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A PYROELECTRIC VIDICON WITH RETICULATED TARGET

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Reticulated targets of deuterated triglycine sulphate have been made by ion beam etching. The use of these targets in the pyroelectric vidicon has resulted in significant improvement in the thermal m.t.f. and M.R.T.

INTRODUCTION

In the E.E.V. P8092 pyroelectric vidicon an infrared image is focussed onto a thin pyroelectric target of deutrated triglycine sulphte (DTGS). This image produces a heat pattern which in turn generates a charge pattern which is read out by the electron beam[1]. The resolution is degraded by thermal diffusion of the heat image.

A reduction in thermal conductivity of the target can be achieved by dividing it into an array of discrete islands with a support film to maintain the integrity of the structure (Figure 1). This process is known as reticulation [23]. Comparative measurements are presented of the performance of reticulated and continuous targets in sealed off tubes.

TARGET RETICULATION

The reticulation process, by removing pyroelectric material reduces the target response. At high spatial frequencies this is more than offset by the increased m.t.f. resulting from the reduction in thermal diffusivity of the target. The loss becomes apparent at low spatial frequencies where the reduced thermal diffusivity of the reticulated target has less effect on the m.t.f.

Target reticulation by chemical etching would normally be subject to undercutting and excessive loss of material. For a reticulation pitch which is of the same order as the target thickness this could make reticulation impossible.

To minimise the loss of material, targets have been reticulated by ion beam etching. This has allowed the etching of vertical sided grooves of controlled width, with no undercutting. Etching has been carried out in a Veeco 'Microetch' unit at the Plessey Company. DTGS was found to etch very rapidly and useful etch rates have been obtained using low energy ions.

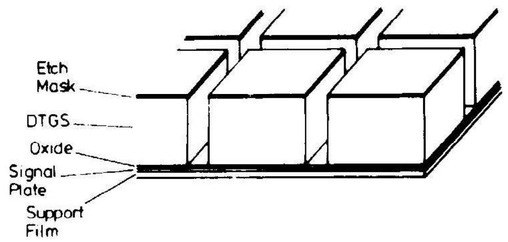

FIGURE 1 RETICULATED TARGET CROSS SECTION

In his analysis of the thermal properties of reticulated layers,[4] Watton has derived the m.t.f. at high spatial frequency as a function of the thermal conductivity - thickness product of the support film (Figure 2). The dashed line in Figure 2 represents the m.t.f. for an unreticulated target. The m.t.f. is seen to fall off steadily for a conductivity-thickness product greater than 0.2uW/^{o}K. However, very little is to be gained by reducing this product below 0.2uW/^{o}K.

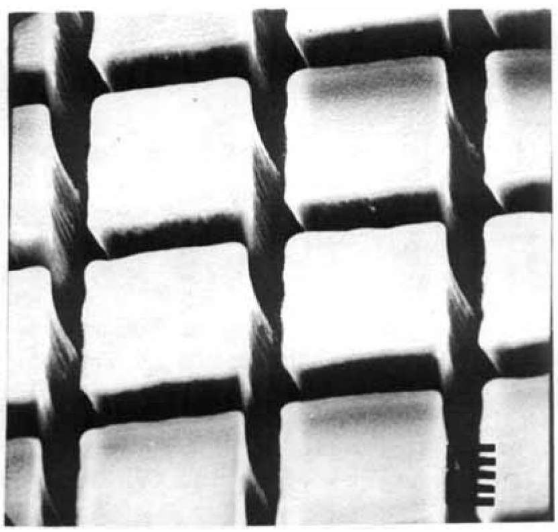

FIGURE 3 SCANNING ELECTRON MICROGRAPH OF A RETICULATED D.T.G.S. TARGET

For a reticulated target the limiting resolution is set by the pitch of the islands. The modulation transfer function is determined by the pitch and the degree of thermal isolation between islands. For a particular groove width the heat flow between islands is determined by the thermal conductivity of the support layer multiplied by its thickness.

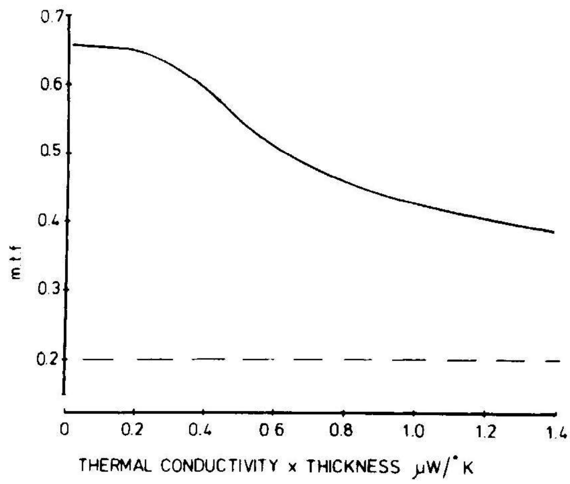

FIGURE 2 THE VARIATION OF m.t.f. (HIGH SPATIAL FREQUENCY) WITH THE THERMAL CONDUCTIVITY - THICKNESS PRODUCT OF THE SUPPORT FILM

Plastics, do not, in general, have a particularly low thermal conductivity. However, very thin plastic films (1-5um) can be prepared which have adequate mechanical strength and a thermal conductivity - thickness product in the required range.

For optimum performance, it is necessary to reticulate the target to its full thickness. Target thickness is not always uniform, so while ensuring full reticulation of the thicker areas, the signal plate on thin areas can suffer prolonged exposure to the ion beam. To prevent perforation of the thin nichrome signal plate a layer of oxide is

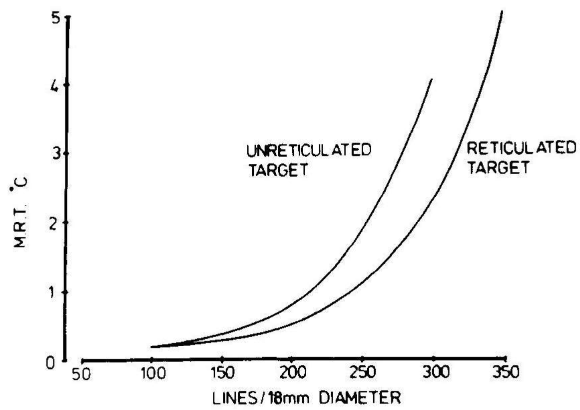

FIGURE 4 COMPARISON OF M.R.T. FOR RETICULATED AND UNRETICULATED D.T.G.S. TARGETS.

formed between the nichrome and the DTGS (Figure 1).

Ion beam etch masks have been made in evaporated aluminium. The masking patterns have been formed by the evaporation of aluminium from a small source through a fine metal mesh held in contact with the target surface. Unfortunately, the mesh can easily become distorted when heated by radiation from the evaporation filament. This leads to uncontrolled variation of groove width, which can produce background shading in the tube.

As an alternative mask, photoresist may be used with advantage. The production of photoresist etch masks involves more handling of the target, but it does allow good dimensional control. The equipment for silicon microcircuit photolithography has ben adapted to the processing of D.T.G.S. targets. These targets are significantly less robust than silicon slices and have, therefore, required the development of special handling techniques.

Apart from these handling difficulties, few problems have been encountered with photolithography on DTGS. Adhesion is adequate and pattern delineation good. Photoresist has excellent masking properties against low energy ions and has been used for most of reticulation work. Figure 3 shows a scanning electron micrograph of a reticulated target. The etch mask is photoresist and the reticulation pitch is 34 μm.

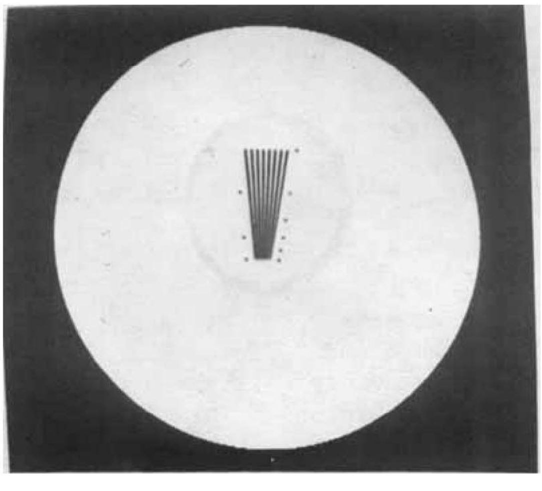

FIGURE 5 RESOLUTION BAR CHART IMAGED WITH A RETICULATED TARGET PYROELECTRIC VIDICON.

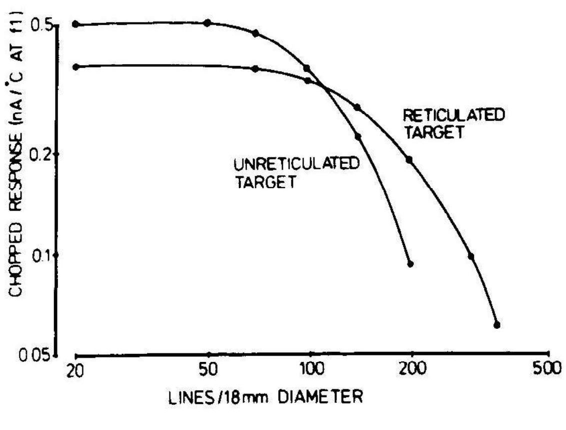

FIGURE 6 COMPARISON OF SYSTEM RESPONSE USING RETICULATED AND UNRETICULATED D.T.G.S. TARGETS.

TUBE PERFORMANCE

Figure 4 comparesthe minimum resolvable temperature (MRT) for reticulated and continuous targets. These measurements were taken with the camera operating in the panned mode with a panning rate of 3mm/sec. The MRT for the reticulated target at 300 lines is half that for the continuous target. The difference in MRT is less marked than may be expected. It is thought that this could be the result of noise contributed by the reticulation structure and by variations in that structure.

Figure 5 demonstrates the spatial resolution which can be achieved. The tube is operating in the chopped mode, chopping frequency 25 Hz. The maximum resolution on the fan is 400 lines/diameter.

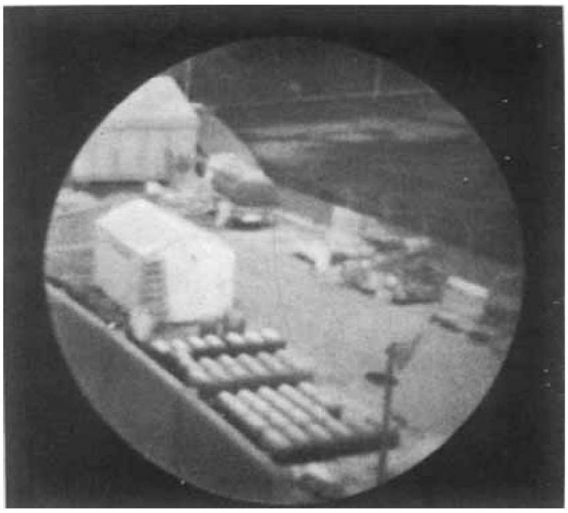

FIGURE 7' TYPICAL THERMAL IMAGE OBTAINED USING A RETICULATED TARGET PYROELECTRIC VIDICON.

The measurements of tube response (Figure 6) were taken with the tube operating at a chopping frequency of 25Hz. The tubes are gas filled and are running at a mean pedestal current of 40nA. These curves each represent the average performance of 6 tubes. As expected the low frequency response of the reticulated target is reduced because of material loss. About 35% of the DTGS is removed during reticulation. The response is down by about 25%. The curves cross over at about 100 lines and at 200 lines/Diameter reticulation gives a 2-fold improvement in response. The response is measured up to 350 lines (10 lp/mm).

It should be noted that with reticulated targets the performance of the system is limited by the m.t.f. of the lens.

A photograph taken from a television monitor (Figure 7) indicates the quality of thermal image available from the reticulated target pyroelectric vidicon. The image is flicker free, operating at standard television frame rate.

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