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A STUDY OF THE PERFORMANCE OF MICROSTUCTURES IN LIQUID XENON

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Abstract—A microgap plate was tested in liquid xenon. The maximum anode voltage before discharges, 450 V, was not high enough for producing charge multiplication. Simulations of microgap and leak microstructure were done. © 1997 Elsevier Science Ltd

Liquid xenon detectors, based either on the ionisation or the scintillation (or even both), have been proposed for a very wide range of applications. Concerning ionisation, the use of liquid xenon has been somehow limited by the relatively low charge yield (8×10^4 ion pairs/MeV for minimum ionising particles) which requires low noise electronics and imposes a lower limit to the energy of the particles that can be detected. Charge multiplication was observed in liquid xenon (Derenzo *et al.*, 1974) but technical difficulties (wires with 3–5 μm diameter) prevent the development of detectors using this process.

Recently, microstrip (MS) and microgap (MG) plates were developed and have found enormous success in gaseous ionisation detectors, triggering intense investigation of new microstructures (microdot chamber, tip array and others). The availability of charge and/or light multiplication in liquid xenon with such a configuration of electrodes would also open up very interesting perspectives in the development of detectors for a wide range of applications.

We have succeeded in operating a microstrip in liquid xenon and observed a gain of the order of 10 (Policarpo *et al.*, 1995). In principle, the microgap would present advantages over the microstrip, such as the much faster collection of the ions and the absence of charge-up effect of the substrate (Angelini *et al.*, 1993). We tested a MG plate, supplied by a group of TU Delft, Netherlands (Marel, 1997), which is schematically depicted in Fig. 1. The drift electrode,

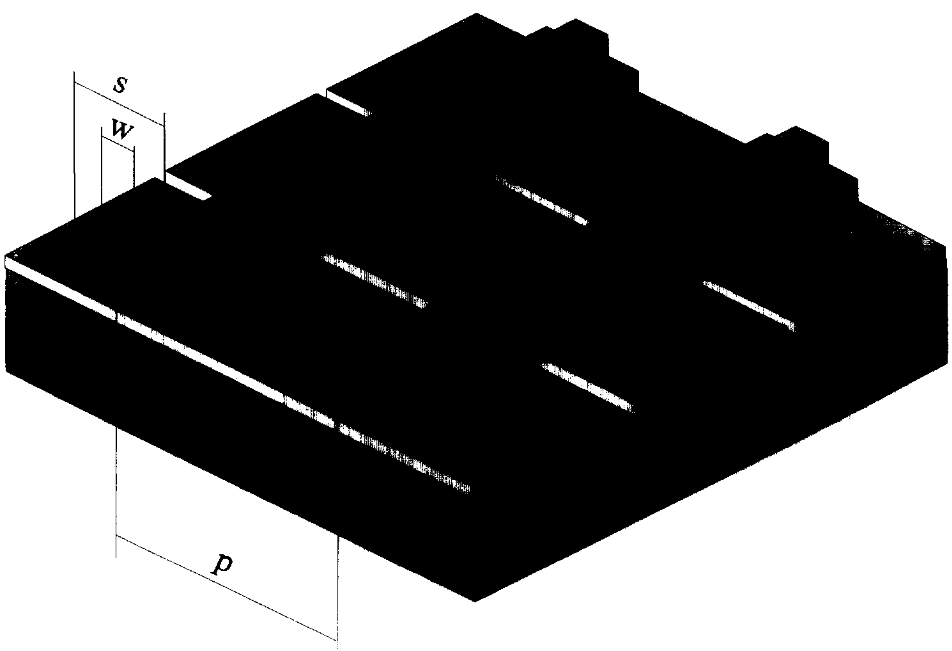

Fig. 1. Schematic drawing of the microgap plate: $P = 200$ μm, W(anode) = 9 μm and S(insulator) = 17 μm.

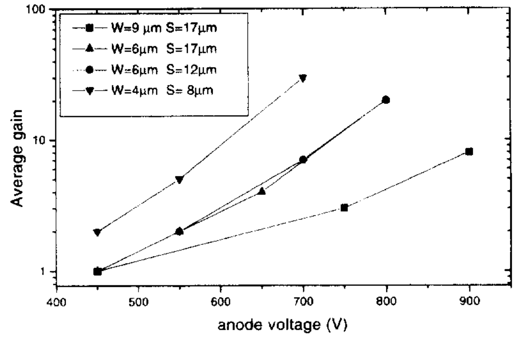

Fig. 2. Computed gain *vs* anode voltage for MG-plates with different geometrical parameters.

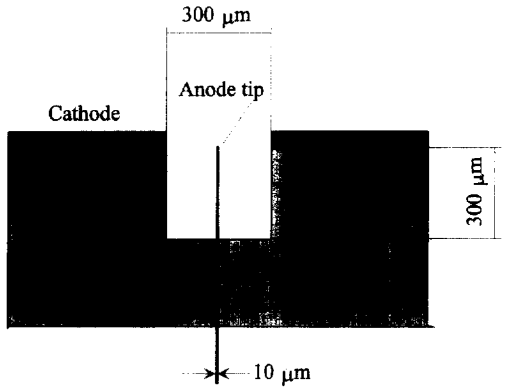

Fig. 3. Schematic drawing of the leak microstructure simulated.

which had an α source deposited on the center, was mounted 3 mm away from the MG plate. The chamber, set-up and readout electronics were similar to those used in Policarpo *et al.* (1995). The signals from the drift electrode, anodes and cathodes were simultaneously observed at the oscilloscope. The microgap chamber was successfully tested with xenon gas at 1.48 bar, exhibiting a gain of about 70 for an anode voltage of 200 V. However, higher voltages are required in the liquid, as no appreciable charge multiplication occurs below $E = 1$ MV/cm (at this electric field $\alpha \approx 10{,}000\ \mathrm{cm}^{-1}$) (Derenzo *et al.*, 1974). At 450 V discharges started to occur before any charge multiplication was observed.

The problem of obtaining charge multiplication in liquid xenon with a microstructure of electrodes was further investigated by means of computer simu

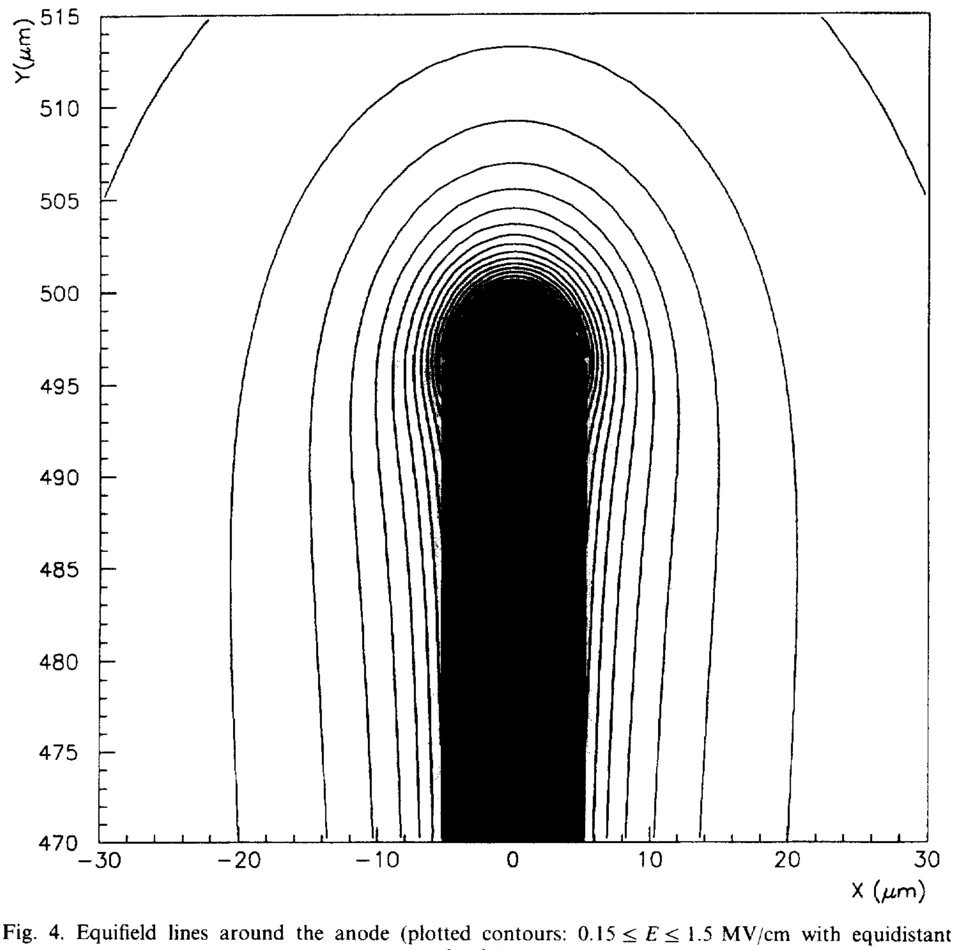

Fig. 4. Equifield lines around the anode (plotted contours: $0.15 \leq E \leq 1.5$ MV/cm with equidistant levels).

lation. Besides understanding the experimental results, our aim was to optimize the configuration of electrodes, so that the high field required to obtain charge amplification in liquid xenon can be achieved without the occurrence of discharges. The calculations of the electric field in each configuration of electrodes were made by means of a computer electrostatic modeler (ELECTRO, I.E.S., Canada) and a program developed by us that calculates the field lines and the gain along them, using published values for the first Townsend coefficient in liquid xenon (Derenzo *et al.*, 1974).

The average gain was evaluated for different values of the width of both the anode and the insulators strips of the MG. The results are presented in Fig. 2. Notice that, for a given anode width and voltage, the gain does not depend on the width of the insulator strip. Furthermore, the maximum voltage applicable depends on the distance between anode and cathode measured along the insulator surface (Marel, 1997), which is consistent with our experimental evidence that the discharges develop along that surface. Taking all this into account, the more favorable MG-plate has $w = 4$ μm and $s = 17$ μm. Nevertheless, it is worth remarking that in a microgap there is a very strong field around the corner between anode and insulator, typically one order of magnitude higher than in the central part of anode, which favours the occurrence of discharges.

The other microstructure investigated was the leak microstructure (Lombardi and Lombardi, 1996) which is schematically depicted in Fig. 3. The equifield lines in the vicinity of the anode are shown in Fig. 4. Here, the high field region is restricted to the tip of the anode, far away from the insulator. Furthermore, with the anode voltage set to 1000 V the calculated gain was about 20. Hence, this microstructure looks very promising and we will test it as soon as it is available.

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