Microchannel Plate Detectors

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1. Introduction

A microchannel plate (MCP) is two dimensional vacuum electron multiplier.

Number of channel: $10^4 \sim 10^7$ (every channel is a miniature electron)

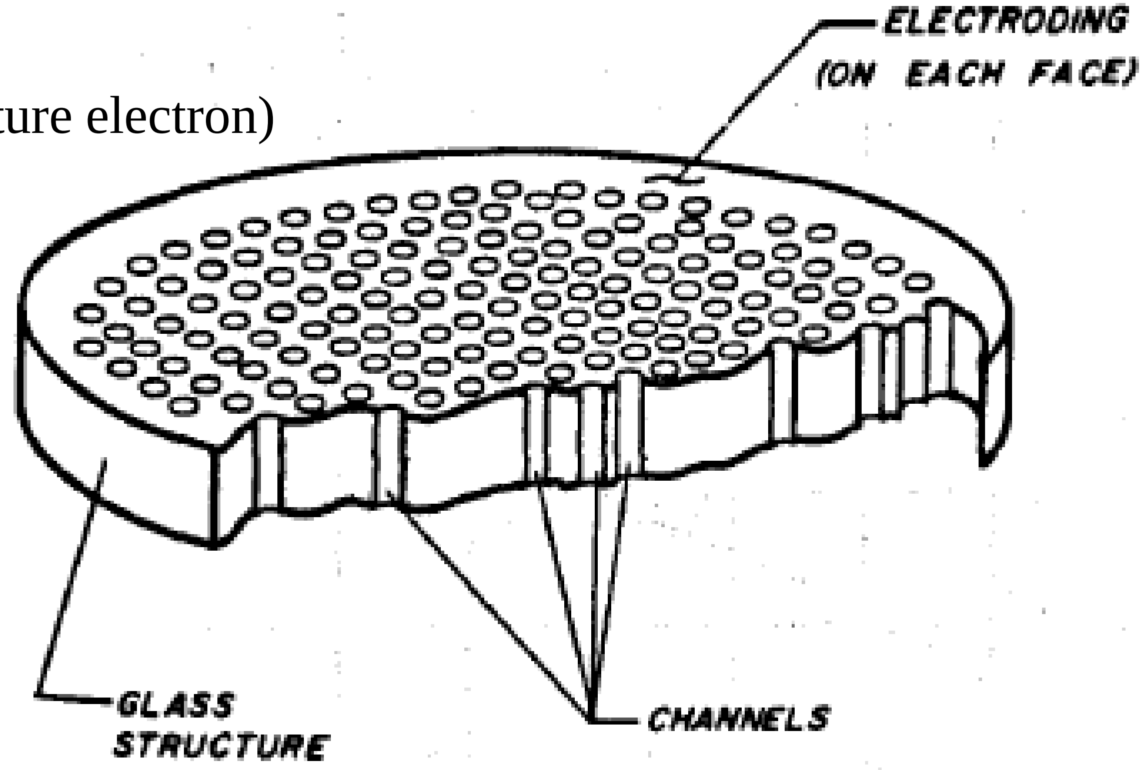
Channel diameter: 4 ~ 100 um

Length to diameter ratio: 40 ~ 100

Bias angle: 8°~ 15°

Total resistance: ~ 100 MΩ

Electron multiplication factor: $10^4 \sim 10^7$



2. Theory of operation

2.1 The straight channel electron multiplier

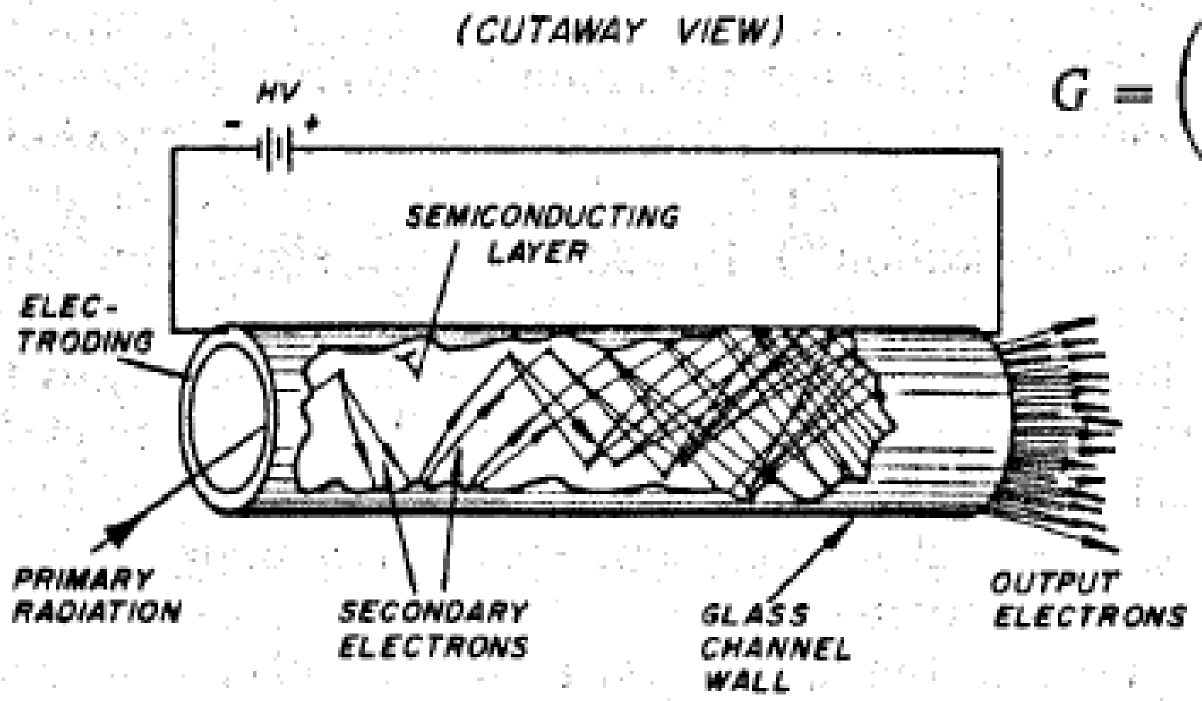


Fig. 2. A straight channel electron multiplier.

$$G = \left(\frac{AV}{2\alpha V_0^{\frac{1}{2}}}\right)^{4V_0\alpha^2/V}$$

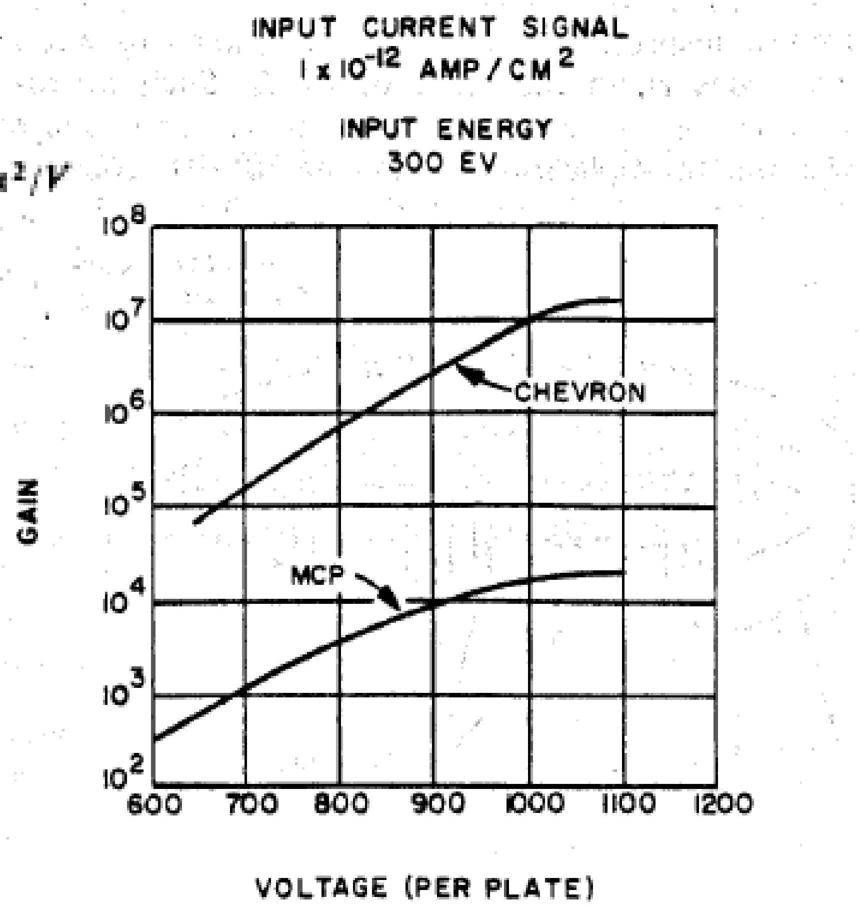
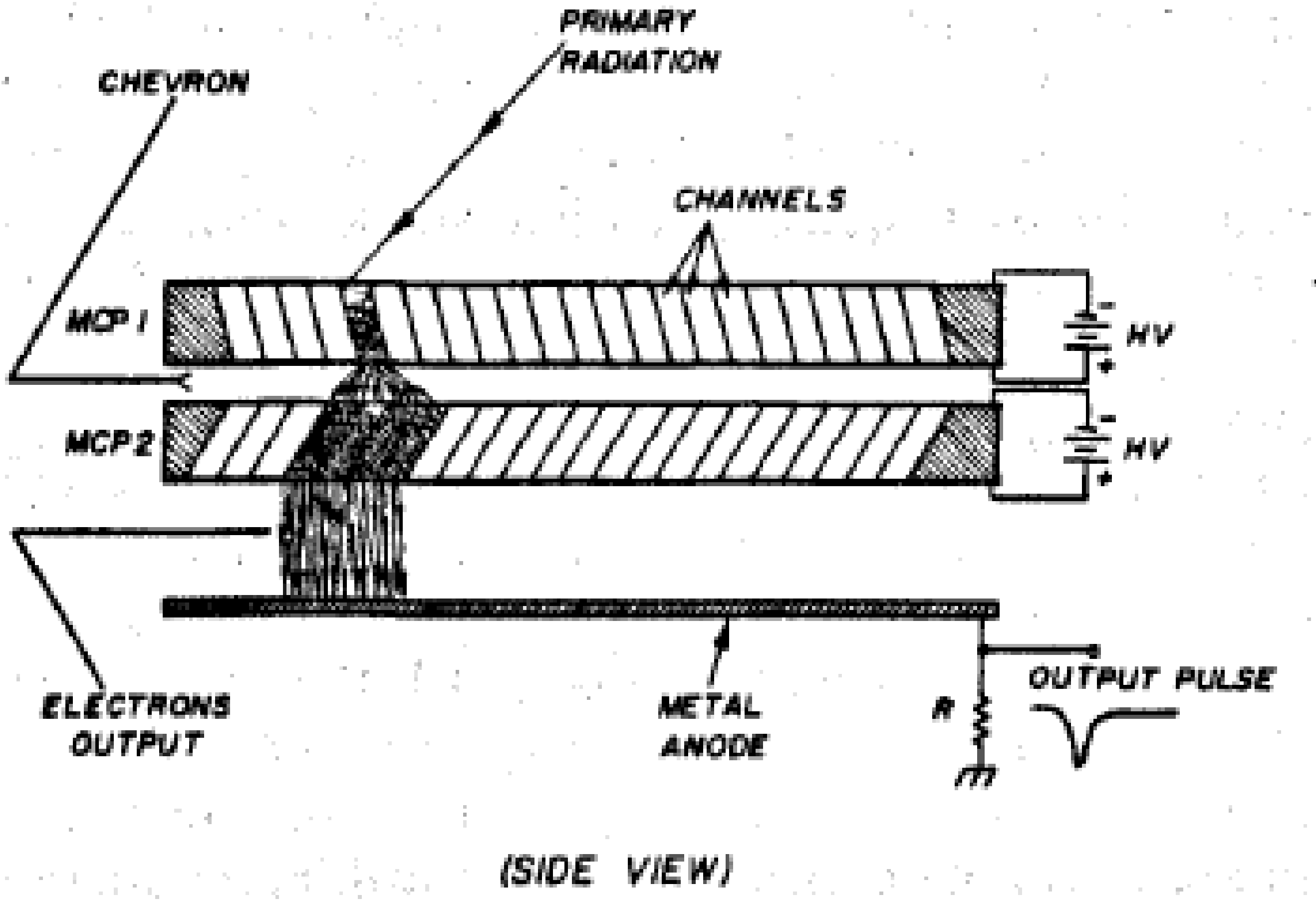


Fig. 3. Gain vs voltage characteristic for a straight channel MCP and a Chevron.

Secondary electron multiplication

2. Theory of operation

2.2 The Chevron



3. Manufacturing technology

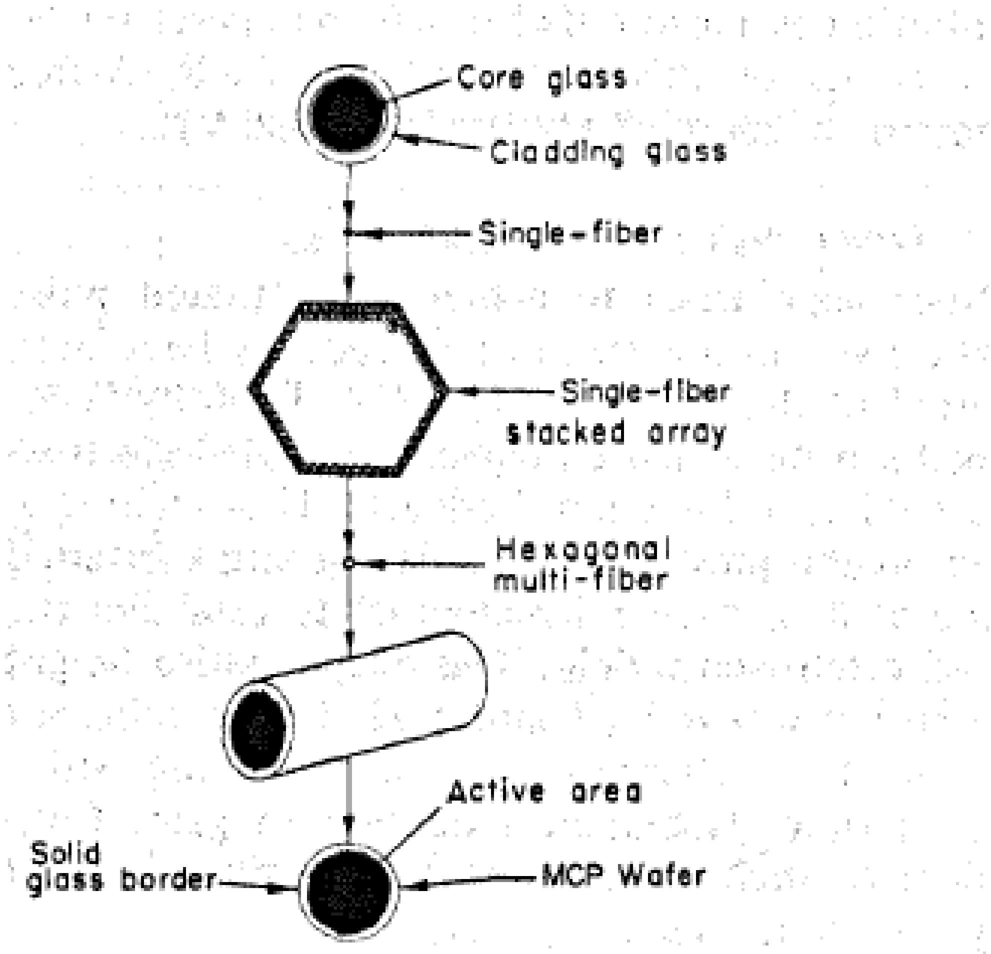


Fig. 9. Etchable core MCP manufacturing process.

4. Performance characteristics

4.1 Detection efficiency

Detection efficiency of channel multipliers[a].

Type of radiation		Detection efficiency (%)
Electrons	0.2 – 2 keV	50–85
	2 – 50 keV	10–60
Positive ions	0.5 – 2 keV	5–85
(H^+, He^+, A^+)	2 – 50 keV	60–85
	50 – 200 keV	4–60
U.V. radiation	300 –1100 Å	5–15
	1100 –1500 Å	1– 5
Soft X-rays	2 – 50 Å	5–15
Diagnostic X-rays	0.12– 0.2 Å	~1

[a] From Schagen[17]).

4. Performance characteristics

4.2 Dead time

4.3 Time of response

4.4 Magnetic field immunity

4.5 Dark count

4.6 MCP lifetime

5. Application

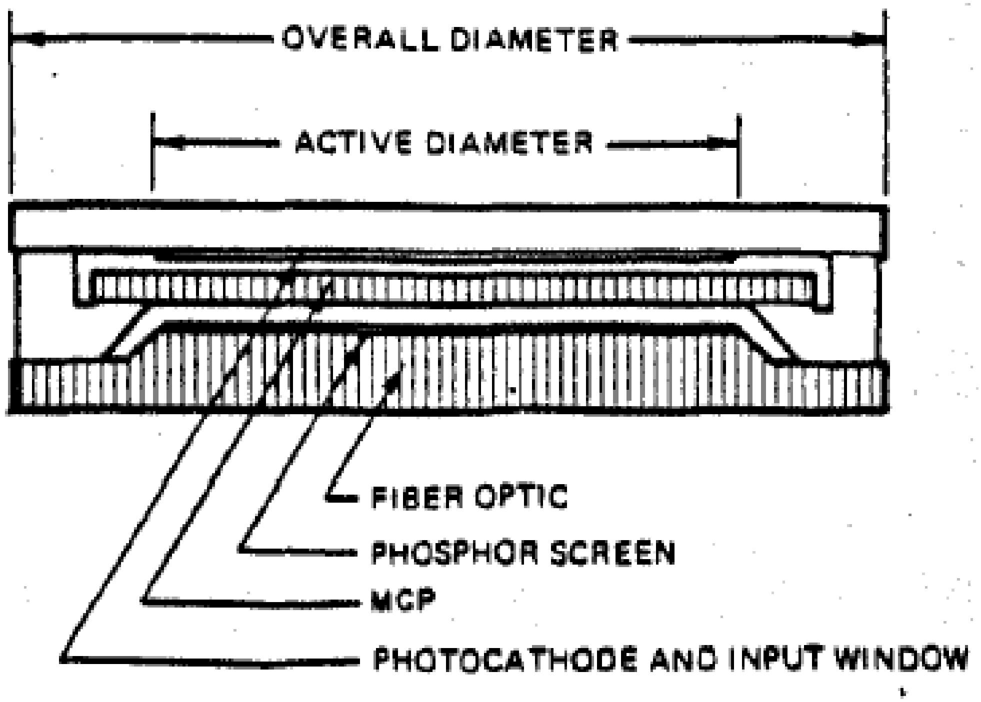


Fig. 15. A proximity focus image intensifier tube.

Image intensifier tube

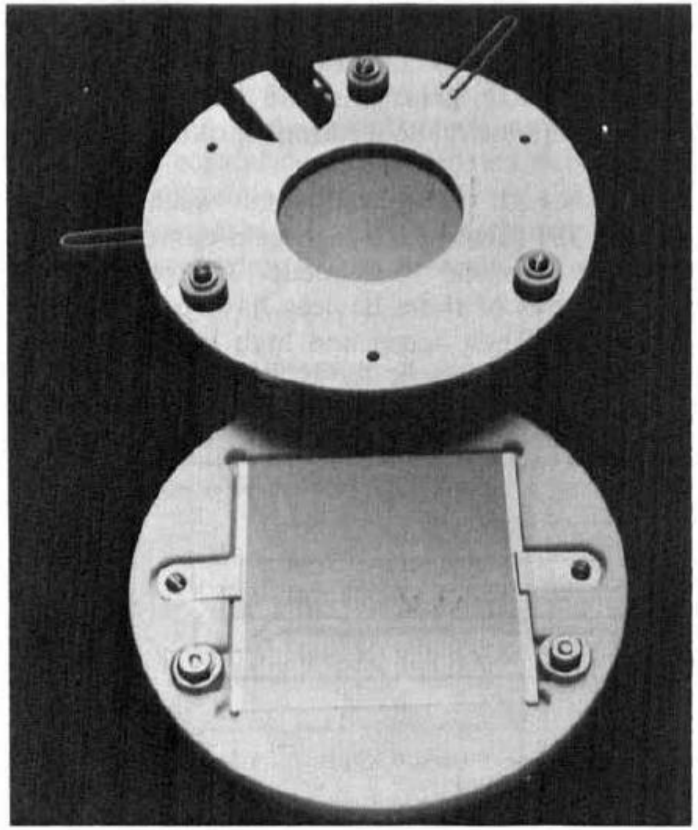


Fig. 16. A Chevron with resistive anode encoder (RAE).

Multianode detector

MCP-PMT (microchannel plate photomultiplier tube)

TOF-MS (time-of-flight mass spectrometer) ……

6. Future developments

1) Thick (5–10 mm) channel plates for enhanced efficiency in gamma-ray imaging applications. Galileo has fabricated such plates with efficiencies of 25% at energies just below the K absorption edge of lead at 88 keV. The plates are capable of space charge saturation, and have been tested as the front element in a Chevron.

2) Funneling of the input channels. This increases the open area ratio from 55% to 90% and allows a proportional increase in electron collection efficiencies when thin films are used over the input electrode of the MCP. The latter are used to suppress positive ion feedback to highly sensitive photocathodes.

3) High strip current MCPs. This of course allows operation at even higher count rates because of the concomitant reduction in channel recovery time.

4) MCPs with channel diameters of 8 μm or less. Such plates will be capable of higher spatial and temporal resolution.

ALD (atomic layer deposition) MCP