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PASSIVATION OF GAS MICROSTRIP DETECTORS AND STABILITY OF LONG TERM OPERATION

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Abstract

We have studied the long term operation of gas microstrip detectors which have been passivated with a layer of nickel oxide. We have used as the active gas CF_4/isobutane (80:20) and three different types of substrates: Tedlar, glass and Upilex. In all three cases we found that the detectors are stable after passivation and can operate for a month without changes in gain at rates of Mhz. The total accumulated charge was approximately 100 mC.

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1. Introduction

Gas microstrip detectors are a relatively new type[1] of device which have shown strong promise as tracking detectors in very high rate environments.[2,3] It has been demonstrated that they are capable of operating efficiently at high fluxes, and there are plans to use them in several large experiments in the future.

It is therefore of importance to prove their long term stability in operation, and ensure that their ageing characteristics will not detract from their designed purpose.

Several problems affect the long term stability of these detectors. The charging of the substrate (which is normally an insulator), sporadic discharges between anode and cathode produced by the high field region along the edges of the anodes and cathode strips, the interaction of the ionized gas in the avalanche area with the substrate, as well as the usual degrading processes occurring in other gaseous detectors.[4,5]

Initial measurements with Tedlar prints[4] indicated long term degradation for several different gases, and inspection of these prints with a scanning electron microscope showed clear effects of chemical interaction with the substrate near the anode edges. While attempting to solve this problem, as well as the spurious anode-cathode discharges, we found that these problems can be solved or reduced by covering the structure with a thin layer of nickel and nickel oxide applied with standard sputtering techniques. A paper dealing with a similar problem has recently been submitted.[6]

The discharges mentioned above are similar to an effect occurring in insulators used in accelerators. This effect is called "flash-over"[7] and is due to the multiplication of electrons on an insulator and is initiated by a single electron emitted by the cathode. It has been shown[8,9] that covering the insulating surface with a layer of a material with a low secondary electron emission coefficient, like CrO or NiO reduces this effect significantly. For our purpose the layer had to be very thin to allow the charges to pass through. We also found[4] that the most likely cause for the initial electron emitted by the cathode was ion impact.

Some of the results on Tedlar substrates presented here have already been shown in a previous work.[4]

In the next section we describe the three detectors used, the sputtering method and the measurements of layer thickness and composition. Then we show the results of the long runs on three different devices with the same passivation layer. Finally we summarize the results of these measurements.

2. Experimental details

We studied the properties of three different prints with substrates of Tedlar, Borosilicate glass and Upilex. Their properties are summarized in Table I. All of them were passivated by sputtering from a nickel target in an atmosphere of argon at 100 m Torr. Of main concern were the physical properties of the passivating layer. The thickness was first measured with a profilometer (Dektak IIA) on the glass print and measurements in different regions of the print indicated thicknesses of (30±10) nm. There were fluctuations from place to place of 20%. The atomic composition and thickness of the layer were measured with a beam of alpha particles of 2.5 MeV. Figure 1 shows the spectrum of backscattered alpha particles. These measurements indicate a passivated thickness of (50±15) nm and about (40 ± 20)%

of the nickel is oxidized. Also seen is a peak due to tungsten produced by the target support as well as a small peak of chromium probably produced by the stainless steel vacuum vessel. These two contaminants account for less than 10% of the total layer. The results mentioned above have also been confirmed with x-ray spectra obtained during SEM observation. The aluminum traces are 1.2 μm thick, compatible with a measurement with a profilometer done before passivation. The sheet resistance measured in the prints are shown in Table I.

Before long runs began we tested all prints for quality and resolution with an ^{55}Fe source using as the active gas argon/ethane (90:10) as well as CF_4/isobutane (80:20). In Figs. 2 and 3 we show the amplitude distribution of the pulses in the Upilex print.

All measurements of gain stability were done with CF_4/isobutane (80:20) as the active gas (at atmospheric pressure) using a gas recirculator and a flow of 100 cc/min. In all cases the drift gap was 3 mm, and the drift voltage was 1000 V. The cathodes were grounded and the anodes were at 690, 790 and 650 volts respectively for the Tedlar, glass and Upilex prints. The backplane was also grounded.

During the long runs (30 days) the detectors were exposed to a high intensity (10 mC) ^{90}Sr electron source, with a collimator of 0.5 cm^2 area. Measurements of gain were done daily . The gas also circulated through a single wire chamber with an ^{55}Fe source and the spectrum was recorded. This was used to monitor gas gain changes (of about 15%) due to variations of ambient temperature, pressure and gas concentration.

3. Results

In Figs. 4, 5 and 6 we show the variation of the gain over a 30 day period in which the detectors were operated continuously at the flux indicated in Table I. The gain remained constant in the Tedlar and glass prints while showing a small (10%) decrease in the Upilex print. Small fluctuations in gain are due to gas changes and an initial change due to some modification in the passivating layer was also observed. We believe that the Upilex gain change can be reduced with a thicker passivating layer.

The Tedlar print had one discharge in the first day of operation and the other two prints did not suffer any discharge. Inspection of the prints after the long runs showed no physical damage to the traces, with the exception of the Tedlar print which had two partial indentations in two different anodes. In previous runs under similar conditions but without passivation, we observed many indentations as well as anode traces cut due to large discharges, mostly near the cathode ends.

The total charge accumulated in the 3 prints is shown in Table I. It corresponds to the following charges per anode length: 11.2, 42.0 and 16.7 mC/cm respectively for the Tedlar, glass and Upilex prints.

4. Conclusions

We have measured the long term gain variations in three different gas microstrip detectors which have been passivated with a thin film of Ni and NiO. The results

are very encouraging and indicate a definite improvement in the stability of these detectors.

The passivating layer fulfills three different functions which are beneficial to these devices. It provides a partially conductive surface with a tunable resistivity that allows charges to drift to the conductive electrodes, thereby eliminating charge build-up effects. It reduces the probability of discharges because of the low secondary electron emission coefficient of NiO, and it reduces the chemical interaction between the substrate material and the active ions in the avalanche region near the anodes.

The sputtering process used to deposit the passivating layer is fairly easy and reproducible, but further work should be undertaken to establish better materials and optimum thicknesses.

We would like to thank D. Bryman for his comments on this paper.

References

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Table I

Substrate	Pitch (μm)	Traces	Resistivity ($\times 10^{14}$ ohms/sq.)	Gain	Flux ($\times 10^5$ Hz/cm^2)	Charge (C)
Tedlar	200	Al	4.0	780	.63	.078
Borosilicate glass	390	Al	1.1	1100	6.1	.235
Upilex	200	Au	2.1	800	3.0	.117

Figure Captions

1. The amplitude spectrum of alpha particles backscattered from the glass print at a spot with aluminum traces.
2. The amplitude spectrum of pulses from the Upilex print with a ^{55}Fe source and argon/ethane (90:10) gas.
3. The amplitude spectrum of pulses from the Upilex print with a ^{55}Fe source and CF_4/iso (80:20).
4. The pulse amplitude of the Tedlar print over a 30 day period with constant irradiation of ^{90}Sr electrons.
5. The pulse amplitude of the borosilcate glass print over a 35 day period with constant irradiation of ^{90}Sr electrons.
6. The pulse amplitude of the Upilex print over a 40 day period with constant irradiation of ^{90}Sr electons.

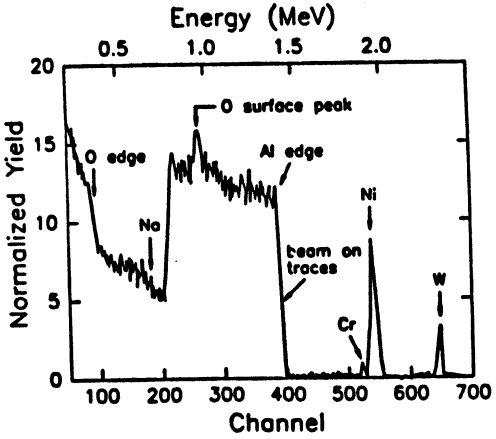

Fig. 1

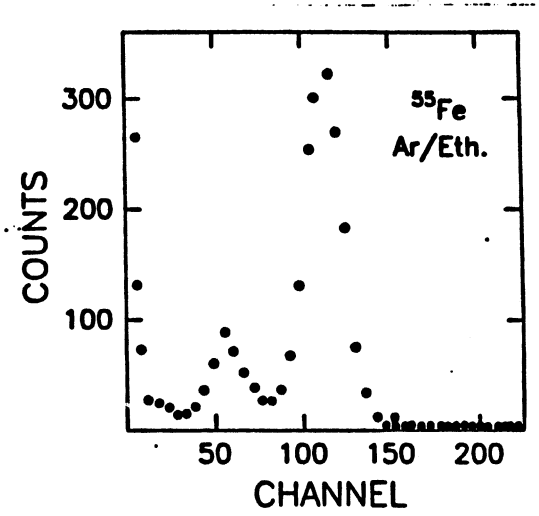

Fig. 2

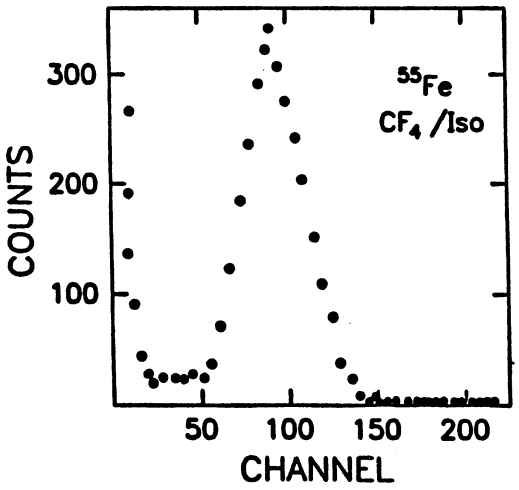

Fig. 3

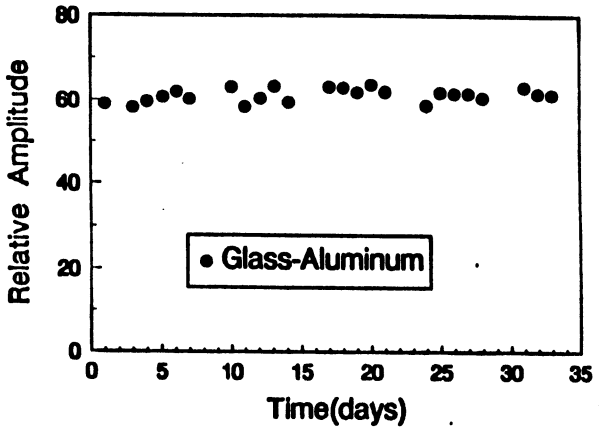

Fig. 5

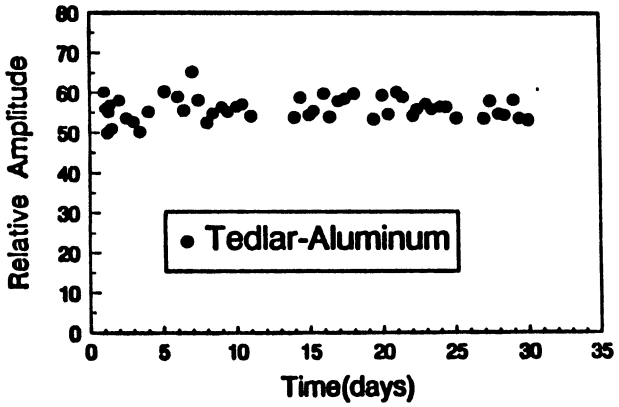

Fig. 4

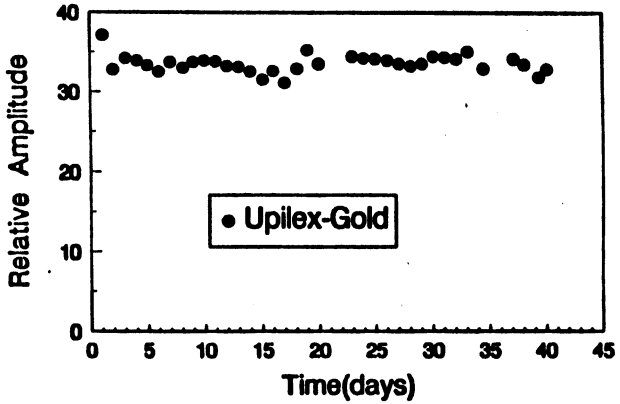

Fig. 6