## PERSONAL INFORMATION

Laboratory of Semiconductor Materials, director
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## EMPLOYMENT HISTORY

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|---|---|
| **2019=** | **Full Professor,** EPFL |
| **2018=** | **Co-affiliation** with the Institute of Physics, School of Basic Sciences, EPFL |
| **2014=** | **Associate Professor,** EPFL |
| **2008-2014** | **Assistant Professor Tenure Track,** Institut des Matériaux, Ecole PolytechniqueFédérale de Lausanne, Switzerland |
| **2005-2010** | **Team Leader** at 'Walter Schottky Institut' (WSI), Technische Universität München, Germany, on leave from 'Centre National de la Recherche Scientifique' (CNRS, France) |
| **2004-2005** | **Visiting Scientist** at the California Institute of Technology, Pasadena, USA, on leave from CNRS |
| | **Senior Scientist and co-founder** of Aonex Technologies (a startup company for large area layer transfer of InP and Ge on foreign substrates for the main application of multi- junction solar cells) |
| **2003** | **Permanent Research Fellow** at CNRS, Ecole Polytechnique, France |
| **2001-2002** | **Postdoctoral Scholar** at the California Institute of Technology, Pasadena, USA<br>Group leader: Professor Harry A. Atwater |
| **1998-2001** | **PhD Student** at Ecole Polytechnique, Palaiseau, France |

## CURRENT INSTITUTIONAL RESPONSIBILITIES

**@EPFL :** Associate Vice-president for Centers and Platforms, Co-lead Advanced Science Building project.

**Board memberships on behalf of EPFL:** Energy Center, Initiative for Media Innovation, International Risk Governance Center, Center for Biomedical Imaging, Institute of Translational Molecular Imaging, Climact Center, Space Innovation (board of directors), GESDA Open Quantum Institute, Swiss Quantum Commission of SCNAT.

**OUSTIDE EPFL, SNSF:** president of the Specialized Committee for International cooperation (FA IZ), member of Division IV, member of the Advanced Postdoc Mobility Grant commission.

## EDUCATION

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|---|---|
| **2006-2009** | **Habilitation in Experimental Physics,** TU München, Munich, Germany |
| **1998-2001** | **PhD in Materials Science**, Ecole Polytechnique, Palaiseau, France<br>Advisor: Pere Roca i Cabarrocas |
| **1997-1998** | **Diplôme d'Etudes Approfondis** (D.E.A.) in Materials Science, Université Paris XI, France -the D.E.A. is the French equivalent to the PhD program courses- |
| **1993-1997** | **Diploma in Physics** -4 year bachelor- at Universitat de Barcelona, Spain |

## CONTINUING EDUCATION

**2022: IMD**, Advanced Academic Leadership program of the ETH Domain (8 full days in presence)

**2020: Oxford Said Business School**, Oxford Executive Leadership (8 week program, online)

## ONGOING FUNDED RESEARCH PROJECTS AS LEADING INVESTIGATOR

| | |
|---|---|
| **2023-25** | Innosuisse 'High temporal and spatial resolution electron microscopy in a scanning electron microscope using in-column light injection' |
| **2022-27** | Horizon Europe Pathfinder: 'SOLARUP: Advanced Strategies for Development of Sustainable Semiconductors for Scalable Solar Cell Applications' |
| **2022-25** | Max Planck Graduate Center for Quantum Materials funding |
| **2021-25** | SNSF: 'Optoelectronic functionality of hybrid III/V TMD stacks' |
| **2021-24** | NCCR-SPIN: Spin Qubits in Silicon |

## SUPERVISED PHD THESES, IMPORTANT CONTRIBUTIONS TO THE CAREER OF SCIENTISTS

**Current PhD students: L.** Webb (1st year), R.l Lemerle (1st year), S. Marinoni (1st year), T. Hagger (2nd year), A. Tiede (2nd year), C. Blaga (3rd year), M. Zendrini (3rd year), D. Dede (4th year), S. Ramanandan (4th year)

**PhD supervision:** 31 PhD students defended their thesis since my arrival at EPFL in 2008. Among them, 10 are female, 5 remain in academia and 2 work in the administration of academic institutions.
**Awards obtained by the PhD students:** Hans-Eggenberger award (S. Escobar-Steinvall), top 7% EDMX thesis (M. Friedl), Wasserman Prize (F.Podjaski), Chorafas Prize (H.Potts), Encouragement of Research in IUMRS-International Conference on Advanced Materials (M.Friedl) and numerous best poster prizes at international conferences.

## CURRENT TEACHING ACTIVITIES

- BA5 Materials Science and Engineering, Functional properties of materials, 2ECTS.
- Supervision of various semester projects and master theses.

## CURRENT MEMBERSHIPS IN BOARDS, PANELS, REVIEWING ACTIVITY

- **Journal related activities**: Advisory board member and editor of Nanoscale Horizons, Royal Society of Chemistry; Editorial Board IOP Quantum Materials, Editorial Board of IOP Nanotechnology; Editorial board of ACS-Photonics.
- **Board:** IRIS Switzerland, EPFL-WISH Foundation.
- **Scientific advisory board:** ICFO (Barcelona, Spain), e-conversion (Munich, Germany), GESDA Open Quantum Institute (Switzerland), COST Action OPERA CA- 20116 (EU)
- **Nobel Sustainability award pre-selection committee** (2023)
- **Consell per a la Recerca i la Innovació de Catalunya, Generalitat de Catalunya (CORICAT)** (Advisory board for Research and Innovation of the Catalan Government, >Fall 2023
- **Max Planck Graduate Center for Quantum Materials**: member.

## ACTIVE MEMBERSHIPS IN SCIENTIFIC SOCIETIES, FELLOWSHIPS IN RENOWNED ACADEMIES (CURRENT)

- Materials Research Society, Royal Society of Chemistry, IEEE, American Chemical Society.

## ORGANIZATION OF CONFERENCES

- Latsis symposium on Earth Abundant materials for Photovoltaics, co-organized with Dr. M. Dimitrievska, SeeFuturePV, Lausanne, June 2022.
- Organization of numerous symposia at Materials Research Society meetings, one Nanowire Growth workshop, one symposium IEEE in Photonics.
- Steering committee of the Nanowire growth workshop/Nanowire week (since 2008).

## PRIZES, FELLOWSHIPS, DISTINGUISHED MEMBERSHIPS

**2020** **Polysphère STI**, best teaching award from the students at the Faculty of Engineering at EPFL.
**2020** **Royal Society of Chemistry membership**
**2015** **European Physical Society Emy Noether Distinction**
**2015** **SNF Back-up schemes Consolidator Grant**
**2013** **Ambassador of the Technical University of Munich**
**2012** **Rodolphe et Rene Haeny Prize**, for ‘the strong commitment in innovating and promoting the Materials Science and Engineering Seminar Series of the Institute of Materials of EPFL’, shared with Prof. H. Frauenrath.
**2012** Invited to attend and present a poster at the **156$^{th}$ Nobel Workshop on Nanoscale Energy Converters**, Örenäs Castle (Sweden)
**2010** **Invited Fellow Institute of Advanced Studies**, Technical University of Munich
**2009** **European Research Council Starting Grant**
**2008** Selected to attend the **58$^{th}$ Nobel Laureate Meeting, Lindau** (550 young researchers selected out of 20 000 proposed by the respective host institutions)
**2006** **Marie Curie Excellence Grant**, granted on September 2006
**2001** PhD from Ecole Polytechnique obtained with the highest Honors *Très honorable, avec les félicitations du jury*.
**1999** Doctoral Fellowship of the French Research Ministry, given to the top 4/40 Master students

## ACADEMIC CAREER BREAKS

**2010** Maternity leave (4 months)
**2004- 2005** Co-starting of the company Aonex Technologies (11 months)

## LANGUAGES

Catalan, Spanish, English, French German (the latter two spoken at home).

## ACADEMIC ACHIEVEMENTS

My research activity aims at pushing the frontier of nanoscale semiconductor processing with a view to impact quantum technology and proposing novel solutions towards sustainable energy harvesting. Our approach incorporates the basic tenets of materials science and engineering, namely relating synthesis, structure and properties or function of materials. The following publication portfolio represents our latest important achievements in the areas of growth, characterization of functional properties and devices; these are three capital aspects of my research. The number of citations is provided, as found in google scholar.

**1. Ordered and size-tailored high purity GaAs nanowires on silicon, surpassing classical limits in photovoltaic energy conversion:** C. Colombo et al Phys. Rev. B. 77, 155326 (2008) 505 citations ; J. Vukajlovik-Plestina et al Nature Comm. 10. 869 (2019), 82 citations; J. Vukajlovik-Plestina et al Nano Lett. 17, 4101 (2017), 61 citations and W. Kim et al Nano Lett. 18, 49 (2018), 82 citations ; P. Krogstrup et al, Nature Photon. 7, 306 (2013), 906 citations.

Nanowires are filamentary crystals with a tailored diameter ranging from the few to 100 nm. Their morphology and reduced size result in plentiful advantages in a large variety of applications ranging from photonics to biotechnology. Nanowires are most commonly obtained by the use of gold nanoparticles that pose serious issues in terms of contamination, limiting its application in semiconductor technology. Together with my group we invented a new process to avoid the use of gold and mastered the synthesis in exquisite manner, providing a path to engineer size, shape and crystal structure along the nanowire (see figure on the right). We also demonstrated how this can be used to integrate advanced semiconductors (such as GaAs) on the silicon platform, commonly used for commercial electronics. This advancement has necessitated the fundamental understanding at the microscopic scale on the initial stages of growth.

Thanks to these advancements we could demonstrate the principal advantage of nanowires for photovoltaic applications. In particular, we established for the first time that the diameter can be tailored to maximize light absorption and minimize material use. In particular, the effects maximizing light absorption can be used to increase the photovoltaic efficiency beyond the classical limits.

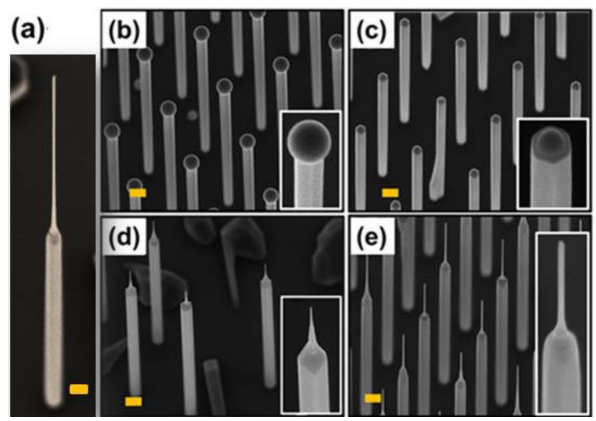

**Figure 1.** Scanning electron micrograph of ordered GaAs nanowire and nanoneedle arrays obtained on silicon, demonstrating the full tailoring of the arrangement and size down to quantum confinement limit. Scale: 100nm

**2. Novel nanowire networks scalable for on-chip topological or spin qubit quantum computing schemes.** M. Friedl, et al Nano Lett.18, 2666 (2018), 125citations; M. Friedl et al, Nano Lett. 20, 3577 (2020) 21 citations ; S. Ramanandan et al Nano Lett. 22, 4269 (2022) 7 citations

Recently, initial milestones have been reached in the area of quantum computing with solid state devices. Several groups have claimed the observation of the so-called Majorana fermions (MFs) within a semiconductor nanowire (NW) system. These discoveries are particularly exciting because if quantum computing can be achieved with MFs, theory tells us that the resulting qubits would be particularly robust against noise which is one of the main reasons why qubits today are limited to operating around 100 millikelvin. Having seen experimental signs of MFs in III-V NWs, researchers are already turning their focus to the next step which is to manipulate these MFs to carry out basic quantum calculations with them. Beyond the fundamental material science challenge of building high-quality branched III-V NWs with pristine interfaces and contacts, the currently-used fabrication methods are quite difficult to scale.

We demonstrated a novel and scalable approach to create InAs and InGaAs NW networks on a chip, ready to be contacted and interfaced in a functional device. These nanowire structures exhibit 1D carrier confinement and coherent electron transport. By applying a modulation doping scheme, we have increased the electron mean free path by two orders of magnitude. The results are exciting to the greater scientific community because it is the first time, to our knowledge, that high-quality branched III-V nanowire structures have been grown using a wafer-scalable approach.

This work has paved the way towards other kinds of quantum computing platforms. In particular, we have applied a similar principle to obtain Ge nanowire networks, for the generation of hole spin qubits.

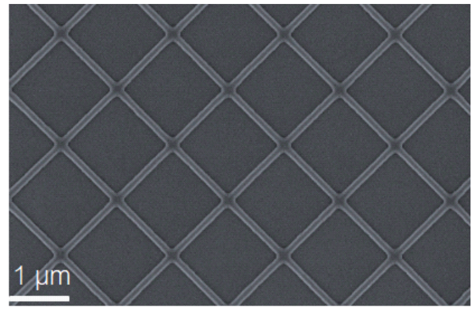


**Figure 2.** Scanning electron micrograph of a set of GaAs nanoscale nanowires able to host an InAs nanowire on top. We have extended this same principle to other semiconductors such as Germanium for spin qubits.

**3. Epitaxial growth of a new earth-abundant semiconductor and demonstration of a 4.4% efficient solar cell.** S. Escobar-Steinvall et al, Nanoscale Advances 3, 326 (2021), 16 citations; R. Paul et al. Crystal Growth & Design 20, 3816 (2020) 33 citations; S. Escobar-Steinvall et al. Nanoscale Horizons 5 (2), 274 (2020) 23 citations, R. Paul et al Sol. Ener. Mater. & Sol. Cells 256, 112349 (2023)1 citation.

Large-scale deployment of solar cells can only be achieved by using materials made of earth-abundant elements. Among the direct-bandgap earth abundant absorbers, zinc phosphide exhibits the highest potential and has been largely unexplored. In our group we tackled from scratch its synthesis. We have demonstrated three different paths to fabricate high quality zinc phosphide, circumventing all challenges due to the mismatch of its structure and coefficient of thermal expansion to any available commercial substrate. The solutions proposed are translatable to other systems and thus applicable to 'materials discovery' approaches.

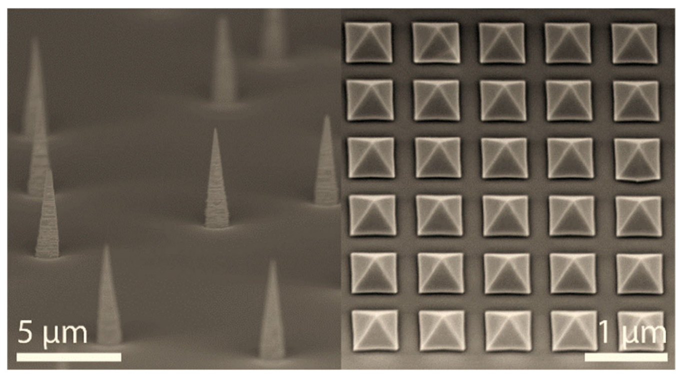


**Figure 3.** Tilted SEM micrograph of two examples of high quality $Zn_3P_2$ structures: nanowires (left) and micropyramids (right).

In all discovered pathways we could achieve a high degree of control on the structure, composition and functionality of $Zn_3P_2$. We also demonstrated a photovoltaic device combining $Zn_3P_2$ with InP with a 4,4% conversion efficiency as well as a path for further improvement.