PROTOTYPE NIR/SWIR LARGE FORMAT ARRAY DETECTOR DEVELOPMENT

Abstract

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1 ABSTRACT

The Astronomical Large Format Array (ALFA) project, led by the European Space Agency (ESA) and involving LYNRED, CEA-LETI and CEA-IRFU, is funding a part of the development of high-performance Infrared (IR) detectors for astrophysics and science applications. The objectives of this project are to design, manufacture and characterize MCT (mercury cadmium telluride) large format arrays. Indeed, the arrays developed do have a 2048×2048 15 µm pitch pixels format, with a detection layer technology sensitive in the Short Wave Infrared (SWIR) spectral band (2.1 µm cut-off), hybridized on a Source Follower Detector (SFD) Read Out Integrated Circuit (ROIC).

The detector design was shared between CEA-LETI and LYNRED. Indeed, CEA-LETI was in charge of the MCT layer design, based on his huge heritage on this technology, especially in the SWIR region with previous developments made for ESA science research projects. In parallel, CEA-LETI and Lynred have commonly worked for years in the development of small pitches detectors, aiming to optimize both manufacturing process and detector performances. The main challenge for ALFA detection layer design was to reproduce or increase the performances already demonstrated for TV format detectors, but at a larger scale, maintaining a good operability all over the detection area.

On the other side, ROIC design was made by LYNRED, considering a huge heritage in high performance ROIC thanks to years of design at cold temperature for space applications. The challenges here were multiple: first, to demonstrate the capacity to manufacture very large formats, much larger than all the detectors already manufactured by Lynred; then, to reach extremely low noise capacity, which is the reason of the use of an SFD input stage; finally, to get various ROIC modes and functionalities, aiming to operate it in different ways.

In order to have a global performance status of the detectors, a specific packaging was developed, aiming to handle the detector properly, and to characterize it at low temperature. Likewise, specific test means were developed, with the objective to be able to receive the detector, and to characterize all its performances with a high level of precision. In total, three test benches have been developed in order to proceed to the whole set of measurements foreseen. For this project, both test means development and detectors characterization were managed by CEA-IRFU, who has a large experience in detectors characterization for science and astronomy applications.

The detector fabrication was shared between CEA-LETI, responsible of the detection layer manufacturing, and LYNRED, responsible of the ROIC manufacturing, and also of the array hybridization and integration in its packaging.

An intermediary characterization step occurred at ROIC level, aiming to verify ROIC functionality and measure its performances at room temperature and then at cold temperature. This step was very important because it allowed determining the operating points and also showed the ROIC limitations in its current version. This was a necessary step before detector performances characterization.

After several years of development, a few detectors have finally been manufactured and characterized thanks to the test means developed. The results obtained are very encouraging for a prototype phase: very good performances have been reached for the detection layers, especially for the dark current which is at a state-of-the-art level, which show that the detection layer challenge has been successful. Other performances have also been measured as the linearity, the quantum efficiency (QE) and the ROIC noise (RON), which show that both ROIC and detector are operational, and that the test means are compliant to the expectations.

As this project phase is now over, a status is done on these results and the activities which could be realized in order to reach a higher maturity level for these detectors, aiming to address science applications. In particular, ROIC design shall be improved, aiming to get both better functionality in all modes and also better noise performance.

One of the detectors manufactured will be used in the frame of Sino-French scientific SVOM mission, with the goal of gamma-ray bursts (GRB) detection in the very deep space.

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