Call for Proposals

No. 47 **22 July 2020**

Priority Programme "Energy Efficient Power Electronics 'GaNius'" (SPP 2312)

In May 2020, the Senate of the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) has established the Priority Programme "Energy Efficient Power Electronics 'GaNius'" (SPP 2312). The programme is designed to run for six years, structured in two three-year funding periods. The present call invites proposals for the first three-year funding period.

The worldwide transition towards sustainable energy generation is accompanied by a further significant rise of the share of electric energy. Power electronics is a key technology enabling efficient distribution, conversion, and use of these large amounts of electric energy. The remarkable progress in wide-bandgap semiconductor materials allows for power semiconductor devices reaching switching speeds an order of magnitude above the state of the art, with significantly reduced ohmic and dynamic losses, and improved thermal properties. The semiconductor material Gallium Nitride (GaN) offers options for new depths of integration and novel converter topologies. GaN-based devices and circuits therefore enable the design of highly compact and efficient power-electronic systems far beyond the present state of the art.

The programme targets group III nitrides for power electronics. It is specifically designed to fund interdisciplinary and cooperative research on novel device geometries, converter designs, converter topologies, and components for efficient power electronic systems. Combining complementary expertise is required to achieve the goals of the programme. The following research topics are addressed:

- Technology and devices: Research topics with the potential to provide significant advancement in epitaxial growth methods for materials and heterostructures as well as in the field of device processing. The goals are to improve current- and voltage-handling capabilities and to overcome limitations of the state-of-the-art technology by exploring, i.a., the enhancement of polarisation effects by introducing novel MeAlN/GaN heterostructures (Me = Sc, Cr, Yr…) and polarisation-induced bulk doping in compositionally graded structures. Further approaches may target material growth/processing strategies forming lateral pn-junctions and concepts for vertical power devices, in particular on low-cost conductive substrates or quasi-substrates. This may include (a) development of conductive nucleation layers and growth on pre-patterned templates, selective-area growth, or local activation/annealing approaches for p-doping, (b) novel 3-dimensional vertical devices and heterostructures, overcoming strain and layer thickness limitations on mismatched substrates, (c) charge balancing or field shaping structures (e.g. SJ-like), or (d) defect reduction, mobility and leakage engineering of vertical device structures (such as trench/fin devices).

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Moreover, the enhancement of on-resistance, breakdown voltage and switching properties, e.g. by employing cascode topologies or monolithic normally-on/normally-off integration or by decoupling low- and high-voltage are in focus.
Materials and devices not part of the group III nitrides (e.g. SiC or Ga2O3) are not part of the Priority Programme. Research on materials should be in a state of maturity to enable devices, converter or system designs and demonstrators within the second funding period.

- Simulation, modelling and characterisation of nitride-based power semiconductor devices, assemblies, components and circuits. This comprises experiments on, and 2- and 3-dimensional numerical simulation of electronic, electromagnetic and thermal properties including robustness and reliability, with a particular emphasis on high energy densities and high-frequency operation. Purpose of the simulations shall be feasibility studies of novel architectures, interpretation of experimental findings, optimisation of circuit and converter designs, and researching device physics. Compact models will be required for circuit simulation, including high power switching behaviour or short circuit conditions. On system level, multi-physics design of power converters targeting compactness, efficiency and reliability are addressed. Projects on modelling and simulation as well as analysis of material properties only, without a direct link to a particular device architecture or device performance, are not intended. Experimental characterisation should be either linked to new device or converter concepts.

- Converter topologies, architectures and systems for GaN-based power converters and high-frequency power amplifiers. New energy conversion topologies and architectures only feasible using GaN are in focus, e.g. topologies and architectures which will be enabled by the high switching speeds or the bidirectional nature of GaN, as well as power converters in which GaN is a game-changing factor with respect to the choice if and/or when to operate them in hard- or soft-switching mode. Multilevel and modular power converter architectures may be explored to significantly increase currents and voltages and/or mitigate EMI problems. Further research topics may include energy conversion systems where through the use of GaN, components like filters or electric machines will have specific benefits in terms of e.g. efficiency, compactness, robustness, reliability or controllability. Research on reliability could e.g. include protection of GaN devices, which can efficiently deal with the fast-switching nature of the devices, and fault-tolerant approaches which can actively handle failures.
  Among others, ideas for energy conversion systems based on GaN which could significantly advance the creation of a fully electronic-based electric grid (e-grid) and impact of the GaN-operation on the components of such grid are encouraged, also considering possible power quality challenges, as well as systems where the significant increase of the bandwidth due to the use of GaN opens new possible applications (e.g. in communication).
  New ideas in converters and systems enabled by GaN technology should be proposed, clearly indicating the novelty introduced by GaN devices. Funding of projects only addressing passive components is not intended.

In a first phase, projects are expected to focus more on introducing and advancing new concepts in the development and modelling of technology, devices and systems, aiming at highlighting the revolutionary impact of GaN on specific applications. In a second phase, the focus will shift more

and more towards the verification of the impact of the new approaches. Projects from all three research areas will have to be interlinked from the beginning in order to allow for efficient progress across the whole research chain.

The Priority Programme intends to support the academic career of young researchers and intense contact between different research teams through workshops and summer schools. It will also provide a gender equality programme and family-friendly working conditions.

Proposals must be written in English and submitted to DFG by **16 November 2020.** Please note that proposals can only be submitted via elan, DFG's electronic proposal processing system. To enter a new project within the existing Priority Programme, go to Proposal Submission – New Project/Draft Proposal – Priority Programmes and select "SPP 2312" from the current list of calls.

In preparing your proposal, please review the programme guidelines (form 50.05, section B) and follow the proposal preparation instructions (form 54.01). These forms can either be downloaded from our website or accessed through the elan portal.

Applicants must be registered in elan prior to submitting a proposal to the DFG. If you have not yet registered, please note that you must do so by **30 October 2020** to submit a proposal under this call; registration requests received after this time cannot be considered. You will normally receive confirmation of your registration by the next working day. Note that you will be asked to select the appropriate Priority Programme call during both the registration and the proposal process.

The review colloquium for the Priority Programme is planned to be held on January/February 2021. The date of this venue will be communicated through the programme website and by a notification to the applicants.

Further Information

More information on the Priority Programme is available at
www.pe.tu-berlin.de/pe/menue/dfg_spp_2312_ganius

The ELAN system can be accessed at:
https://elan.dfg.de/en

DFG forms 1.91, 50.05, 53.01 and 54.01 can be downloaded at:
www.dfg.de/formulare/1_91
www.dfg.de/formulare/50_05
www.dfg.de/formulare/53_01_elan
www.dfg.de/formulare/54_01

For scientific enquiries please contact the Priority Programme coordinator:
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