

Characterization and possible astrophysics applications of UV sensitive SiPM devices

G. AMBROSI⁽¹⁾, B. BERTUCCI⁽¹⁾⁽²⁾, M. CAPRAI⁽¹⁾, E. FIANDRINI⁽¹⁾⁽²⁾,
M. IONICA⁽¹⁾, L. TOSTI⁽¹⁾⁽²⁾ and V. VAGELLI⁽¹⁾⁽²⁾

⁽¹⁾ INFN, Sezione di Perugia - Perugia, Italy

⁽²⁾ Dipartimento di Fisica, Università degli studi di Perugia - Perugia, Italy

received 21 April 2018

Summary. — The National Institute of Nuclear Physics (INFN) is involved in the R&D of Silicon Photomultiplier (SiPM) sensors optimized to detect near-UV (NUV) photon radiation in low-intensity photons and high-precision time measurements, in collaboration with the Bruno Kessler Foundation (FBK). The performances of $6 \times 6 \text{ mm}^2$ NUV-HD SiPMs with $30 \times 30 \mu\text{m}^2$ microcell area and the possible prospects for production and packaging of multi-sensor modules for astrophysical applications are discussed in this paper.

SiPM sensors are high performance, solid state photomultipliers with high signal amplification ($\sim 10^6$) and short rise time $o(\text{ns})$, widely used in low-intensity photon detection applications. The $6 \times 6 \text{ mm}^2$ NUV-HD (Near UltraViolet - High Density) SiPMs, produced by FBK [1], are made of 40394 $30 \times 30 \mu\text{m}^2$ microcells with a fill factor of $\sim 76\%$. They were tested in the laboratories of INFN to verify their performances for possible applications as Cherenkov light detectors.

The electrical characterization was made in a temperature controlled environment. The devices were characterized in current and in pulse mode. Their breakdown voltage (about 28 V) was evaluated from the dark current response as a function of the inverse bias, as reported in fig. 1(a). The current signal from the device was converted to a voltage pulse using an AdvanSiD Transimpedance Amplifier (TIA) [2] front end electronics board and read with an oscilloscope. To maximize the suppression of pile up, the dark count rate measurement was performed using the Differential Leading Edge Discrimination (DLED) [3] technique.

The devices show a low breakdown drift in temperature ($< 30 \text{ mV}/^\circ\text{C}$, fig. 1(a)) and the maximum of the PDE in Near-UV region ($\sim 50\%$ at $\sim 350 \text{ nm}$, fig. 1(b)). Furthermore, the SiPMs perform a low dark count rate ($< 100 \text{ kHz}/\text{mm}^2$ at a temperature lower than 25°C , fig. 1(c)) and high gain ($\sim 2 \times 10^6$ at 20°C , fig. 1(d)). These features confirm that these devices may be excellent light detectors to equip the focal planes of telescopes for ground based Imaging Air Cherenkov Telescopes (IACT) arrays.

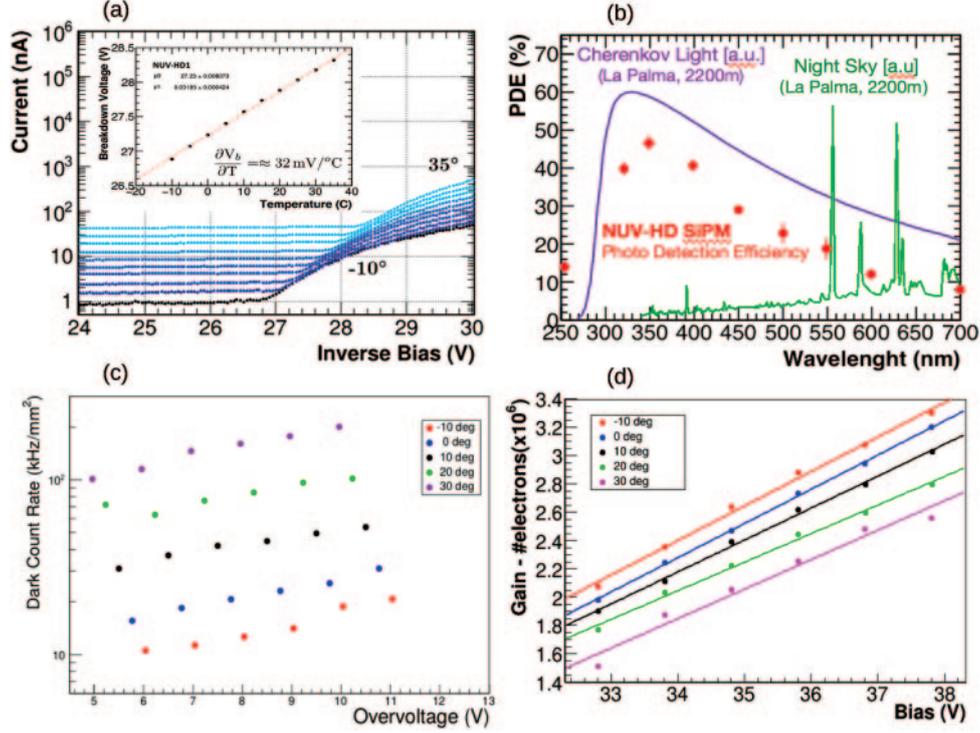


Fig. 1. – (a) Dark current measured at different temperatures as a function of applied bias; in the inset: temperature dependence for the breakdown voltage; (b) Photon Detection Efficiency (red) as a function of wavelength, estimated Cherenkov signal spectra (purple) and background spectra (green) in La Palma site [4]; (c) dark count rate at different values of overvoltages and temperatures; (d) bias voltage dependence for the SiPM gain for several temperatures.

INFN is currently developing the concept, mechanics and electronics for the focal plane camera to equip a Schwarzschild-Couder Telescope prototype. The procedures for packaging multiple SiPMs on modules are being developed for the assembling, test and commissioning of the prototype. Further details are available in [5] and [6].

* * *

The authors acknowledge the support received from *Progetto Premiale TECHE.it*.

REFERENCES

- [1] www.fbk.eu.
- [2] <http://advansid.com/>.
- [3] GOLA A. *et al.*, *IEEE Trans. Nucl. Sci.*, **59** (2012) 358.
- [4] BENN R. C. *et al.*, *New Astron. Rev.*, **12** (1998) 503.
- [5] VAGELLI V., these proceedings.
- [6] TOSTI L., *Disegno e caratterizzazione di un dimostratore di camera a SiPM per il piano focale dei telescopi dell'osservatorio Cherenkov Telescope Array* (Master Thesis) 2016.