3.5 First Results on a Sealed Gas Photomultiplier for the Visible Light Range

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Vacuum photomultipliers have found widespread application in science and technology. However, for mechanical reasons, they cannot be constructed in flat and large area geometries, desirable in many applications in particle physics, medicine, and general fast imaging.

Gas photomultipliers (GPMT) [1], operating at atmospheric pressure, can be made with very large areas; they are sensitive to single photons and, unlike vacuum PMTs, can operate in intense magnetic fields. Large area UV-sensitive imaging photomultipliers combining CsI photocathodes and wire chambers, sensitive to single photons, have already become a standard part of Ring Imaging Cherenkov (RICH) detectors. More recent works [2] suggested the use of cascades of Gas Electron Multipliers (GEMs), introduced by Sauli [3]. GPMTs made with GEMs [2] are only a few millimeters thick, have high gain, small photon feedback, fast timing and good localization properties [4]. GPMTs with CsI photocathodes are currently operating in gas flow mode. However, bialkali photocathodes for the visible spectral range are extremely chemically reactive, in practice necessitating operation in a baked, sealed, and gettered device. The feasibility of preparation of a sealed GPMT with CsI and a 3-GEM multiplier was recently demonstrated [5].

We have built a system and developed techniques for bialkali photocathode production and their sealing in gas in an electron multiplier package. We have prepared a series of sealed bialkali gas photomultipliers with two Kapton GEMs. In the best case, the GPMT had a gain of 2×10^4 with Ar/CH_4 (95:5) at a pressure close to one atmosphere, with no ion-induced feedback (Fig. 1). A photocathode sealed in a photodiode mode, with Ar and no GEM, is now stable for more than 12 months. Gas sealed GPMTs were stable for up to 15 weeks. The highest QE obtained for a sealed device is 13%. It is consistent with expected QE loss due to backscattering of electrons from the gas and to the high temperature of the sealing, which damages the photocathode. We developed a way to suppress ion feedback by a factor of at least 10^4 with a gating electrode, albeit at the cost of introducing some dead time on a µs scale. However, the sealing process should still be improved. We have examined In/Bi as a lower temperature substitute to In/Sn. We have employed Cr/Cu-plated windows that appear to be superior to the currently used Cr/Ni/Au-plated ones. We are currently preparing 3-GEM GPMT devices in an improved package, which should have gains sufficient to detect single photons. If necessary, they will incorporate ion-gating electrodes. The new devices will incorporate 2D readout electrodes; recent investigations having shown that such multi-GEM devices can yield resolutions in the 100 µm range with a very simple delay-line readout system.

Though the results reached so far are very promising, the long-term operation of visible-light GPMTs has still to be demonstrated. Important parameters yet to be measured are the behavior at high counting rates and photocathode and GEM aging. While in the short term, bialkali photocathodes operated with Kapton GEMs seem to be stable, GEM production from UHV-compatible insulators such as glass, ceramic and silicon is being investigated.

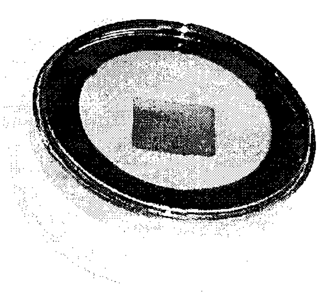

Fig. 1 An Ar/CH4 (95:5)-filled, sealed GPMT.

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Full text of the paper is available at http://www.ipj.gov.pl/~balcerzm/dowziecia/NSS2002GPMT.pdf

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