KØBENHAVNS UNIVERSITET
UNIVERSITY OF COPENHAGEN

AT THE GRADUATE SCHOOL OF SCIENCE HAS

MORTEN STILLING
CIV.REG.NO.: 100277-2953

COMPLETED THE PH.D.-STUDY AT THE

NIELS BOHR INSTITUTE

ON JUNE 23th 2008

ON THE BASIS OF THE DISSERTATION

Magnetoresistance in MgO-based magnetic Tunnel Junctions with Fe, Co, and FeCo Electrodes

SUPERVISOR: Karsten Flensberg

IN ACCORDANCE WITH MINISTERIAL ORDER NO.18 OF JANUARY 14th 2008 CONCERNING THE AWARD OF THE DANISH PH.D.-DEGREE

COPENHAGEN, JULY 7th 2008

RALF HEMMINGSEN
RECTOR

NILS O. ANDERSEN
DEAN

KØBENHAVNS UNIVERSITET
UNIVERSITY OF COPENHAGEN

VED DET NATURVIDENSKABELIGE FAKULTETS PH.D.-SKOLE HAR

MORTEN STILLING
CPR.NR.: 100277-2953

GENNEMFØRT PH.D.-STUDIET VED

NIELS BOHR INSTITUTET

DEN 23. JUNI 2008

OG FÅET GODKENDT AFHANDLINGEN:

Magnetoresistance in MgO-based magnetic Tunnel Junctions with Fe, Co, and FeCo Electrodes

VED HOVEDVEJLEDER: Karsten Flensberg

JF. UNDERVISNINGSMINISTERIETS BEKENDTGØRELSE
NR. 18 AF 14. JANUAR 2008 OM PH.D.-GRADEN

KØBENHAVN DEN 7. JULI 2008

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Evaluation of Ph.D. Thesis by M.Sc. Eng. Morten Stilling:

"Magnetoresistance in MgO-based Magnetic Tunnel Junctions with Fe, Co, and FeCo Electrodes"

107 pages + list of references (total 118 pages) plus 4 articles in reprint/preprint.

JUNE 23, 2008
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Morten Stilling (MS) has submitted a Ph.D. thesis on his theoretical work over the last three years on magnetic tunnel junctions. MS has followed an industrial Ph.D. program where part of his time has been spent at the industrial partner, Atomistix A/S. As part of the requirements for this, the student has to complete both a business related program as well as a scientific research project. At Atomistix MS has collaborated closely with the development group headed by Jeremy Taylor and he has formulated requirements for new features in the software necessary for his research project. After the development of these features MS has tested it and given feed back to the development department. In addition, he has worked in the support division of the company and been in close contact with many customers and made a major contribution to the companies support infrastructure and training courses for customers. For his research project MS has been embedded in the Nano-Science Center and has been a member of the theory group. He has also taken theoretical physics courses as required by the Ph.D. School. His collaborators in the theory group have been his supervisors, Kurt Stokbro and Karsten Flensberg and, in particular, Hector Mera.

MS's work belongs to the main stream of current international efforts to develop novel models, materials and processes for advanced spin-sensitive components, e.g. sensors for hard disk read heads and tunnel junctions for magnetic random access memories (MRAMs).

The thesis has a clear structure and it is well written in a fluent style. It includes the necessary ingredients: introduction, theoretical methods, theoretical results, comparison with published data, and a concluding chapter with perspectives. There are very few grammatical errors.

The focus is on calculating the zero-bias and finite bias current-voltage characteristics of MgO based magnetic tunnel junctions with three kinds of electrodes (Fe, Co and FeCo).

On the positive side:

- Good overview of the spintronics applications and of the research field
- Fine overview of the DFT and NEGF method used in the thesis. Advantages and disadvantages/difficulties about the DFT and NEGF method are discussed. Also it is demonstrated a good understanding of the software used in the work.
- Lattice structure properties of the considered MgO based magnetic tunnelling junctions are examined in detail and the computational scheme is outlined
- Tunnelling mechanisms in the considered MgO based magnetic tunnelling junction structures are comprehensively studied and analyzed. Comparison with available published works is made and discussed.
- Good account of the origin and magnitude of various contributions to the tunnelling conductance as a function of voltage bias and as a function of the magnetic configuration of the electrodes (parallel or anti-parallel).
- Interesting data, fine presentation and analysis.
- Critical sense, sound conclusions.

On the negative side:

- Only weak correlations between calculated results and published experimental data, so-called non-ideal tunnelling structures are to blame, results from paper no. 4 should have been included in Thesis.
- Inadequate concluding summary of "good ideas for what to do next" –more specific suggestions are called for both for models, methods and new experiments. One example could be the study of the critical thickness of MgO in the structures, at which the dislocation or other extended defects start to form.
- Incomplete information for references, e.g., missing page numbers etc.

The oral presentation at the defense on June 23, 2008 went well. MS gave a pedagogical talk presenting the field and his work. In the examination he answered most questions satisfactorily although there was some vagueness concerning basic magnetism.

In conclusion, we can recommend that Morten Stilling be granted the Ph.D. degree in Physics.

Jørn Bindslev Hansen	Hongqi Xu	Per Hedegård
Docent, DTU	Professor, Lund Univ.	Professor mso, NBI