Summary of session 5: New aging effects

P. Križan[a,b]

[a]Jožef Stefan Institute, Ljubljana, Slovenia

[b]Faculty of Mathematics and Physics, University of Ljubljana, Slovenia

1. New aging effects in new detectors

Aging tests with a micro strip gas chamber (MSGC) with a gas electron multiplier (GEM) were carried out as a part of the tests of detectors for the inner tracking system of the HERA-B spectrometer [1]. The test have shown that aluminum is not suitable for an operation with neither Ar/DME nor Ar/CO_2 gas mixtures. A water admixture of 0.3% to the counting gas reduces the number of discharges in the GEM holes and at the edges of insulator, but leads to massive aging of the detector in the case of Ar/DME and Ar/CO_2 as well. The study also pointed out that the aging tests should be performed as close as possible to the real conditions. Consequently, the irradiated area of the detector should be as large as possible while the detector should be operated with a gas flow which is comparable to the final gas flow.

The aging properties of a chamber with three consecutive GEM amplification stages (triple-GEM) detectors built for the COMPASS experiment at CERN were investigated as well [2]. These low-mass detectors with an active area of 31×31 cm^2 are built with a choice of materials imposed by practical constraints, but making use of non-outgassing epoxies. Operated with Ar/CO_2 (70:30) at an effective gain of $8.5 \cdot 10^3$, one quarter of the detector area was exposed to an 8.9 keV X-ray beam. After accumulating more than 7 mC/mm^2, which corresponds to seven years of nominal operation in COMPASS, no loss of gain or degradation of energy resolution were observed. This observation confirms the results of previous measurements demonstrating the relative insensitivity of GEM detectors to aging when operated with clean Ar/CO_2. Two reasons may explain this result: the fact, that the gas amplification is localized inside the GEM holes, far from any electrodes and walls, and the small effect of possible polymerization deposits on the electric field in this region.

An aging study of a combination of a MICROMEGAS chamber and a GEM preamplification stage was performed for the first time [3]. An early sharp gain drop was observed and the voltage on both the MICROMEGAS and GEM had to be raised to restore the initial gain. This phenomenon does not appear to affect overall detector performance. The MICROMEGAS-GEM combination has an aging performance comparable to a triple GEM but with one preamplification device fewer.

A novel type of aging was observed [4] on anode wires of a rather well-known counter, the straw drift-tube. Counters with gold-plated tungsten wires were irradiated with a ^{90}Sr β-source. Three different wire diameters were employed in four different gas mixtures, Xe/CO_2/CF_4, Ar/CO_2/CF_4, Ar/CO_2/$C_2H_2F_4$, and Ar/CO_2/$C_2H_2F_4$. For the first two mixtures an increase of the anode wire diameter of a few microns (wire swelling) was observed in the center of the irradiated zone. A quite different wire swelling effect was observed for the other two gas mixtures. In this case the wire diameter stayed almost constant in the center of the irradiated zone, but along the wire toward the gas outlet deposits containing tungsten and oxygen caused an increase of the radius of up to more than one third. The authors conclude that for different gas mixtures the gas avalanche creates different types of radicals. The chemical activity of some of them is so high that they easily penetrate through the gold coating and react with the tungsten, finally causing a large amount of tungsten-oxygen compounds to form along the wire surface.

2. Aging effects in single-photon detectors for RICH counters

Single-photon counting in gas chambers is mainly used for RICH counters, where a UV photon is absorbed, and the resulting photoelectron has to be detected with a very high efficiency. Since the pulse height distribution due to the avalanche of a single primary electron is exponential, the detection efficiency depends exponentially on the gas gain and electronics threshold. As a result, single-photon counters are very sensitive to aging, in particular to deposits on the anode wires.

This is in particular true for the operation with gas mixtures where TMAE has been added as the light-sensitive gas additive. The main aging characteristics of such mixtures were already known at the time of the first workshop. Recently, more tests and cross checks were carried out to understand whether the aging properties could be substantially improved. Such a detector typically withstands an irradiation resulting in a few mC/cm of accumulated charge per wire length. The precise value depends on the gas, wire diameter, and gas system design, but remains much below the requirements at a hadron machine (e.g. in the HERA-B RICH a few hundred mC/cm).

One of the tests presented at this workshop involved a new combination of aging and test beam checks of the two HERA-B prototype TMAE chambers [5]. The observed behavior, a fast drop of gain of about 50-100%/mC/cm, followed by a slower drop of 6-20%/mC/cm in gain, is quite similar to those obtained with a 33 micron carbon wire [6,7], but was conducted up to about a factor of 4 higher accumulated charges.

Following the proposition of J. Va'vra [6,7] for in-situ heating of aged anode wires, a test chamber was constructed with a system for heating the wires with elevated currents [8]. For groups of cells, combinations of aging at 2.5 MHz photoelectron rate and heating effects were measured, and compared to the non-aged cells. The results show a sharp rise of the average pulse height as a result of one-hour heat treatments. This rise is followed by a quick fall to a value which is, however, higher than the one prior to heating. The aging then continues with a time constant more or less equal to the previous one. Although the physics and chemistry of this behavior are not fully understood, it seems that a recipe with as frequent as possible in-situ heating of the anode wires should slow down the aging process.

The long-term operational experience with large-area CsI photocathodes, produced for the ALICE HMPID prototypes, was reviewed [9] with respect to the main known aging sources: exposure to air and ion impact. A degradation of 20% in quantum efficiency was observed after exposure to air for about 1 h at a relative humidity of 50%. The consequences of the contact with high levels (larger than 1000 ppm) of O_2 are not quite clear. However, the effect was more pronounced in the case of a photocathode showing already some aging symptoms. Irradiation leading to local accumulated charge densities up to 1 mC cm^{-2} produced neither variations of the CsI QE nor detector performance instabilities. The photocathode response was found to be very stable, provided the exposure to O_2 and H_2O was limited to the ppm level.

Both a systematic study of photosensitive wire chamber based detectors and mechanisms leading to their aging were discussed in some detail in a review contribution [10]. The main conclusion from the experiments carried out within the study is that the cleanliness of the system is a decisive factor in the performance of this kind of detectors. In addition, the quality of the solid photocathode preparation seemed to be the main factor in the aging characteristics of CsI photocathodes. New experimental data were presented on aging of photosensitive vapors trimethilamine (TMA) and ethylferrocene (EF), as well as on CsI and SbCs photocathodes. The study also concluded that, as a consequence of aging, thin polymer deposits on the cathode can provoke breakdowns through the Malter-type mechanism.

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