

GraNitE: Graphene heterostructures with Nitrides for high frequency Electronics

Main area: New layered materials and heterostructures

Keywords: graphene; III-N thin films; heterostructures; high frequency vertical devices

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Abstract

The GraNitE project aims at the realization of high quality graphene (Gr) heterostructures with thin films of Nitride (III-N) semiconductors, i.e. GaN, AlN and related alloys ($\text{Al}_x\text{Ga}_{1-x}\text{N}$). These will be employed for the implementation of novel vertical devices, such as the Gr/AlGaIn/GaN Schottky diode with a gate modulated Schottky barrier for logic applications, and the Hot Electron Transistor with Gr Base for ultra-high-frequency ($f_i > 1\text{THz}$) applications. In particular, taking benefit from the wide bandgap of III-N and from the high mobility 2DEGs of Gr and AlGaIn/GaN interface, excellent $I_{\text{on}}/I_{\text{off}}$ ratios ($> 10^8$) and very low off-state currents ($I_{\text{off}} < 10^{-12}\text{A}$), i.e. very low power dissipation, are expected for such devices. Gr/III-N heterostructures will be fabricated on different kinds of substrates (Al_2O_3 , SiC, GaN and large area Si wafers) using two complementary approaches, i.e. (i) the transfer of Gr from Cu to III-N, and (ii) the direct (CVD) growth of Gr on III-N layers and the (MBE/MOCVD) growth of III-N thin films on Gr. High resolution structural and electrical characterization of the heterostructures (TEM, SPM) will be employed to understand the mechanisms of current transport at the interfaces. Multiscale process simulations will be employed to describe the growth kinetics as a function of the process parameters. Device operation will be also simulated for the design of heterostructures suitable to achieve specific functionalities. These activities are aimed to complement those of WP1 and WP4 of the Graphene Flagship (GF) core project.

The GraNitE consortium includes 2 public research institutions (CNR-IMM, Italy; CNRS-CRHEA, France), a spin-off company (TopGaN, Poland) and a large enterprise (STMicroelectronics, Italy) with wide and complementary competences both on III-N and on Gr. CNR-IMM holds large experience in the advanced processing of Nitrides for high power and high frequency devices (HEMTs technology) and of Gr for RF transistors, in the multiscale simulations and high resolution characterization (SPM, TEM). TopGaN holds know-how in the heteroepitaxial growth of high quality III-N layers on SiC and sapphire, and in the homoepitaxial growth on bulk GaN, for high power electronics and optoelectronics (LEDs). CNRS-CRHEA holds technology for III-N growth on large area Si wafers and recently developed CVD Gr growth on AlN thin films on Si. STMicroelectronics is one of the largest EU industries, with a strategic commitment in high frequency electronics and a GaN pilot line in the Catania fab. Thanks to this unique combination of expertises, the GraNitE project can give a key contribution in the development of a novel hybrid Gr/III-N technology, extending the range of potential applications both of Gr and Nitrides. Due to the potential impact in high frequency electronics and optoelectronics, the integration of Gr with III-N is currently under investigation in US, Korea and Japan. The inclusion of GraNitE activities in the framework of the GF would strengthen EU position in this research field, with substantial impacts on EU economy and society.

Consortium

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