NTNU – Trondheim
Norwegian University of
Science and Technology

Faculty of Information Technology, Mathematics and Electrical Engineering
Department of Electronics and Telecommunications
Research group: Materials and Device Technology

Member of Scientific Staff:
Prof. Helge Weman

Date: 23.06.2014

CV and publication list for Prof. Helge Weman

www.iet.ntnu.no/~weman

Name: Helge Weman

Nationality: Norwegian and Swiss

Born: 25th Aug. 1960 in Stockholm, Sweden

Present position: Professor in nano-electronics&nano-photonics at NTNU

Academic degrees:

- 1992: *Docent habilitation (Materials science)*: Linköping University, Sweden.
- 1988: *PhD (Materials science)*: Linköping University, Sweden.
  Title: "*Optical studies of excitonic impact ionization and complex defects in silicon*"
  Advisor: Prof. Bo Monemar, thesis opponent: Prof. Hans-Joachim Queisser.
- 1983: *Master of Science (Applied physics)*: Linköping Inst. of Technology, Sweden.

Work experience:

Employment:

- 2012 - : *Chief Technology Officer* (20%) and Founder of CrayoNano AS, Trondheim, Norway
- 2005 - : *Professor in* "Nanoelectronics and nanophotonics" at Dept. of Electronics and Telecom, Norwegian University of Science and Technology (NTNU), Trondheim, Norway.
- 1996 - 2005: *Senior scientist*, Swiss Federal Institute of Technology (EPFL), Switzerland.
- 1997 - 2005: *Associate professor* at Linköping University (Part time ~ 20 %/ year).
- 1992 - 1996: *Assistant professor* at Linköping University.

Visiting Assignments:

- Jan. – June 2011. *Visiting scientist (on sabbatical leave)*, IBM Zürich Res. Lab, Switzerland.
- July – Dec. 2008. *Visiting professor (on sabbatical leave)*, Swiss Federal Institute of Technology (EPFL), Lausanne, Switzerland. With prof. Eli Kapon.
- 1993 - 2002. *Visiting scientist*, Grenoble High Magnetic Field Lab., France. ~1 month/year.
- Oct. 1993 - March 1994: *Visiting associate professor,* NTT Opto-electronics Lab, Photonic Functional Device Lab, Atsugi, Japan.
- Aug. 1989 - Nov. 1991: *Postdoc*. at Center for Quantized Electronic Structures (QUEST), University of California, Santa Barbara, USA. With Profs. J.L. Merz, P.M. Petroff, A.C. Gossard and H. Kroemer (Nobel physics laureate in 2000).

Publications:

- Internationally refereed journal papers: 120 (and ca. 250+ conference papers).
- 45 invited conference talks, 3 book chapters/reviews, 6 patent applications.
- h-index: 19. Total citations: 1116 (ISI Web of Science 20-05-2014).

Present external projects as project leader/participant:

1. "Low cost, ultra-high efficiency graphene nanowire solar cells (GRANASOL)" (2015-2018) funded by the funded by Research Council of Norway (RCN) NANO2021 program (project leader).
2. "III-V nanowire/graphene hybrid structures" (2012-2016) funded by RCN's FRINATEK program (project leader).

3. "Semiconductor nanowires", (2012-2014) funded by RCN's FORNY2010 program.
4. "Semiconductor/graphene hybrid devices for energy applications (SEGRA)" (2013-2015, project leader Dong-Chul Kim) funded by RCN's NANO2021 program.

Membership in academic and professional committees, scientific review work:

- Panel member of evaluators for "Technical Physics", Swedish Research Council.2011/2012
- Elected member of Norwegian Academy of Technological Sciences (NTVA). 2010-
- Editorial Board Member of "Nanoscience & Nanotechnology-ASIA". 2011-
- Member of American Nano Society. 2011-
- Member of Norwegian Solar Cell Technology Center.
- Member of European Physical Society.
- Member of Materials Research Society.
- Member of Society of Photographic Instrumentation Engineers (SPIE).
- Member of "NTNU-NanoLab" leader group. 2006-
- Member of study board for "Master of Nanotechnology" at NTNU. 2006-2011
- Program committee of bi-annual "Int. nanowire growth workshop".
- Program committee of bi-annual "Int. conf. on Optoelectronic Properties of Materials".
- Project reviewer for various National Research Councils (Sweden, Austria, France, Israel)
- Journal referee for: Nature Nanotechnology, Nature Communications, Nano Letters, Nanotechnology, Phys. Rev. Lett., Phys. Rev. B., Appl. Phys. Lett., J. Appl. Phys., Semicond. Sci. Tech., J. Cryst. Growth., ...

Former PhD Students (9):

- Mazid Munshi ('14), Guro Kristin Svendsen (co-supervisor), ('13), Christian Weigand ('12), Jelena Todorovic (co-supervisor) ('12-), Dheeraj Dasa ('10), Fredrik Karlsson at Linköping University ('04), Lorenzo Sirigu (co-supervisor) at EPFL-Lausanne ('02), Johan Hammersberg at Linköping University ('98), Masaya Notomi (co-supervisor) Linköping University ('97).

PhD students presently under supervision (5):

- Andreas Mulyo ('14-) co-supervisor, Johannes Reinertsen ('12-), Dingding Ren ('12-) co-supervisor, Vidar Fauske ('11-) co-supervisor, Lyubomir Ahtapodov ('09-).

Post Doctors presently under supervision (3):

- Lars Martin Aas ('14-), Junghwan Huh ('12-), Cheng Guan Lim ('11-)

Fields of interest and present research activities:

Since 2005 I lead a research group that now consists of 5 PhDs and 3 postdocs (+several master students) that fabricates and characterizes nano-scale semiconductor materials and devices for use as e.g. energy efficient light emitters and solar cells. I grow the heterostructured III-V semiconductor nanowires with atomic precision using a molecular beam epitaxy system in collaboration with Prof. Fimland. Processing of the nanowire devices is done by e.g. electron beam lithography, nanoimprint and focused ion beam techniques using NTNU NanoLab. Characterization using techniques such as low temperature photocurrent and electroluminescence is done in order to understand and utilize quantum size effects for future photonic, sensing and photovoltaic device applications. At the institute I have built an advanced Nanophotonics lab, based on a scanning confocal optical microscope, where we can measure the light from single nanoparticles or devices down to low temperatures (2 K), time-resolved (pico/femto seconds), and at high magnetic fields (11 Tesla). In 2010 I initiated a new project on nanowire/graphene hybrid structures, and in 2012 I co-founded CrayoNano As based on this technology. I have filed six patent applications on this topic together with NTNU Technology Transfer Office (TTO).

Selected peer-reviewed publications since 2009 - :

1. *Semiconductor quantum-wires and nano-wires for optoelectronic applications*
H. Weman, S. Palmgren, K.F. Karlsson, A. Rudra, E. Kapon, D.L. Dheeraj, B.-O. Fimland, and J.C. Harmand,
J. Mater. Sci.: Mater. Electron. **20**, S94 (2009).
2. *Observation of free exciton photoluminescence emission from single wurtzite GaAs nanowires*
T.B. Hoang, H. Zhou, A.F. Moses, D.L. Dheeraj, B.-O. Fimland, and **H. Weman**,
Appl. Phys. Lett. **94**, 133105 (2009).
3. *Growth and structural characterization of GaAs/GaAsSb axial heterostructured nanowires*
D.L. Dheeraj, G. Patriarche, H. Zhou, J.C. Harmand, **H. Weman**, and B.-O. Fimland,
J. Cryst. Growth. **311**, 1847 (2009).
4. *Wurtzite GaAs/AlGaAs core-shell nanowires grown by molecular beam epitaxy*
H. Zhou, T.B. Hoang, D.L. Dheeraj, A.T.J. van Helvoort, L. Liu, J.C. Harmand, B.-O. Fimland, and **H. Weman**,
Nanotechnology **20**, 415 701 (2009).
5. *Engineering parallel and perpendicular polarized photoluminescence from a single semiconductor nanowire by crystal phase control*
T.B. Hoang, A.F. Moses, L. Ahtapodov, H.L. Zhou, D.L. Dheeraj, A.T.J. van Helvoort, B.-O. Fimland, and **H. Weman**,
Nano Lett. **10**, 2927 (2010).
6. *Model for refection and transmission matrices of nanowire end facets*
G.S. Svendsen, **H. Weman**, and J. Skaar
J. Appl. Phys. **109**, 103101 (2011).
7. *Correlated micro-photoluminescence and electron microscopy studies of the same individual heterostructured semiconductor nanowires*
J. Todorovic, A.F. Moses, T. Karlberg, P. Olk, D.L. Dheeraj, B.O. Fimland, **H. Weman,** and A.T.J. van Helvoort,
Nanotechnology **22**, 325 707 (2011).
8. *Effect of substrate annealing on the Au-catalyzed growth of ZnO nanostructures*
C.C. Weigand, D. Skåre, C. Ladam, J. Grepstad, and **H. Weman,**
Nanoscale Res. Lett. **6**, 566, (2011).
9. *On the formation of ZnO nanosheets grown by catalyst-assisted pulsed laser deposition*
C.C. Weigand, M.R. Bergren, C. Ladam, J. Tveit, R. Holmestad, P.E. Vullum, J.C. Walmsley, Ø. Dahl, T.E. Furtak, R.T. Collins, J. Grepstad, and **H. Weman,**
Crystal Growth and Design **11**, 5298 (2011).
10. *Investigations of Bragg reflectors in nanowire lasers*
G.S. Svendsen, **H. Weman**, and J. Skaar,
J. Appl. Phys., **111**, 123102 (2012).
11. *Epitaxial relationship of ZnO nanostructures grown by Au-assisted pulsed laser deposition on c- and a-plane sapphire*
C.C. Weigand, J. Tveit, C. Ladam, R. Holmestad, J. Grepstad, and **H. Weman,**
J. Crystal Growth, **355**, 52 (2012).
12. *Vertically aligned GaAs nanowires on graphite and few-layer graphene: Generic model and epitaxial growth*
M.A. Munshi, D.L. Dheeraj, V.T. Fauske, D.C. Kim, A.T.J. van Helvoort, B.-O. Fimland, and **H. Weman,**
Nano Lett. **12**, 4570 (2012).
13. *A story told by a single nanowire: Optical properties of wurtzite GaAs*
L. Ahtapodov, J. Todorovic, P. Olk, T. Mjåland, P. Slåttnes, D.L. Dheeraj, A.T.J. van Helvoort, B.O. Fimland, and **H. Weman**
Nano Lett. **12**, 6090 (2012).
14. *Advances in semiconductor nanowires grown on graphene*
A.M. Munshi and **H. Weman**,
Phys. Status Solidi RRL **7**, 713 (2013).
15. *Comparison of Be-doped GaAs nanowires grown by Au- and Ga-assisted molecular beam epitaxy*
D.L. Dheeraj, A.M. Munshi, O.M. Christoffersen, D.C. Kim, G. Signorello, H. Riel, A.T.J. van Helvoort,
H. Weman, and B.O. Fimland,
J. Cryst. Growth **378**, 532 (2013).
16. *Compositional characterization of GaAs/GaAsSb nanowires by quantitative HAADF-STEM*
H. Kauko, T. Grieb, R. Bjørge, M. Schowalter, A.M. Munshi, **H. Weman**, A. Rosenauer, A.T.J. van Helvoort,
Micron **44**, 254 (2013).
17. *Controlling crystal phases in GaAs nanowires grown by Au-assisted molecular beam epitaxy*
D.L. Dheeraj, A.M. Munshi, M. Scheffler, A.T.J. van Helvoort, **H. Weman**, and B.O. Fimland,
Nanotechnology **24**, 015601 (2013).

18. *Polarization dependent photocurrent spectroscopy of single wurtzite GaAs/AlGaAs core-shell nanowires*
D.C. Kim, D.L. Dheeraj, B.O. Fimland, and **H. Weman**,
Appl. Phys. Lett. **102,** 142107 (2013).

19. *Crystal phase engineering in self-catalyzed GaAs and GaAs/GaAsSb nanowires grown on Si(111)*
A. M. Munshi, D.L. Dheeraj, J. Todorovic, A.T.J. van Helvoort, **H. Weman**, and B.O. Fimland,
J. Cryst. Growth **372**, 163 (2013).

20. *Comparison of Be-doped GaAs nanowires grown by Au- and Ga-assisted molecular beam epitaxy*
D.L. Dheeraj, A.M. Munshi, O.M. Christoffersen, D.C. Kim, G. Signorello, H. Riel, A.T.J. van Helvoort,
H. Weman, and B.O. Fimland,
J. Cryst. Growth **378**, 532 (2013).

21. *Electrical, optical and structural properties of Al-doped ZnO thin films grown on GaAs(111)B substrates by pulsed laser deposition*
C.C. Weigand, R. Crisp, C. Ladam, T.E. Furtak, R.T. Collins, J. Grepstad, and **H. Weman,**
Thin Solid Films **545**, 124 (2013).

22. *The effects of Sb concentration variation on the optical properties of GaAsSb/GaAs heterostructured nanowires*
J. Todorovic, H. Kauko, L. Ahtapodov, A.F. Moses, P. Olk, D.L. Dheeraj, B.O. Fimland, **H. Weman**, and A.T.J. van Helvoort,
Semiconductor Science and Technology **2**8, 115004, (2013).

23. *Self-catalyzed MBE grown GaAs/GaAsSb core-shell nanowires in ZB and WZ crystal structures*
S.G. Ghalamestani, A. M. Munshi, D.L. Dheeraj, B.O. Fimland, **H. Weman**, and K.A. Dick,
Nanotechnology **24**, 405601 (2013).

24. *Position controlled uniform GaAs nanowires on silicon using nanoimprint lithography*
A. M. Munshi, D.L. Dheeraj, V.T. Fauske, D.C. Kim, J. Huh, J.F. Reinertsen, L. Ahtapodov, K.D. Lee, B. Heidari, A.T.J. van Helvoort, B.O. Fimland, and **H. Weman,**
Nano Lett. **14**, 960 (2014).

25. *Inducing a direct-to-pseudodirect bandgap transition in wurtzite GaAs nanowires with uniaxial stress*
G. Signorello, E. Lörtscher, P.A. Khomyakov, S. Karg, D.L. Dheeraj, B. Gotsmann, **H. Weman** and H. Riel,
Nature Commun. **5**, 3655 (2014).

Book chapters/reviews (3):

26. *Heterostructured III-V nanowires with mixed crystal phases grown by Au-assisted MBE*
D.L. Dheeraj, H.L. Zhou, A.F. Moses, T.B. Hoang, A.T.J. Van Helvoort, B.O. Fimland, and **H. Weman**,
Ch. 2 in "Nanowires", ed. Paola Prete, IN-TECH, Austria, 2010, http://sciyo.com/books/show/title/nanowires

27. *III-antimonide nanowires*
H. Weman and D.L. Dheeraj
Chapter 5 in the book "Advances in III-V Semiconductor Nanowires and Nanodevices", eISBN 978-1-60805-052-9, Ed. Jianye Li, Deli Wang and Ray R. LaPierre, Bentham science publishers, Ch. 5, pp. 89-104, 2011.

28. *Advances in semiconductor nanowires grown on graphene*
A.M. Munshi and **H. Weman**,
Phys. Status Solidi RRL **7**, 713 (2013). (Review article in focus issue on "Semiconductor Nanowires")

Patent applications (6):

1. *Epitaxial growth of semiconductor nanowires on graphitic layers*
H. Weman et al., UK patent appl. «1021112.6«, filed Dec. 13, 2010. PCT appl. WO 2012/080252 A1, filed Dec.13, 2011.
2. *Graphene top contact to metal catalyst nanowires*
H. Weman et al., UK patent application «1200355.4», filed Jan. 10, 2012. PCT filed Jan. 10, 2013.
3. *Hybrid multilayer*
H. Weman et al., UK patent application «1211038.3», filed June 21, 2012. PCT filed June 21, 2013.
4. *Semiconductor films*
B.O. Fimland and D.L. Dheeraj, and **H. Weman**, UK patent application «1211037.5», filed June 21, 2013. PCT filed June 23, 2014.
6. *Radial p-n junction nanowire solar cell*
Cheng. G. Lim and **H. Weman**, UK patent application «1314566.9», filed Aug. 14, 2013.
5. *Nanowire hot carrier solar cell*
H. Weman, UK patent application, filed June 21, 2014