Ga_2O_3 - an emerging semiconductor for high power and radiation resistant electronics

Proposers

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Introduction

Ga_2O_3 is an emerging semiconductor characterised by a wide bandgap of 4.9 eV, high transparency in the ultra violet and visible spectral region, and a high breakdown voltage - superior to conventional semiconductors. These characteristics make Ga_2O_3 a promising candidate for the development of high power and high temperature electronics as well as solar blind photodetectors. In addition, the high resistance of wide bandgap materials to radiation opens the way for the development of radiation hard electronics for applications in space or other radiation environments and as particle detectors. In this thesis, the PhD student will gain experience in all research steps leading from fundamental materials science to the actual device fabrication and testing. The main objectives of the work will be the synthesis of thin films of Ga_2O_3 and related compounds followed by careful characterisation of structural and optical properties. Microfabrication techniques will then be applied for doping and the deposition of electrical contacts to design Schottky diodes and radiation sensors. The effect of ionizing radiation on these devices will be tested and their potential for particle detection evaluated.

Partner 1 Specialty

The INESC-MN team has considerable expertise in semiconductor characterization, processing and microfabrication. Team members have many years of experience in studying radiation effects in wide bandgap semiconductors and recently fabricated the first particle detection device based on Ga_2O_3 micro-lamellas.

Partner 2 Specialty

The INESC-ID group will contribute with its sound knowledge on device testing and integration. The most promising radiation sensors will be combined with front-end electronics for signal amplification and shaping.

Project outline/goal

The materials and device development will follow the following steps:

i) Ga_2O_3 thin films will be grown by chemical vapour deposition and magnetron sputtering using the clean room facilities of INESC-MN. Growth parameters such as substrate material, precursor sources, growth temperature and gas flows will be optimised. Bandgap engineering by growing compounds with Al or In will be a second objective. Structural and optical characterisation of the obtained layers will assess their quality for device fabrication. The PhD student will have access to the vast infrastructure of the ion beam laboratory at the Nuclear and Technological Campus (CTN) of IST and its facilities for numerous characterisation techniques.

ii) Photolithography will be used for the lateral patterning of contact and device structures at INESC-MN. Doping of the layers will be realised by ion implantation of donor and acceptor impurities such as Sn and Mg, respectively. Schottky and ohmic contacts will be developed and optimised. Electrical characterisation and ion beam induced charge measurements will allow to establish the best surface treatment and deposition procedures.

iii) Radiation resistance of the developed devices will be investigated upon proton and gamma irradiation using the irradiation facilities at CTN. The best configurations for radiation sensing will be investigated and most promising sensors integrated into a full detector system at INESC-ID.

Student profile

Profile sought: preference, but not limited, to students with a background in physics, materials science and electrical engineering.