

**Dr. Thibaud DENNEULIN**

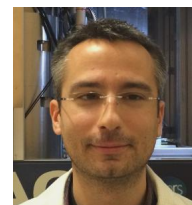
**Address:** Forschungszentrum Jülich GmbH  
52425 Jülich, Germany



**Tel:** +49 24 61 61 85 177



[t.denneulin@fz-juelich.de](mailto:t.denneulin@fz-juelich.de)



## ELECTRON MICROSCOPY AND NANOMATERIALS RESEARCHER



### PROFESSIONAL EXPERIENCE

**2017-present**  
**Jülich,**  
**Germany**

**Post-doctoral Researcher - Forschungszentrum Jülich - Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons - Electromagnetic field mapping group**

Electron microscopist for the DARPA-funded project entitled "Manipulation of magnetic skyrmions for logic-in-memory applications"

- ↳ Characterization of heavy metal/ferromagnetic multilayer samples using transmission electron microscopy (TEM)
- ↳ Magnetic imaging of Néel-type skyrmions and domain walls using electron holography and Fresnel images

Contact: Pr. R. Dunin-Borkowski, +49 2461 61-9297, [r.dunin-borkowski@fz-juelich.de](mailto:r.dunin-borkowski@fz-juelich.de)

**2013-2017**  
**Toulouse,**  
**France**

**Post-doctoral Researcher - CEMES (Center for fabrication and structural characterization of materials) CNRS - Electron microscopy group**

Electron microscopist for the EMRP-funded *Nanostrain* project entitled "Novel electronic devices based on control of strain at the nanoscale"

- ↳ Characterization of epitaxial piezoelectric metal oxides using TEM
- ↳ Development of new optical schemes for electron holography using a multibeam microscope (Hitachi I2TEM)
- ↳ In-situ biasing and indentation using Hysitron and Nanofactory holders

Contact: Dr. M. Hÿtch, +33 5 62 25 78 83, [hÿtch@cemes.fr](mailto:hÿtch@cemes.fr)

**2009-2012**  
**Grenoble,**  
**France**

**Ph.D. Student - CEA-LETI (Laboratory of electronics and information technologies) - Physical characterization laboratory - Electron microscopy group**

Strain measurements in microelectronic devices using TEM techniques

- ↳ Development of dark-field electron holography (DFEH) on a FEI Titan TEM
- ↳ Comparison of DFEH with nanobeam electron diffraction (NBED) and aberration corrected scanning TEM (HRSTEM)
- ↳ Sample preparation by focused ion beam (FIB)

Contact: Dr. D. Cooper, +33 4 38 78 19 27, [david.cooper@cea.fr](mailto:david.cooper@cea.fr)

**2009, 6 months**  
**Grenoble**

**Internship - CEA-LETI - Laboratory of lithography - Metrology group**

- ↳ Characterization of photoresist patterns using 3D atomic force microscopy (3D-AFM) and critical dimension scanning electron microscopy (CD-SEM)

**2008, 5 months**  
**Massy**

**Internship - Alchimer company**

- ↳ Electrochemical grafting of polymers on silicon wafers.

**2007, 4 months**  
**Paris**

**Internship - ESPCI (School of Industrial Physics and Chemistry) - Laboratory of analytical chemistry**

- ↳ Scanning electrochemical microscopy (SECM) for the polymerization of surfaces.



### EDUCATION

- ❖ 2009-2012: **Ph.D. Thesis** - "Dark-field electron holography a reliable technique for measuring strain in microelectronic devices" - University of Grenoble - defended the 15<sup>th</sup> of November 2012 - Jury:  
Dr. Patricia Donnadiou, SIMAP, Grenoble, France (President)  
Dr. Martin Hÿtch, CEMES, Toulouse, France (Manuscript reviewer)  
Pr. Wilfried Vandervorst, IMEC, UCL, Louvain, Belgium (Manuscript reviewer)  
Pr. Pierre Stadelmann, EPFL, Lausanne, Switzerland (Examiner)  
Dr. Jean-Luc Rouvière, CEA-INAC, Grenoble, France (Supervisor)  
Dr. David Cooper, CEA-LETI, Grenoble, France (Supervisor)
- ❖ 2007-2009: **Master of Materials Science** - Paris Diderot University (*1<sup>st</sup> rank /20 students*)
- ❖ 2004-2007: **Licence of Chemistry** - Paris Diderot University



## LANGUAGES

|                |               |
|----------------|---------------|
| <b>French</b>  | Mother tongue |
| <b>English</b> | Fluent        |
| <b>Spanish</b> | Basic         |



## SKILLS

|                         |                                    |
|-------------------------|------------------------------------|
| <b>Characterization</b> | TEM, FIB/SEM, AFM, FTIR            |
| <b>Softwares</b>        | Office, Digital Micrograph, COMSOL |
| <b>Programming</b>      | C/C++, Latex                       |



## PUBLICATIONS

- ❖ N B Selvaraj, M Fernandes, I M Reaney, J CC Abrantes, **T Denneulin**, E Snoeck, P Maria Vilarinho, A Maria Senos, "Linking sintering stresses to nano modification in the microstructure of BaLa<sub>4</sub>Ti<sub>4</sub>O<sub>15</sub> by transmission electron microscopy" *Materials Characterization* 142, 1-8 (2018)
- ❖ NN Ledentsov, VA Shchukin, Yu M Shernyakov, MM Kulagina, AS Payusov, N Yu Gordeev, MV Maximov, AE Zhukov, **T Denneulin**, N Cherkashin, "Room-temperature yellow-orange (In, Ga, Al) P–GaP laser diodes grown on (n11) GaAs substrates" *Optics Express* 26, 13985-13994 (2018)
- ❖ **T Denneulin**, N Wollschläger, AS Everhardt, S Farokhipoor, B Noheda, E Snoeck, M Hÿtch, "Local deformation gradients in epitaxial Pb(Zr<sub>0.2</sub>Ti<sub>0.8</sub>)O<sub>3</sub> layers investigated by transmission electron microscopy" *Journal of Physics: Condensed Matter* 30, 215701 (2018)
- ❖ N von den Driesch, D Stange, D Rainko, I Povstugar, P Zaumseil, G Capellini, T Schröder, **T Denneulin**, Z Ikonik, J-M Hartmann, H Sigg, S Mantl, D Grützmacher, D Buca, "Advanced GeSn/SiGeSn Group IV Heterostructure Lasers, "Advanced GeSn/SiGeSn group IV heterostructure lasers" *Advanced Science* 5, 1700955 (2018)
- ❖ N Cherkashin, **T Denneulin**, M J Hÿtch, "Electron microscopy by specimen design: application to strain measurements" *Scientific Reports* 7, 12394 (2017)
- ❖ **T Denneulin**, W Maeng, C-B Eom, M Hÿtch, "Lattice reorientation in tetragonal PMN-PT thin film induced by sample thinning for transmission electron microscopy" *Journal of Applied Physics* 121, 055302 (2017)
- ❖ **T Denneulin**, M Hÿtch, "Four-wave dark-field electron holography for imaging strain field" *Journal of Physics D: Applied Physics* 49, 244003 (2016)
- ❖ F Röder, F Houdellier, **T Denneulin**, E Snoeck, M Hÿtch, "Realization of a tilted reference wave for electron holography by means of a condenser biprism" *Ultramicroscopy* 161, 23-40 (2016)
- ❖ **T Denneulin**, F Houdellier, M Hÿtch, "Differential phase-contrast dark-field electron holography for strain mapping" *Ultramicroscopy* 160, 98-109 (2016)
- ❖ D Cooper, **T Denneulin**, N Bernier, A Béch , JL Rouvi re, "Strain mapping of semiconductor specimens with nm-scale resolution in a transmission electron microscope" *Micron* 80, 145-165 (2015)
- ❖ **T Denneulin**, D Cooper, JL Rouvi re, "Practical aspects of strain measurement in thin SiGe layers by (004) dark-field electron holography in Lorentz mode" *Micron* 62, 52-65 (2014)
- ❖ F. Glowacki, C Le Royer, Y Morand, J-M P dini, **T Denneulin**, D Cooper, J-P Barnes, P Nguyen, D Rouchon, J-M Hartmann, O Gourhant, E Baylac, Y Campidelli, D Barge, O Bonnin, W Schwarzenbach, "Ultrathin (5 nm) SiGe-On-Insulator with high compressive strain (–2 GPa): From fabrication (Ge enrichment process) to in-depth characterizations" *Solid State Electronics* 97, 82-87 (2014)
- ❖ JL Rouvi re, A B ch , Y Martin, **T Denneulin**, D Cooper, "Improved strain precision with high spatial resolution using nanobeam precession electron diffraction" *Applied Physics Letters* 103, 241913 (2013)
- ❖ **T Denneulin**, JL Rouvi re, JM Hartmann, D Cooper, "The addition of strain in uniaxially strained transistors by both SiN contact etch stop layers and recessed SiGe sources and drains" *Journal of Applied Physics* 112, 094314 (2012)
- ❖ D Cooper, **T Denneulin**, M Py, JP Barnes, L Hutin, C Le Royer, A B ch , JL Rouvi re, "Strain mapping with nm-scale resolution for the silicon-on-insulator generation of semiconductor devices by advanced electron microscopy" *Journal of Applied Physics* 112, 124505 (2012)
- ❖ **T Denneulin**, JL Rouvi re, A B ch , M Py, JP Barnes, N Rochat, JM Hartmann, D Cooper, "The reduction of the substitutional C content in annealed Si/SiGeC superlattices studied by dark-field electron holography" *Semiconductor Science and Technology* 26, 125010 (2011)
- ❖ M Py, JP Barnes, P Rivallin, A Pakfar, **T Denneulin**, D Cooper, JM Hartmann, "Characterization and modeling of structural properties of SiGe/Si superlattices upon annealing" *Journal of Applied Physics* 110, 044510 (2011)

## CONFERENCES



- ❖ **Electron holography workshop (2018) - Berlin**  
Oral: "Strain measurement in ferroelectric thin films using off-axis dark-field electron holography"
- ❖ **GRK Symposium (2017) - Erlangen**  
Oral: "Observation of domain switching mechanisms in ferroelectric thin films using in situ biasing in a TEM"

- ❖ **Colloque National du GDR Oxyfun (2017) - Toulouse**  
*Oral:* “Observation of ferroelectric domain switching mechanisms using in-situ biasing in a TEM”
- ❖ **European Microscopy Congress (2016) - Lyon**  
*Invited oral:* “Electron interferometry techniques for strain analysis using a multi-biprism microscope”  
*Poster:* “Deformation measurement and in-situ biasing of piezoelectric thin films in a TEM”
- ❖ **Colloque National du GDR Oxyfun (2016) - Autrans**  
*Oral:* “Deformation measurement and in-situ biasing of piezoelectric thin films in a TEM”
- ❖ **Joint Workshop GDRi Mecano and GDR Oxyfun (2015) - Louvain-la-Neuve**  
*Oral:* “Structural characterization of piezoelectric materials by transmission electron microscopy”
- ❖ **International Microscopy Congress (2014) - Prague**  
*Oral:* “Strain analysis of PZT thin films by aberration-corrected HRTEM and dark-field electron holography”  
*Poster:* “Projector lens and CCD camera distortions in a Hitachi HF-3300 TEM”
- ❖ **European Microscopy Congress (2012) - Manchester**  
*Poster:* “Practical aspects of strain measurement in thin layers by dark-field electron holography”  
*Poster:* “Strain measurement in uniaxially strained devices by dark-field electron holography”
- ❖ **Electron holography workshop (2011) - Toulouse**  
*Oral:* “Dark-field electron holography applied to Si/SiGe and Si/SiGeC superlattices”
- ❖ **Microscopy of Semiconducting Materials XVII (2011) - Cambridge**  
*Poster:* “Evaluation of the substitutional carbon content in annealed Si/SiGeC superlattices by dark-field electron holography”, Student prize for the best presentation (Proceeding: [J. Phys.: Conf. Ser. 326 012024](#))
- ❖ **Frontiers of Characterization and Metrology for Nanoelectronics (2011) - Grenoble**  
 “Annealed Si/SiGeC Superlattices Studied by Dark-Field Electron Holography, ToF-SIMS and Infrared Spectroscopy” (Proceeding: [AIP Conf. Proc. 1395 105-10](#))



## TEACHING

- Optics practical works - INSA Toulouse engineering school (2015) - 15H
  - ↳ Supervision of students for the construction of an optical microscope using an optical bench.
- Introduction to image analysis - Summer school on functional oxides, Carry-le-Rouet (2016) - 6H
  - ↳ Introduction to ImageJ, Digital Micrograph and geometrical phase analysis (GPA)