EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN/PPE 90-147
CERN/LAA/MC 90-11
2 October 1990

**FIRST TESTS OF THE GASEOUS PIXEL CHAMBER
FABRICATED ON A CERMANIC SUBSTRATE(*)**

D. Mattern, M.C.S. Williams and A. Zichichi
LAA-LAD Group, CERN, Geneva, Switzerland

ABSTRACT

The excellent properties of the gaseous pixel chamber have been previously described. We present here the first results from a pixel chamber built on ceramic substrate instead of Kapton. The advantages of this construction technique will also be discussed.

Presented at the 2nd London Conference on Position-Sensitive Detectors
4-7 September 1990, London, England

(*) The work presented here is supported totally by the LAA project.

1. INTRODUCTION

The gaseous pixel chamber has been previously described [1]. Essentially it is a foil consisting of a small anode spot surrounded at some distance by a cathode plane. Fig. 1 shows a cross section of this device built on Kapton foil. The voltage is applied to the anode spot by means of a plated through hole. We mount this foil in a gas tight box, through which we flow pure isobutane. Electrons are liberated by a charged particle passing through the gas volume above the foil. These electrons undergo gas amplification approaching the anode. Finally limited streamers are formed and therefore large signals on various electrodes. We have now built a similar structure on a ceramic substrate. This paper describes the construction method and the results obtained with this ceramic structure.

2. CONSTRUCTION

Electrical circuits can be constructed on ceramic plates by printing with pastes. After each layer is printed, the plate is fired in an oven at about 900°C. Another layer can then be printed which is subsequently fired. These pastes are obtainable in either a conductive or insulating variety, thus with this technique one can build a multilayer circuit on a ceramic board. The method of printing is screen printing using a stainless steel mesh screen. Lines of 100 μm width can be achieved. One has to take care that the surface to be printed is flat, otherwise either the screen has to stretch to accommodate the different levels (which introduces distortions) or certain areas will not be printed. The device described below was built on a 800 μm thick ceramic plate [2] with pastes produced by EMCA [3]. The thickness of each layer of paste is 40 μm before firing and 12 to 14 μm after firing.

The design of the gaseous pixel chamber uses a conductive hole to connect the anode spot to the high voltage bus line. Lasers have been used to create small holes in ceramic plates but this is still in the experimental stage. Even if a hole could be created, one is still left with the problem of making the hole conductive. We have therefore chosen a different solution. This solution is: we first print a narrow ridge of dielectric material and then print a 100 μm conductive line at right angles to this ridge. Thus the conductive line goes up one side of the ridge and down the other. We then fill each side of this ridge with dielectric material. This results in having a thin anode line buried under dielectric material except at certain spots where it comes to the surface. The size of the exposed anode spot is defined by the width of the conductive line and by the width of the top of the ridge. In our case the anode is a square spot of 100 by 100 μm . We need to have the layer of dielectric covering the anode bus line as thick as possible. We thus make the dielectric ridge by printing three layers of widths 350, 275 and 100 μm successively. The anode lines can be successfully printed over this ridge. At some distance we need to put the cathode plane. Since the anode

bus line has to run beneath it, we need a certain thickness of dielectric to hold off the applied high voltage. The figure supplied by the manufacturer is > 28 volts/ μm . We have 15 layers of dielectric (a thickness of $195 \mu\text{m}$) between the anode bus and cathode, this should hold off more than 5460 volts. At a radius of 2 mm from the anode spot we start building these layers of dielectric. The cross section of a pixel is shown in fig. 2. There are a total of 22 layers.

The top view of a pixel is shown in fig. 3. One should note that there is a single bus line running to each anode spot rather than having the anodes strung together in series. The reason for this is that the surface of the dielectric just above the anode bus line needs to be charged with electrons. By having a single anode bus line, rather than two that would result from connecting them in series, reduces this charging effect. The other feature that can be seen is the shield line. The main reason for this shield line is to provide additional termination for field lines emanating from the anode bus line. This should reduce the field around the edge of the cathode just above the anode bus line and thus increase the voltage where field emission of electrons occur. However above this shield line the surface of the dielectric will need to be charged with electrons or positive ions (depending on the voltage of the shield line) and maybe this shield line adds more problems than it solves. The pixels are spaced 6 mm apart in the x direction and 10 mm apart in the y direction. The larger spacing in the y direction is to provide a ground plane to shield the anode bus line.

3. TESTS WITH ^{55}Fe SOURCE

We connected the anodes of a line of 12 pixels to a high voltage supply via a $10 \text{ M}\Omega$ resistor. We also connected the shield line to a voltage supply via a $10 \text{ M}\Omega$ resistor. We could study these two signals via 1nF decoupling capacitors. The cathode was grounded.

We installed the surface in a gas tight box through which we flowed pure isobutane. There was a thin mylar window 3 cm above the pixel surface. We irradiated the surface with a ^{55}Fe source. We could measure the average charge of the pulse with a Tektronic 2440 digital oscilloscope and the counting rate with a discriminator and scaler. Fig. 4 shows the average charge versus anode voltage. Shown for comparison on this figure are measurements performed on the Kapton foil chamber with similar geometry. The anode spot size for the Kapton foil chamber was $500 \mu\text{m}$ and $200 \mu\text{m}$, while the ceramic chamber anode spot is $100 \mu\text{m}$. It is remarkable that the gain of the ceramic chamber is so similar to the Kapton foil. The geometry of the anode is somewhat different in the two cases, as well as the thickness and type of dielectric used.

4. TESTS WITH A CHARGED PARTICLE BEAM

We constructed a chamber using a ceramic pixel plate. Facing this plate we had another board, the roof. The roof design is shown in fig. 5, it was fabricated on a G10 substrate. The cross section of the pixel chamber is shown in fig. 6. We could vary the potential of the central field shaping spot (mounted opposite to the anode). The roof grid was at ground potential.

We installed this chamber in a 6 GeV/c pion beam in the CERN East hall. We flowed pure isobutane through the chamber (some argon was added to the mixture later). We applied 500 volts to the field shaping electrode of the roof board. Fig. 7 shows the increase of efficiency for detecting through going particles as a function of the voltage across the pixel. Unfortunately we had some voltage breakdowns for voltages above 6.2 kV so that we could not reach full efficiency. Fig. 8 shows the charge distribution (as measured on the the pixel device with no additional amplification) of the cathode pulse for 3 different gas mixtures but with the same applied high voltage of 6.1 kV between the anode and cathode. It is interesting to note that there is a slow increase in the peak position of the distribution for increasing argon concentration, but a much more dramatic change in the shape of the charge distribution. The distribution of large pulses on the right of the peak is due to two (or more) pixels firing when more than one particle traverses the chamber. The efficiency for detecting particles also increases slightly with increasing argon concentration.

5. CONCLUSIONS

We have shown that a gaseous pixel chamber can be built by printing techniques on a ceramic plate. This has the important advantage that no holes need to be drilled (as with the Kapton foil). Also we can have pickup pads close to the anode spot, buried beneath the dielectric layer. We have observed large pulses induced on these electrodes. The direction of streamer growth could be found by having separate pickup pads on each side of the anode and measuring the induced charge on these two pads (this is analagous to solving the left-right ambiguity for conventional drift chambers). The layer of dielectric covering the anode bus line is very thin (35 μm). We believe that the efficiency for detection of through going particles will be increased by making this layer thicker.

The size of the anode is 100 μm^2 . This is considerably smaller than the 500 μm diameter anode used for the Kapton foil. This may possibly give a more spherical uniform electric field around the anode spot. Thus, the gas avalanche process will start at a more defined position. We, therefore, expect to obtain better spatial resolution with the ceramic device than with the Kapton foil. This is presently being investigated.

Acknowledgements

As before we have enjoyed the excellent work of the printed circuit workshop here at CERN run by Mr. Gandi. We are also very much aware that Mr. Donato who runs the 'Thick Layer' section is a master of creating ceramic structures.

REFERENCES

- [1] D. Mattern, M.C.S. Williams and A. Zichichi, CERN/EF 90-4 and submitted to Nucl. Instr. and Methods.
- [2] The ceramic board was type HA-96 NTK Substrate from Comatel, Issy Les Moulineaux, France.
- [3] The pastes used are C8300 low warp multilayer dielectric and 3264-3 Gold, these are produced by EMCA. The Grip Industrial Estate, Linton, Cambridge CB1 6NR, England.

FIGURE CAPTIONS

- Fig. 1 Cross section of gaseous pixel chamber.
- Fig. 2 Cross section of a single cell of the ceramic pixel chamber.
- Fig. 3 Top view of part of the ceramic pixel plate.
- Fig. 4 Average charge of anode signal versus anode voltage.
- Fig. 5 Design of roof board.
- Fig. 6 Cross section of pixel chamber.
- Fig. 7 Efficiency for detecting minimum ionising particles.
- Fig. 8 Charge of the cathode signal for minimum ionising particle for various gas mixtures.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8