EDF-2021-MATCOMP-R: Advanced materials and structures, and critical electronics

Proposals are invited against the following topics:

EDF-2021-MATCOMP-R-RF: Advanced RF components

Budget

The Union is considering a contribution of up to EUR 40 000 000 to support proposals addressing the abovementioned topics and their associated specific challenge, scope, targeted activities and main functional requirements.

Several actions, addressing different topics, may be funded under this call.

Specific challenge

Gallium Nitride (GaN) technology is a key enabler for high-performance RF electronic components, which are the cornerstone of critical military systems like radar and electronic warfare. GaN has replaced the former Gallium Arsenide (GaAs) technology, providing higher power, bandwidth and linearity to electronic RF amplifiers. GaN technology is deemed strategic for defence systems, and only a few non-European countries worldwide master the whole supply chain needed to provide GaN components for defence applications.

Reducing size, weight,power and -cost (SWaP-C) of RF transceiver modules for phased arrays with active electronically scanned arrays (AESA) is essential for radar, electronic warfare and communication systems.

Being aware of the strategic importance of non-restricted access to GaN technology, several European countries started, more than a decade ago, a roadmap for the development of GaN technology for defence applications in Europe. This roadmap was mainly implemented under the EDA framework. Several projects addressing GaN technology for civil applications received funding under the Horizon 2020 framework. Those activitiesenabled significant steps towards a European native capacity in GaN. Despite the achieved milestones, further efforts are still needed to develop and consolidate a robust and competitive European supply chain for GaN components.

GaN-based RF transceiver modules are key enablers for modern active electronically scanned array (AESA) antennas, which are one of the essential components of high-end, state-of-the-art military RF systems used for radar or electronic warfare applications. Manufacturing GaN components with shorter gate lengths will allow both for the operation in higher frequency ranges and for shrinking of the transmit/receive modules (TRM), providing adequate RF performance with a high module integration (typically within a lambda/2-spacing). In addition, heterogeneous integration in the same package (SiP, system in package concept) with other technologies (GaAs, BiCMOS, SiGe or CMOS) will extend the functionalities of these modules and meet their SWaP-C requirements.

Scope

There are two key aspects for the building of a GaN supply chain for defence applications in Europe, both of which have been developed in parallel through the aforementioned projects.

The first is the accessibility to the material itself (GaN substrates and technologies) and the availability of the processes to manufacture the components (GaN foundries). The second is the capability to design and implement GaN-based solutions (MMIC, etc.) for real and demanding defence applications.

Following those two work strands, proposals should address firstly, the need to secure supply of epitaxial wafers with GaN-HEMT structures and the development of an improved GaN manufacturing process.

Secondly, proposals should focus on novel applications in higher frequency bands (Ku, Ka and above, provided these upper bands are progressively enabled by the new GaN manufacturing process) and maturing the applications in the lower microwave bands (pursuing higher bandwidths, TX/RX integration, efficient thermal management, etc.).

Proposals should seek complementarity to other former or ongoing projects in other EU programmes and in the EDA framework.

Targeted activities

The proposals must cover the following activities as referred in article 10.3 of the EDF Regulation:

- Activities aiming to increase interoperability and resilience, including secured production and exchange of data, to master critical defence technologies, to strengthen the security of supply or to enable the effective exploitation of results for defence products and technologies;
- Studies, such as feasibility studies to explore the feasibility of new or improved technologies, products, processes, services and solutions;
- The design of a defence product, tangible or intangible component or technology as well as the definition of the technical specifications on which such design has been developed which may include partial tests for risk reduction in an industrial or representative environment.

The proposed activities should in particular include:

- Activities to increase resilience and strengthening the security of supply of European SiC substrate and epitaxy. These are of prime importance to secure the supply chain for GaN military applications.
- Improvement of existing processing capabilities and development of new technologies for RF-devices and modules under industrial manufacturing conditions with regard to throughput, yield and costs.
- Investigations to gain a deeper understanding of physical effects limiting reliability and device degradation under military relevant operation conditions.
- Among the new emerging materials, technologies, processes and tools, the proposed activities can optionally include exploration, in the same study, of benefits of other materials in comparison to GaN on SiC, e.g. GaN on Diamond or other suitable substrates, new transistors structures and with shorter gate lengths, improved PDKs, and new methods for measurement and characterization.
- Detailed investigation of the appropriate GaN processes for the specific applications and target frequency bands in order to face related challenges in terms of achieving a

sufficiently high output power, efficiency etc. within a small device area, especially when moving up in frequency.

- The design, building and testing of GaN MMIC technological demonstrators for different frequency bands and applications with the aim to demonstrate the capacity of the new technologies in terms of power efficiency, linearity and time recovery. Investigation, design and analysis of novel structures and topologies for the MMIC design, in order to fulfil the requirements for high-end defence applications such as but not limited to AESA, EW, robust communication systems, SatCom.
- Investigation of new methods for packaging, including low cost plastic packaging and heterogeneous integration of GaN MMICs with other active technologies (BiCMOS, SiGe, CMOS, GaAs) and passive technologies (combiners, circulators, filters) in a same package. This System in Package (SiP) approach will enable a more integrated level for these devices, moving from the concept of TR module to TR channel.
- Assessment of Wafer based Level Packaging (WLP) technology applied to RF sensors SiP.
- Development of complements to make the WLP technology compliant with defence specifications for 2D and 3D integration.

Functional requirements

The activities should fulfil the following requirements:

- Coverage of a wide frequency range between 100 MHz and 100 GHz (at least from S to Ka band).
- Improvement of parameters such as output-power density, power added efficiency, power gain, noise figure and linearity. This could lead to review epitaxy definition and fundamental technology modules (for example gate, ohmic contact, passivation or other...).
- Better integration, at integrated circuit level, reducing all factor contributing to losses: for instance number of interconnection levels, low loss passives components, pad size reduction...
- Compliance of GaN technology in regards to fast switching (range of nanoseconds), fast recovery mode in case of intense RF pulse, capability to operate under modulated bias (memory effect), robustness against very high Voltage Swing Wave Ratio, modulated signal for radio usage.
- Ability to develop wideband, frequency agile multi-functional RF-modules in order to fulfil different system requirements for radar, electronic warfare and communications (e.g. in terms of bandwidth, output power etc.)
- Improvement of reliability key figure of merit. This includes the capacity of the technology to sustain a minimum operative temperature of 200°C associated to a Mean Time To Failure (MTTF) compliant of the usage defined by the applications.
- Stable performance behaviour versus long operating time.
- Robustness against environmental specific conditions (moisture for instance) taking into account integration aspects.
- Advanced packaging integration including multi dies integration, moulding encapsulation, power management, extension to millimetre wave, up or down assembly of the elementary dies, internal metallic shielding, mixed analogue to digital heterogeneous integration.

Expected impact

- To progress towards European non-dependence in GaN technology to avoid criticalities about components and electronic ITAR restrictions for defence purpose, increasing EU technological sovereignty.
- To improve the life time of the technologies by power management optimization.
- To deliver circuits meeting the needs of various military platforms: radar, electronic warfare and communications systems for land, marine and airborne applications.
- To improve the competitiveness of European Industries in this strategic technology
- To be able to deliver to the European Armed forces high-end, state-of-the-art RF military systems non subject to export restrictions.