Study of in-situ heating of aged anode wires

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In-situ anode wire heating with elevated currents has been studied as a means for elimination of polymer deposits in a methane+TMAE filled wire chamber. One hour heating of an aged wire at 200^0C results in a recovery of the initial gain, which is followed by a quick drop. However, the gain remaining after this drop is higher than its value prior to heating, so periodic heat treatments of anode wires would have a beneficial effect. Results of mass spectrometry of anode wire deposits are also presented.

1. INTRODUCTION

One of the causes for wire chamber aging are deposits on the anode wire, resulting in a decrease of the gain. This is especially pronounced in chambers using TMAE as a photosensitive additive and represents a problem for high rate and high gain operation [1–3].

A TMAE+methane filled wire chamber of the JETSET type [4], has been considered as one of the possible candidates for the photon detector of the HERA-B Ring Imaging Cherenkov counter [5]. Due to the expected high single-photon count rates, a study was undertaken of detector aging and of the possibility to recover the gain by heating the anode wires. The idea was proposed some time ago by J. Va'vra [1,2].

Below we describe the detector, its readout, the heating system and results on average single photo-electron pulse heights as a function of time for groups of wires that have been aged, not aged, heated and not heated. Data have been taken every 30 minutes over a period of 300 hours at an aging rate corresponding to 2.5 MHz of photo-electrons per anode wire.

2. EXPERIMENTAL APPARATUS

The test chamber [6,7], consisting of 8×8 cells of 8×8 mm^2 cross section and 10 cm length, was constructed from gold-plated bronze sheets, which have been slotted for assembly. A 50 μm gold-plated tungsten anode wire has been stretched along the axis of each cell and connected to the readout electronics or the heating system on the bottom end-plate and to a "diode bridge" at the quartz photon entrance window. The gas system was constructed of stainless steel tubes and valves (Whitey SS-44F6RT). After passing a fraction (40 %) of the methane carrier gas through a TMAE bubbler at room temperature, the mixture enters one row of 8 cells at the bottom, spills over the top into the adjacent cells and exits at the bottom, thus ensuring good mixing and equal flow through all the cells. The methane gas was 99.995% pure (4.5 quality) with less than 2 ppm of oxygen and less than 5 ppm of water.

The readout system consisted of specially designed, home made, charge sensitive preamplifiers with 4 mV/pC gain [8], amplifiers (EG&G ORTEC Timing amplifier 574), CAMAC discriminator (Philips Scientific 16 channel discriminator 7106), CAMAC counters (CAEN 16 channel ECL 100 MHz Scaler C257) and a CAMAC clock

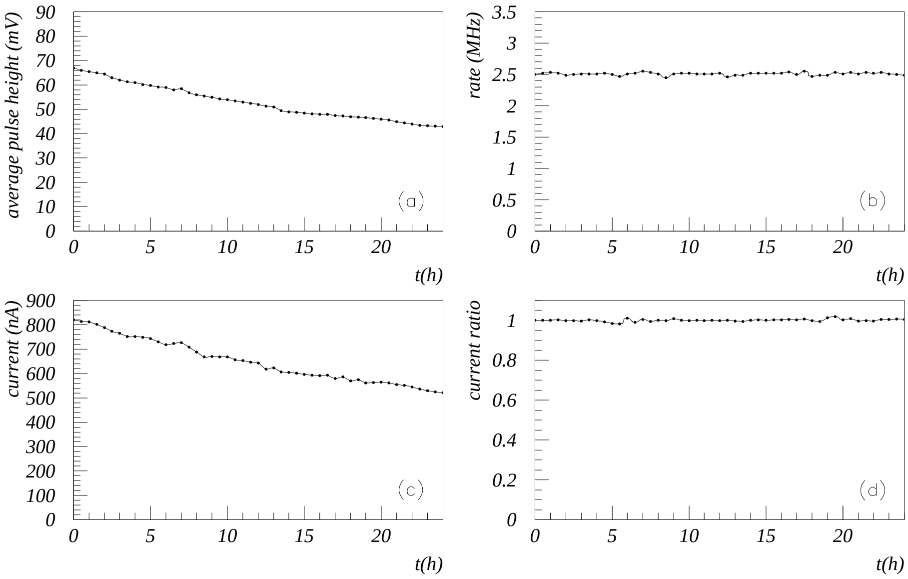

Figure 1. (a) Time dependence of average pulse height of aged cells. (b) Time dependence of the zero-threshold rate. (c) Time dependence of the total chamber current. (d) Time dependence of the normalized ratio of total chamber current to the sum of products of average pulse heights and zero-threshold rates over all cells.

(CAEN Preset counter and gate generator C423). The data taking was monitored by a personal computer using the LabView program package. The detector current was measured with a sensitive current meter (Keithley 617) during the entire experiment.

The detector was illuminated with a UV lamp in the focal plane of a spherical mirror [9], producing light rays parallel to the axis of the cells. The initial gas gain was estimated to be $2 \cdot 10^5$.

The heating system was composed of a voltage supply together with a voltmeter and ammeter in order to monitor the wire resistance and thus temperature. The value of the temperature coefficient of resistance $\alpha = 4.5 \cdot 10^{-3}$ K^{-1} was obtained from the producer [10]. The current flows up one wire, through the connecting diode and down the adjacent wire. At 3.3 V a current of 0.29 A was obtained, which corresponds to a wire temperature of 200^0C. The gas used during wire heating was pure methane.

3. MEASUREMENTS AND RESULTS

As only 16 readout channels were available, measurements were done with 16 cells divided into 4 groups of 4 cells each. The first group has been aged and heated, the second group has not been aged but has been heated nonetheless, the third group has been aged but not heated and the fourth group has neither been aged nor been heated.

During the 300 hours of aging with illumination corresponding to about 2.5 MHz of photoelectron production rate and 4-6 kHz background per cell at 2650 V on the cathodes, a measurement was performed every 30 minutes. The measurement consisted of count rates for all 16 cells as a function of threshold voltage. The threshold could be set by the computer program, allowing quick scans to be performed. The avalanche multiplication factors (gas gain) of the experiment correspond to an exponential pulse height distribution, which in turn results in an exponential dependence of the count rate versus threshold volt-

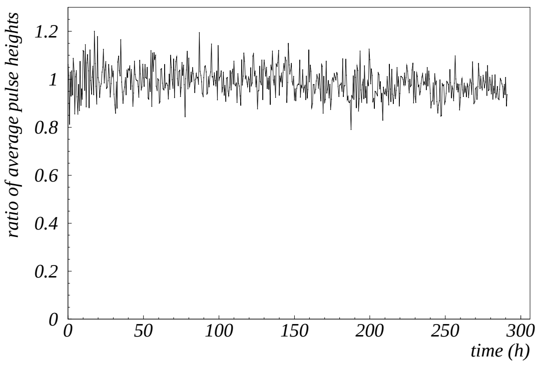

Figure 2. Ratio of average pulse heights of heated to not-heated cells that have not been aged.

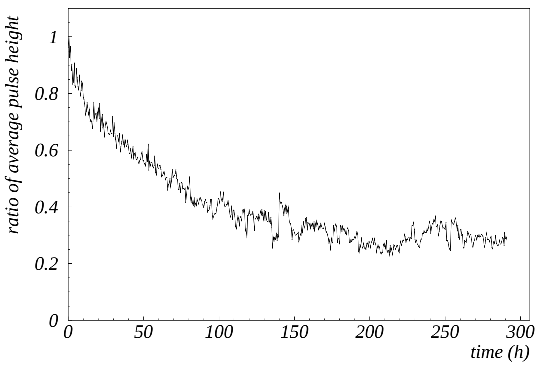

Figure 3. Ratio of average pulse heights of aged to not-aged cells that have not been heated.

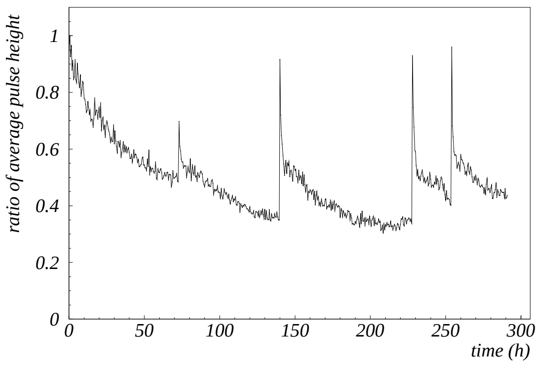

Figure 4. Ratio of average pulse heights of heated aged cells to heated not-aged cells.

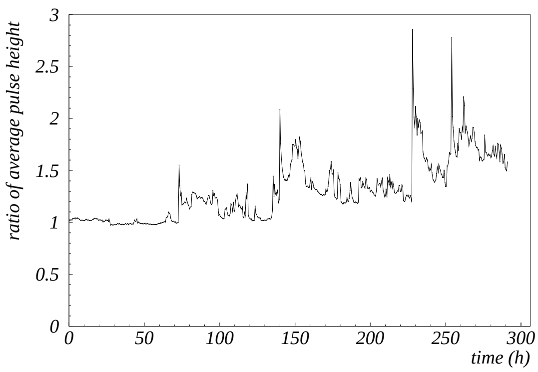

Figure 5. Ratio of average pulse heights of heated to not-heated aged cells.

age. The measured count rate extrapolated to zero threshold thus gives the photoelectron production rate, while the absolute value of the logarithmic derivative of this measured distribution is equal to the inverse of the average pulse height.

Fig. 2 shows the ratio of average pulse heights of heated to not-heated cells that have not been aged. The constancy of this ratio shows that heating does not influence not-aged cells. Fig. 3 then shows the ratio of the average pulse heights for aged to not-aged cells that have both not been heated. For the first 24 hours of measurement we show in Fig. 1 the average photoelectron production rate per cell (count rate extrapolated to zero threshold), the average pulse height (note that the average is only for the 8 aged cells), the total current from all cells and the normalized ratio of the measured current to the sum of products of photoelectron rate and average pulse height over all cells. As can be seen in Fig. 1b, the illumination has been constant during the first 24 hours, which was found to be true also for the period of the entire experiment. After 73 hours of aging, corresponding to a collected charge of 14 mC per anode wire, a 15 minute heating of 8 wires (2 groups of 4) was performed. As seen in Fig. 4, which gives the ratio of average pulse heights of heated aged to not aged cell groups, the heating produces a spike in the ratio. The next heating was performed after 140 hours of aging (24 mC per wire) and lasted for one hour. The corresponding spike in Fig. 4 reaches ~ 0.9, after which the ratio quickly drops to a value somewhat higher than the value prior to heating. The one-hour heating procedure was repeated at 228 hours (28 mC per wire) and at 254 hours (34 mC per wire). The ratio of heated to not-heated aged cell groups is given in Fig. 5. It shows that in-situ heating of the anode wires produces an increase of the average pulse height over that of not-heated cells. Consequently, it appears that by heating the anode wires, it is possible to slow down the aging process.

Finally we show in Fig. 6 the results of mass spectrometry of deposits evaporated from the anode wire at different temperatures. It is seen that at 310^0C some heavy fragments appear to be liberated from the anode wire. It would be worthwhile to examine the effect of heating at this temperature. Within the present study, this has not been performed due to possible melting of soldered wire contacts. The influence of higher gas flows on gain increase during heating has also not been systematically investigated, which might be the subject of some further work.

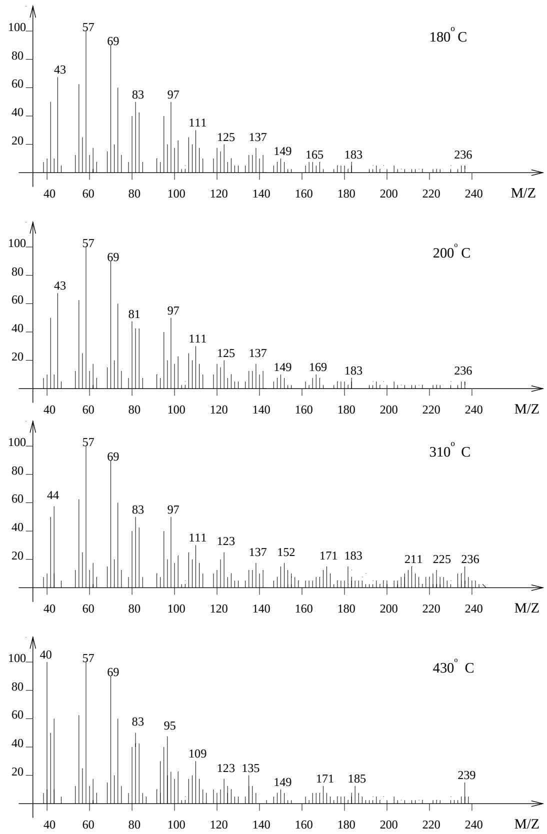

Figure 6. Results of mass spectrometry of evaporated anode wire deposits at four different temperatures to which the same wire has been consecutively heated.

4. CONCLUSIONS

Following the proposition of J. Va'vra [1,2] for in-situ heating of aged anode wires, we have constructed a test chamber with a system for heating the wires with elevated currents. The readout system allowed computer controlled quick threshold scans to be recorded giving the average pulse height as well as the photoelectron production rate. For four groups of four cells, combinations of aging at 2.5 MHz photoelectron rate and heating effects have been measured. 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 we do not understand the physics (and/or chemistry) of this behavior, we believe that a recipe with as frequent as possible in-situ heatings of the anode wires should slow down the aging process.

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