notation and

1 For example on page 16 „Each pairs of QWs is separated by GaAs spaces, which size decrease when getting closer to the surface.” Such a detail has to be explained directly in more detail or should be mentioned at a later time.
2 E.g., PRB 56, R7076 (1997).
3 E.g. on page 20 „10 V V“.
4 E. G. on page 16 „The peaks around ... 250 nm ... are given by the absorption ... as can be seen from a comparison with the reflectivity of GaAs (blue curve).“ However, the blue curve in Fig. 2.6 is not drawn between 200 and 450 nm.
in the following complex context. The introduction into the Mueller matrix ellipsometry is very well handled.

Chapter 4 is devoted to the experimental study of local linear anisotropies. After a short description of the sample structure, the optical functions of semiconductor layers, the fitting procedure, and first experimental results by Mueller matrix ellipsometry are presented where the agreement between experiment and model – as can be seen for example in Fig. 4.5 – is very impressive.

Chapter 5 presents a mathematical approach to model the laser eigenmodes in the presence of local linear birefringence and linear gain dichroism caused by symmetry reduction. This model is in my opinion a very important step towards semiconductor spin-VCSELs and one of the highlights of this very nice thesis.

Chapter 6 finally focuses on the numerical and experimental investigation of local anisotropies in spin-LEDs and spin-VCSELs. The successful application of the theory to real devices is a convincing demonstration of the accuracy of the model which explains especially the important transition from linear polarization to circular polarization and the dependence on the frequency shift on spin polarization.

Overall evaluation of the thesis: The presented work makes a significant contribution to the field of semiconductor spin VCSELs and the modelling of light polarization in the presence of local anisotropies. The scientific results and the publications are impressive and well presented. Some minor spelling mistakes and linguistic weaknesses\(^5\) exist but do not really matter. Most of the presentation is clear, of high quality, and will be an important reference. The thesis is on a very high scientific level and I therefore emphatically recommend acceptance of this thesis.

\(^5\) If easily possible, Tibor Fördös should rephrase the third sentence of his resume „In this thesis, a general method ...“.