

Doctoral project

Automation of the characterization of crystalline defects using Scanning Electron Microscopy (SEM): application for the GaN industry.

– Contrast modeling and computer vision for characterization of microstructural defects –

Description of the doctoral work:

The doctoral researcher will be a part of the local team for the HORIZON project AddMorePower (Advanced modeling and characterization for power semiconductor materials and technologies), which is funded up to 6 M€ over 48 months by the European Commission.

The goal of AddMorePower is to advance x-ray and electron probe related characterization techniques, making them quantitative and automated tools for the power semiconductor industry. Additionally, the project aims to refine modeling and data management methods to enhance and efficiently use characterization data. This will promote the integration and development of European power semiconductor technologies, allowing for a broader and faster market penetration, while also providing new opportunities for other industries that rely on mono- and poly-crystalline materials.

Scanning Electron Microscopy (SEM) can generally be used to characterize microstructural defects in crystalline materials. Electron Channeling Contrast Imaging (ECCI) allows for the direct observation of crystal defects, such as dislocations in the subsurface (approximately 100 nm deep) of bulk materials [1]. This emerging SEM technique has the potential to identify contrast changes at the surface using specific crystallographic orientation rules and use them to characterize defects in a non-destructive way [2,3]. However, it is not yet explored for power electronics materials. The ambition is to make ECCI a robust and non-destructive probe for crystal defects in semiconductors. To achieve this, a combination of known electron imaging conditions with machine learning/computer vision-based indexing of defects and comparison with simulated data is the goal. Subsequently, an automated procedure assisted by machine learning-based image processing combined with dynamical simulations of electron channeling contrast and Discrete Dislocation Dynamics (DDD) [4] is envisioned to open new routes for the day-to-day use of ECCI in industry.

- [1] H. Kriaa, A. Guitton, N. Maloufi; SCIENTIFIC REPORTS, 2017 (9742)
- [2] H. Kriaa, A. Guitton, N. Maloufi; MATERIALS, 2019, 12 (10), 1587
- [3] H. Kriaa, A. Guitton, N. Maloufi; MATERIALS, 2021, 14 (7), 1696
- [4] A.A. Kohnert, H. Tummala, R.A. Lebensohn, C.N. Tomé, and L. Capolungo; SCRIPTA MATERIA, 2020,

Your skills

The following qualifications are required:

- Excellent knowledge in materials science and physics, including electron microscopy.
- Experience with computation languages such as Python or MatLab for modeling or simulations.

The following qualifications are beneficial:

- Experience in characterization of microstructures using electron microscopy.
- Experience in computer vision.

We offer

A 36-month full-time doctoral contract is available, starting ideally on September 1, 2023, but with flexibility to start earlier, including health coverage and paid holidays. The position offers a dynamic international environment and close supervision by senior scientists. The opportunity to develop numerical skills such as modeling, computer vision, etc. is available to foster a career in academia or industry. The gross salary for the position is approximately 2534 €/month¹.

The doctoral school:

As PhD student, you will be registered at the Université de Lorraine and will be part of the C2MP (*Chimie, Mécanique, Matériaux, Physique*: Chemistry, Mechanics, Materials, Physics) doctoral school. You will have the opportunity to benefit from a wide range of training programs during your PhD.

¹ The median gross salary in France is 2500 €/month (source: French Ministry of Employment, <https://code.travail.gouv.fr/outils/simulateur-embauche>).

The local team of AddMorePower includes:

- **Dr. Antoine GUITTON (local team leader)**, associate professor HdR, expert in microscopy and materials plasticity. [www.antoine-guitton.fr]
- **Dr. Vincent TAUPIN**, CNRS research scientist HdR, expert in continuum modeling of materials mechanics.
- **Dr. Julien GUYON**, research engineer, expert in SEM and development of cutting-edge techniques

Additionally, the team **includes another doctoral researcher** and **one postdoctoral researcher**, as well as a collaborator, Prof. Laurent CAPOLUNGO from Los Alamos National Labs, USA, and academic and/or industrial collaborators within the AddMorePower project.

Host laboratory of the doctoral researcher:

The LEM3 laboratory (*Laboratoire d'Étude des Microstructures et de Mécanique des Matériaux*: Laboratory of Study of Microstructures and Mechanics of Materials) is a joint research center of the Université de Lorraine, the French National Center for Scientific Research (CNRS), and the engineer school Arts et Métiers. LEM3 is one of the largest research institutes for the physics of materials and engineering in France. It is located in Metz, near the tripoint along the junction of France, Germany, and Luxembourg, and forms a central hub for science in Europe. Over 250 scientists from France and around the world work at LEM3 to perform world-class research in materials science, mechanics, and processes. By conducting both fundamental and applied research, researchers at LEM3 work on long-term solutions for the major challenges facing society, industry, and science.

Advantages of working at the LEM3:

As a valued member of our team, you will have access to a comprehensive social protection system in France as a foreign worker, including:

- **Universal healthcare coverage:** Universal healthcare coverage: Our comprehensive healthcare system ensures that all necessary medical treatments, including doctor visits, prescription drugs, and hospital stays, are covered with a reference reimbursement rate of around 90% on average thanks to the Alsace/Moselle local regime (compared to 70% in the other regions of France).
- **Generous annual paid leave:** Take advantage of the LEM3's generous annual leave policy, which allows you to take up to 45 days of annual leave to recharge and rejuvenate.
- **Retirement pensions:** Contribute to the French retirement system and enjoy a pension when you reach retirement age.
- **Unemployment benefits:** If you lose your job, you may be eligible for unemployment benefits to help you cover your expenses while you search for new employment.
- **Sickness benefits:** If you are ill or injured, you may be eligible for daily sickness benefits to cover your lost income.
- **Maternity, paternity, and family leave:** Take time off to care for your family and bond with your new child.
- **Professional training and development opportunities:** Take advantage of the many professional training and development opportunities available in France, to improve your skills and advance your career.
- **Free education:** Education is free in France for children up to 18 years old.
- **Personalized housing allowance:** Assistance for housing costs for low-income individuals.
- **Participation in your public transportation subscription:** 50% of your subscription fees for home-work journeys on public transportation will be supported by the Université de Lorraine.

It is important to note that the level of financial assistance provided by the state may vary depending on your income and the composition of your household.

- **Opportunity for teaching:** There may be the opportunity for you to teach at the Université de Lorraine, which includes an additional salary for this responsibility.

Application:

Please send a detailed CV, a cover letter, and transcripts of your Bachelor and master's degree to the email addresses provided in the header. Recommendation letters are not required, but please include the contact information of your references.

Applications without the requested attachments may not be considered.