Instrumental technique (MCP detectors)
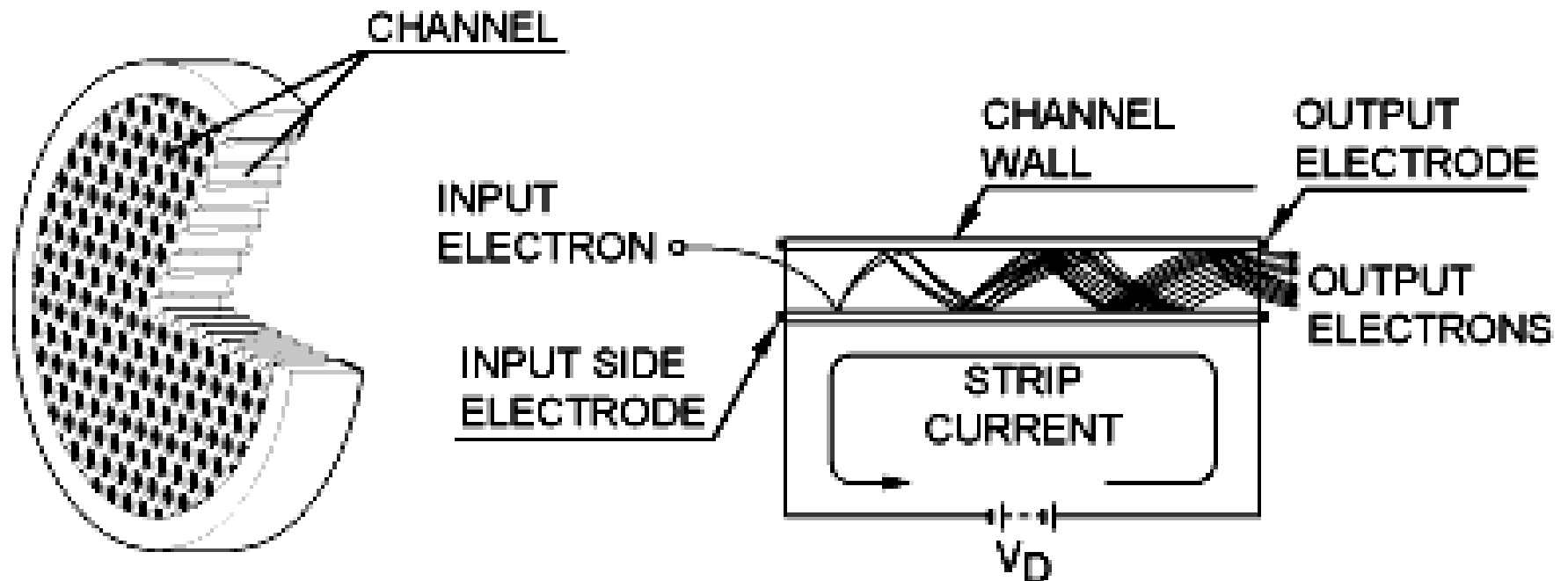
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Schematic of a MCP detector

MCP as an assembly of millions miniature SEMs

Schematic of a MCP detector

Microchannel Plates have a combination of unique properties like high gain, high spatial resolution and high temporal resolution.

They can be used in a large variety of applications including, imaging spectroscopy, electron spectroscopy and microscopy, mass spectrometry, astronomy, molecular and atomic collision studies, cluster physics etc.

Parts of the MCP detector (convertor)

A Converter is the part responsible for conversion of initial particles into electrons or photons that in turn efficiently interact with a Microchannel Plate.

Photocathodes are used for visible and IR radiation.

Open, windowless photocathodes of CsI or MgF2 deposited on MCP operate well through the extreme UV and soft x-ray region.

Specially formulated luminescent screens are used for neutrons, heavy ions and high-energy particles.

No Converters are usually necessary for ion detection in mass-spectrometry applications and UV and VUV radiation.

Parts of the MCP detector (an assembly of MCPs)

An Assembly of MCPs consists of single, double (so-called Chevron or V-stack) or triple (Z-stack) MCPs adjacent to one another.

Number of MCPs required depends on application.

Typical image intensifier for low-level light contains single MCP,

Typical TOF-MS ion detector has two MCP.

A three plate (Z-stack) MCP Detector is used to detect (count) and image single particles.

Parts of the MCP detector (a readout device)

For detection and particle counting applications where position resolution is not required, single metal anode can be used as a readout device.

MCP detectors with metal anode are widely used in mass-spectrometry.

For imaging applications with low temporal resolution phosphor screen (P20, P22, P46, etc.) coupled with CCD camera can be used.

For imaging applications with moderate and high temporal resolution state-of-the art anode configurations have been developed :
Resistive anodes (one and two dimensional)
Wedge and strip designs, Delay-Line-Readout

Properties of MCP -

Channel Bias Angle
Channels are tilted to prevent incident particles from passing through the channels. The optimum angle is between 5° and 15°.

Open Area Ratio (OAR)
The OAR is the ratio of the open area to the total effective area of the MCP. OAR limits ultimate detection sensitivity of MCPs.

Gain
The gain of an MCP, g, is given by the following equation using the length-to-diameter ratio of the channel: $g = \exp(G*(L/d)$, where G is the secondary emission characteristics of the channel called gain factor.
L - Channel length, d - Channel diameter

Properties of MCP -

Pulse height distribution
Pulse height distribution is usually characterized by the ratio of FWHM to the peak value in the pulse height distribution: FWHM/A

Transit time
The width of the single event peak determined mainly by temporal characteristics of readout device and electronics.

Spatial Resolution
Since each channel of the MCP serves as an independent electron multiplier, the channel diameter and center-to-center (c-c) spacing determine MCP resolution.

Properties of MCP -

Dark Current

A typical MCP shows an exceptionally low dark current, less than 0.5pA/cm2 at an applied voltage of 1 kV.

Resistance

Glass composition and reduction processing conditions (time and temperature) can control the MCP resistance. MCP resistance is typically in the range between 100 and 1000 MW . For applications requiring high output currents, low-resistance MCPs of 20 to 30 MW are available.

Commercially available MCPs

The microchannels are typically approximately 10 micrometers in diameter (6 micrometer in high resolution MCPs) and spaced apart by approximately 15 micrometers; they are parallel to each other and often enter the plate at a small angle to the surface (~8° from normal).

Commercially available MCPs

Microchannel Plate Detectors with Single Metal Anode (MCP-MA)

Open Microchannel Plate Imaging Detectors (MCP-GPS and MCP-IFP)

Thank you