2025.9

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Microchannel plate (MCP)

MCP General Catalog

MCP General Catalog

Microchannel plate (MCP) is a two-dimensional sensor that detects electrons, ions, VUV rays, X-rays and gamma rays in a vacuum, and amplifies the detected signals. These MCPs are widely used in many types of analytical equipment such as for mass spectroscopy, semiconductor inspection, and surface analysis.

Hamamatsu Photonics offers two types of products: MCP bare plates and MCP assemblies with integrated read-out devices. We offer a wide range of options, such as signal readout devices and number of MCP stages, to provide MCPs/MCP assemblies suitable for each analysis and measurement application.

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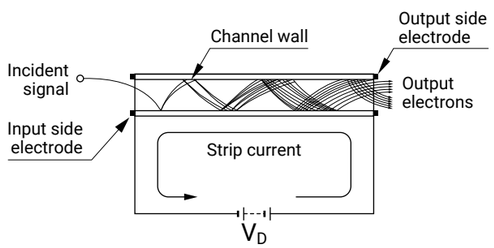
Basic principles of MCP (Microchannel Plate)

Principle

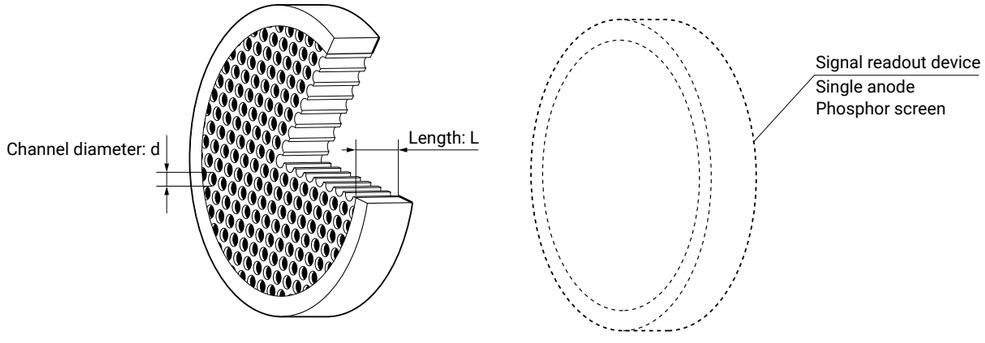
A potential gradient is established along the channel when a voltage V_D is applied between the input and output sides of the MCP.
Secondary electrons are emitted when an incident signal enters a channel from the input side and hits the channel wall.
These secondary electrons are accelerated by the potential gradient and follow parabolic trajectories.
They then hit the opposite wall in the channel causing further secondary electrons to be emitted.
The electrons emitted in this way travel towards the output side while striking the channel wall repeatedly. As a result, the exponentially multiplied electrons are extracted from the output side.

● Schematic structure of MCP

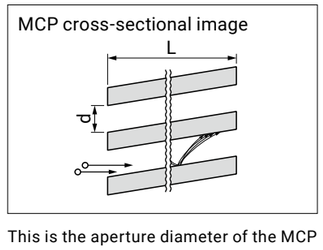


Structure

The performance of an MCP is determined primarily by a combination of channel diameter, open area ratio (OAR), and bias angle.

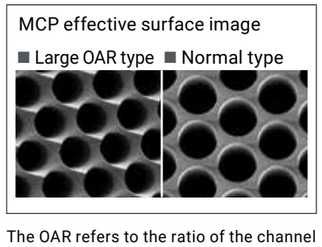


● Channel diameter



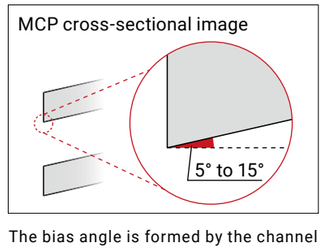
This is the aperture diameter of the MCP channel. The ratio of the channel diameter (d) to the channel length (L) is referred to as α (α=L/d), and this α and the secondary emission factor inherent to the channel wall material determine the gain of the MCP.

● Open area ratio (OAR)



The OAR refers to the ratio of the channel open area to the entire effective area of the MCP. The higher the OAR, the more incident signals are directed into the channel, enabling efficient detection. For details on the large OAR type, see page 06.

● Bias angle



The bias angle is formed by the channel axis and the axis perpendicular to the plate surface. The bias angle is usually selected at an appropriate value between 5° and 15° in consideration of the relative sensitivity to the incident angle and resolution.

Detection efficiency of MCP

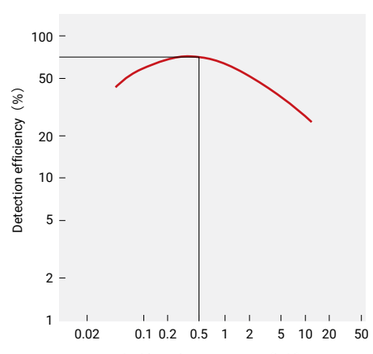
MCPs are sensitive to electron beams, ions, UV rays, X-rays, alpha rays, charged particles, neutrons, etc.
The table below shows the detection efficiency of MCP, while the graph illustrates its efficiency as a function of the incident energy of the electron beam. For electron beams, the maximum detection efficiency is achieved at energies between 0.5 and 1.0 keV.
These results are based on previously published data.

■ Radiation type and detection efficiency

Radiation type	energy/wavelength	detection efficiency (%)
Electron beam	0.2 keV to 2 keV	50 to 85
	2 keV to 50 keV	10 to 60
Ion	0.5 keV to 2 keV	5 to 85
	2 keV to 50 keV	60 to 85
	50 keV to 200 keV	4 to 60
UV	300 Å to 1100 Å	5 to 15
	1100 Å to 1500 Å	1 to 5
Soft X-ray	2 Å to 50 Å	5 to 15
Hard X-ray	0.12 Å to 0.2 Å	to 1

NOTE: The results will vary depending on the MCP's opening rate (OAR), the angle of incidence and its energy, and whether or not it is coated.

■ Electron beam energy and detection efficiency

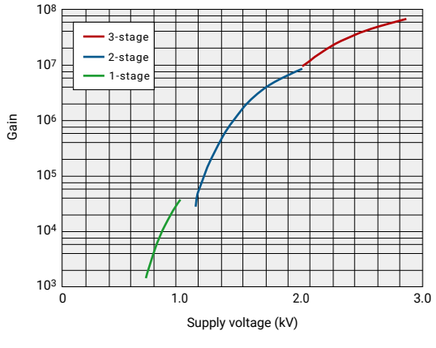


The above table and graph are quoted from the references below.

M.Galanti et al. ; J. F. Renaud: "A High Resolution, High Sensitivity Channel Plate Image Intensifier for Use in Particle Spectrographs", Rev. Sci., Inst., 42, 12, 818 (1971)
J.L. Wiza: "Microchannel plate detector", Nucl. Inst. and Meth., 162, P.587 (1979)
K.Oba et al.: "High Gain Micro-Channel Plate Multipliers for Particle Tracking or Single Photo-Electron Counting", IEEE Trans., NS-28, L, P.705(1981)

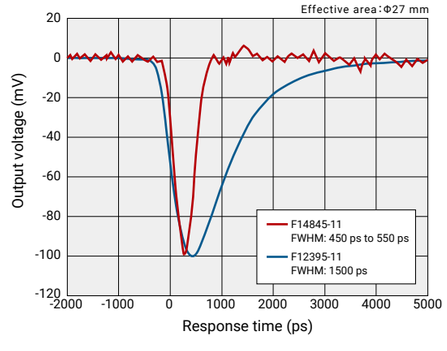
Characteristics

MCP gain



The figure shows the gain characteristics depending on the number of MCPs. With a one-stage MCP, a gain of 10^4 or higher can be obtained at a supply of 1 kV, while a two-stage MCP provides a gain of 10^6 or higher, and a three-stage MCP provides a gain of 10^7 or higher. The number of MCPs can be selected from one to three depending on the model.

Time response characteristics (MCP assembly)



The figure shows the output waveforms of two types of MCP assemblies. Even when two MCP stages are used, the travel distance of the electrons is extremely short, indicating that it has excellent response characteristics.
Various types of MCP assemblies are available with different response times, and the fastest model has a response speed of 450 to 550 ps (FWHM). Please select the one according to your application and measurement target.

MCP

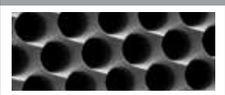
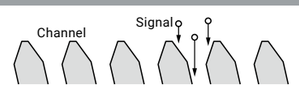
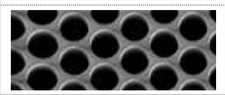
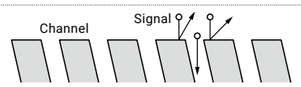
MCPs are made of millions to tens of millions of conductive glass capillaries bundled together to form a thin plate.
Each of these capillaries (channels) acts as an independent secondary electron multiplier, forming a two-dimensional electron multiplier. MCPs are available in various shapes and sizes, and can be chosen depending on the application.

About MCP shapes

Hamamatsu Photonics' MCPs can be modified to a variety of shapes for the design and development of analytical and measuring equipment. Whether it is the size of the MCP, the presence or absence of a center hole, or special processing such as notches, we can provide the optimal solution for each customer's needs with advanced technology based on our extensive manufacturing and development experience.

Topic Realization of large OAR with a funnel MCP

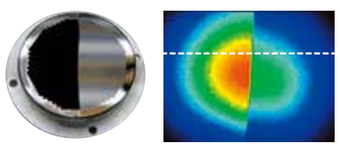
By making the effective area on the input side of the MCP funnel-shaped and increasing the OAR to 90 %, more signals can be corrected than with a standard MCP. When a funnel MCP is used in two or more stages, a resistance-matched K type is provided for the latter stage.

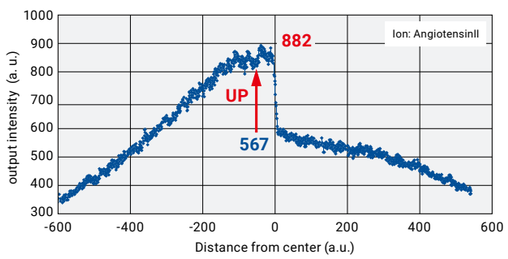
Items	OAR	Enlarged image	Cross section
Funnel MCP	90 % min.		
Normal MCP	57 % min.		

Ion detection experiment (fluorescence output intensity image with pseudo color)

This is an experiment using an MCP with only half of the effective area (left side) made into a funnel type. The improvement in output intensity can be seen only in the area made into a funnel type.

■ Fluorescence output intensity image with pseudo color





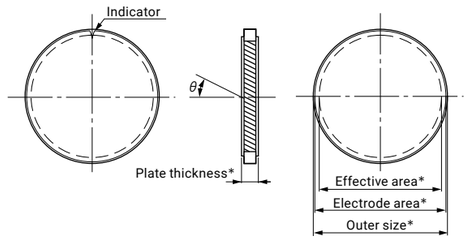
Specifications

Items		F1551	F1094		F1552		F1217		F1942	F2395	F2396	Unit
Suffix		-01	-01H *2	-011	-011	-011F *3	-01	-011F *3	-015	-04	-04	—
Outer size		Φ17.9	Φ24.8		Φ32.8		Φ49.9		Φ86.7	Φ113.9	96.9 × 78.9	mm
Electrode area		Φ17.0	Φ23.9		Φ31.8		Φ49.0		Φ84.7	Φ112.0	95.6 × 77.3	mm
Effective area		Φ14.5	Φ20.0 *2		Φ27.0		Φ42.0		Φ78.0	Φ105.0	90.0 × 72.0	mm
Plate thickness		0.48	0.48		0.48		0.48		0.72	1.00	1.00	mm
Channel diameter		12	12		12		12		12	25	25	μm
Channel pitch		15	15		15		15		15	31	31	μm
Bias angle		8	8	12	12		8	12	8	8	8	°
Open area ratio	Min.	57	57		57	90	57	90	57	57	57	%
Resistance *4		100 to 700	10 to 100	10 to 50	6.7 to 33		10 to 200	4 to 20	5 to 50	5 to 50	5 to 50	MΩ
Gain *4	Min.	1 × 10^4										—
Electrode material		Inconel										—
Dark current *4		0.5										pA·cm^2
Maximum linear output *4		7 % of strip current *1										—
Supply voltage *5		1.0							1.2	1.0		kV
Operating ambient temperature *5		0 to +50										℃
Resistance-match *6		Within ±10 %										—

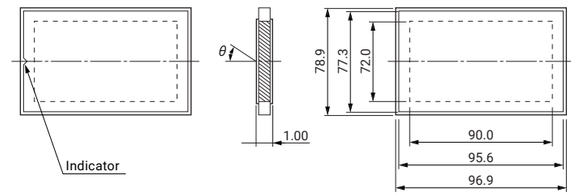
*1: Strip current is the current that flows through channel walls when a voltage is applied between MCP IN and OUT. It is given by dividing the applied voltage by the MCP resistance.
*2: The center hole type (-01 H) has a 6 mm diameter hole in the center of the MCP.
*3: A resistance-matched K type is provided for the latter stage of F (funnel) type.
*4: Supply voltage: 1.0 kV, vacuum: 1.3 × 10-4 Pa, operating ambient temperature: +25 °C
*5: Vacuum: 1.3 × 10^{-4} Pa
*6: Resistance-match means that resistance values of MCPs are to be matched when they are used in two stages.

Dimensional outline (Unit:mm)

● F1551 / F1094 / F1552 / F1217 / F1942 / F2395



● F2396



*: The dimensions of each MCP are listed in the product specifications table above.

MCP Assembly

MCP assemblies have multiple signal readout devices such as phosphor screens, coaxial connectors, and electrode leads to meet application needs. The devices are of: (1) single anode (electrical signal output), and (2) phosphor screen (visible light output). Select the ideal output device for your application.
Either one- or two-stage MCPs can be selected for the assembly. A gain of about 1×10^4 can be obtained with one-stage, and about 1×10^6 with two-stage, allowing uses in the analog mode (the output signal is measured as a continuous electrical current) or the counting mode (the low-level signal can be measured by binary processing).

Applications

- Mass spectrometry
- Surface analysis
- Scanning electron microscope
- Acceleration beam monitor
- Electron spectroscopy for chemical analysis
- Velocity map imaging (VMI)

Topic Additional functions through assembly for even greater ease of use

Hamamatsu Photonics' MCP assembly is not only easy to handle but also maximizes the performance and characteristics of the elements.
Below are some examples of features and characteristics unique to Hamamatsu Photonics' MCP assemblies.

Floating operation

Hamamatsu Photonics offers floating operation assemblies that allow the MCP incident surface to be set to positive and negative high voltages. These assemblies provide high withstand voltage coupling between the anode section and the connector, which eliminates the need to fix the anode section to ground potential and allows the MCP incident surface to be set to any floating potential. Floating potentials can be used to measure positive and negative ions and to improve detection efficiency by accelerating ions. As the voltage range that allows floating varies depending on the product, please consult us for the required voltage range.

Operation in higher pressure environment

MCPs are sensors that are designed to operate in a high vacuum environment due to their measurement target.
However, there are some difficulties including the need for a large vacuum pump to create a high vacuum environment. Hamamatsu Photonics has a lineup of assemblies that support low vacuum operation and are adapted to applications such as portable mass spectrometers.

Selection guide

MCP assembly lineup

Hamamatsu Photonics offers an extensive lineup of products that support a variety of functions and sizes.
This page describes the different case sizes, effective diameters, response speeds, and the number of MCPs that are available as standard. For detailed product specifications, see each product information page.
In addition, if you require a size or shape that is not in the lineup, we can customize it for you, so please feel free to contact us.

Simplified comparison table

Items	F14845	F14844	F13446	F13447	F12334	F12395	F12396	F2225			F2226		Unit
Suffix	-11	—	-11		-11			-11	-21	-21PGF	-14	-24	—
Effective area	Φ25	Φ14.5	Φ27	Φ42	Φ20	Φ27	Φ42	Φ42			Φ77		mm
Response speed	550	—	1300	1800	1500			—			—		ps
Standard number of MCPs	1	2	2		2			1	2	2	1	2	—

P.10

F14845-11

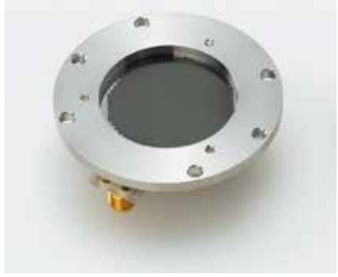
- Fast response
- Wide dynamic range
- Long life time

P.12

F14844

- Compact and lightweight
- Operates even under low vacuum conditions (up to 1 Pa)

P.14



F13446-11 / F13447-11

- Compact
- Floating operation

P.16

F12334-11 / F12395-11 / F12396-11

- Thin and lightweight
- Fast response

P.18

F2225-11 / F2225-21 / F2225-21PGF

- Vacuum flange integrated (F2225-21PGF)

P.20

No image

F2226-14 / F2226-24

F14845-11

F14845-11

Features

- DC output: Up to 200 μA
- Pulse linearity: Up to 3.2 V
- Hybrid type detector combined with AD (Avalanche Diode)

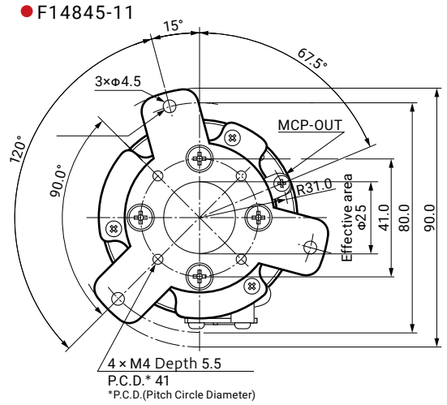
Specifications

Items		F14845-11	Unit
Number of MCPs		1	–
Effective area		Φ25	mm
Signal readout		Single anode	–
Channel diameter		12	μm
Pulse width (FWHM)		550	ps
Gain *1	Min.	1×10^6	–
Pulse height resolution *1	Max.	–	%
Dark count *1	Max.	–	$S^{-1} \cdot cm^2$
MCP supply voltage *2		1.0	kV
MCP-OUT to anode supply voltage *2		6.0	kV

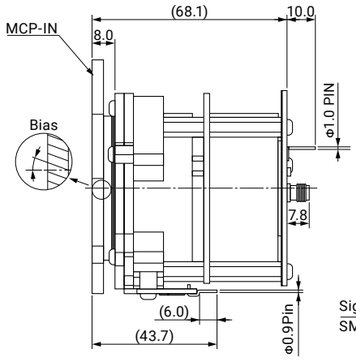
*1: Supply voltage: 1.0 kV/MCP, vacuum: 1.3×10^{-4} Pa, operating ambient temperature: +25 °C
*2: Vacuum: 1.3×10^{-4} Pa

Dimensional outline (Unit:mm)

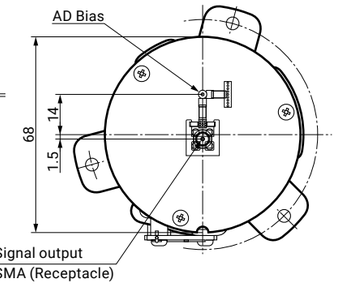
● F14845-11



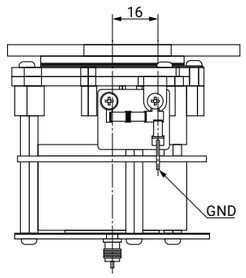
Front view



Side view



Rear view



Side view

F14844

F14844

Features

- Operates even under low vacuum conditions (up to 1 Pa)
- Compact and lightweight

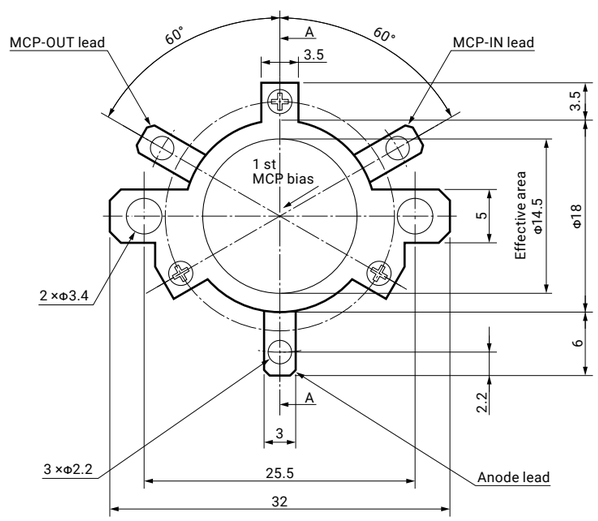
Specifications

Items		F14844	Unit
Number of MCPs		2	–
Effective area		Φ14.5	mm
Signal readout		Single anode	–
Channel diameter		12	μm
Pulse width (FWHM)		–	ps
Gain *1	Min.	1×10^6	–
Pulse height resolution *1	Max.	–	%
Dark count *1	Max.	3	$S^{-1} \cdot cm^2$
MCP supply voltage *2		2.0	kV
MCP-OUT to anode supply voltage *2		0.1	kV

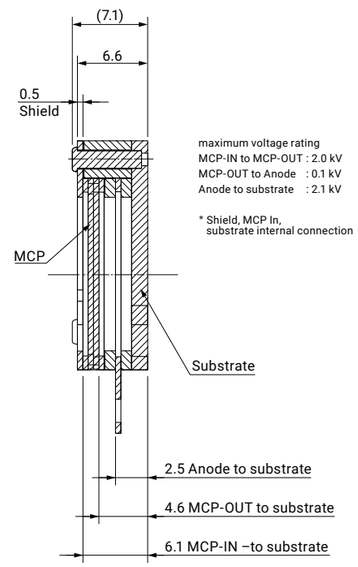
*1: Supply voltage: 1.0 kV/MCP, vacuum: 1.3×10^{-4} Pa, operating ambient temperature: +25 °C
*2: Vacuum: 1.3×10^{-4} Pa

Dimensional outline (Unit:mm)

● F14844

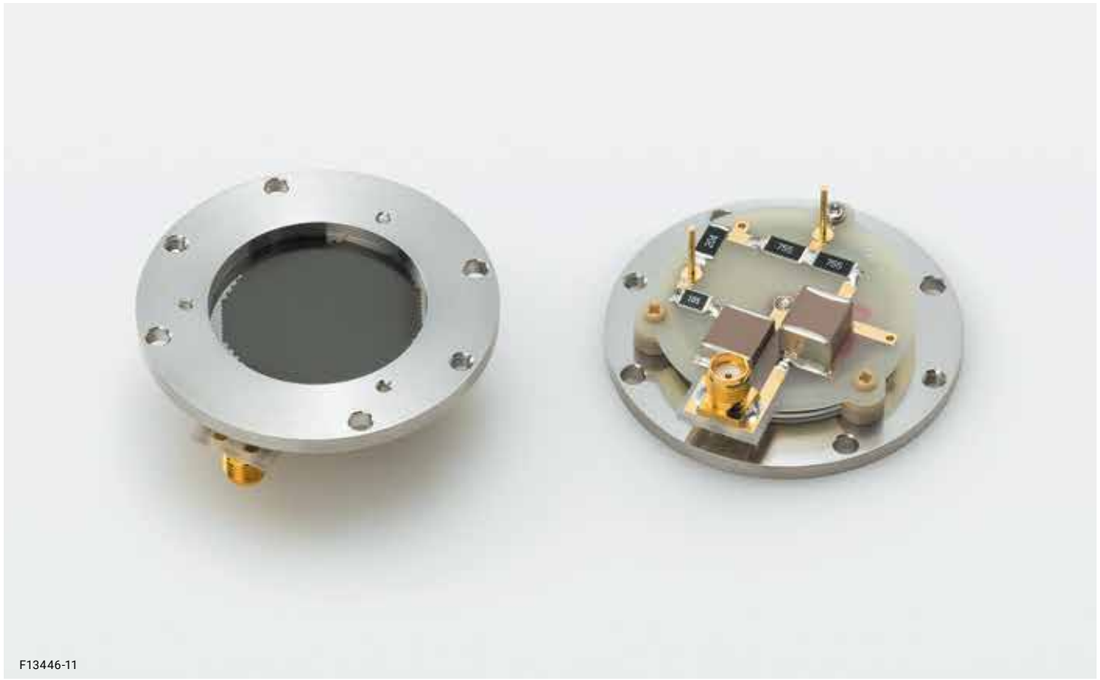


Front view



A-A Cross-sectional view

F13446-11 / F13447-11



Features

- Compact
- Floating operation

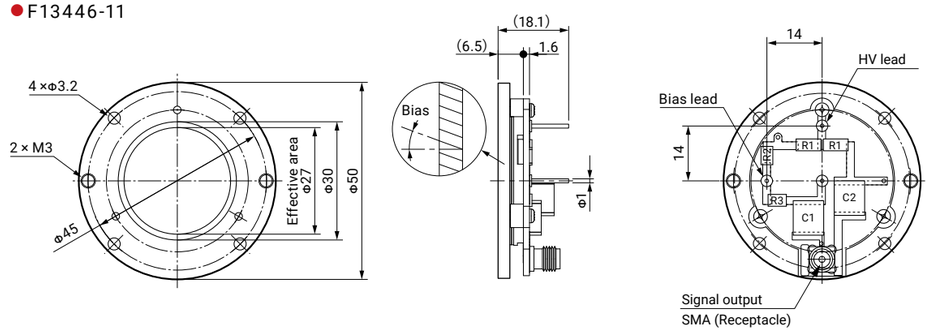
Specifications

Items		F13446-11	F13447-11	Unit
Number of MCPs		2		–
Effective area		Φ27	Φ42	mm
Signal readout		Single anode		–
Channel diameter		12		μm
Pulse width (FWHM)		1300	1800	ps
Gain *1	Min.	1×10^6		–
Pulse height resolution *1	Max.	–		%
Dark count *1	Max.	3		$S^{-1} \cdot cm^2$
MCP supply voltage *2		-2.0		kV
MCP-OUT to anode supply voltage *2		0.1		kV

*1: Supply voltage: 1.0 kV/MCP, vacuum: 1.3×10^{-4} Pa, operating ambient temperature: +25 °C
*2: When supplying a maximum of -2.1 kV to the HV electrode
*3: Vacuum: 1.3×10^{-4} Pa

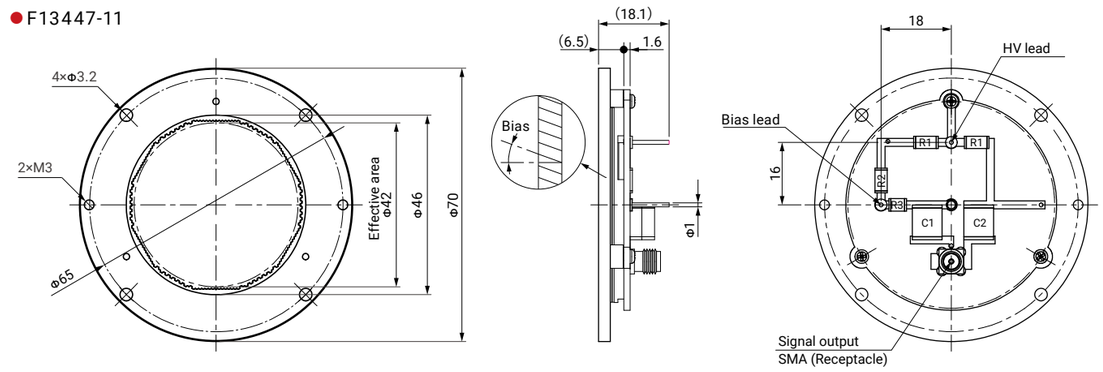
Dimensional outline (Unit:mm)

● F13446-11



Front view　　Side view　　Rear view

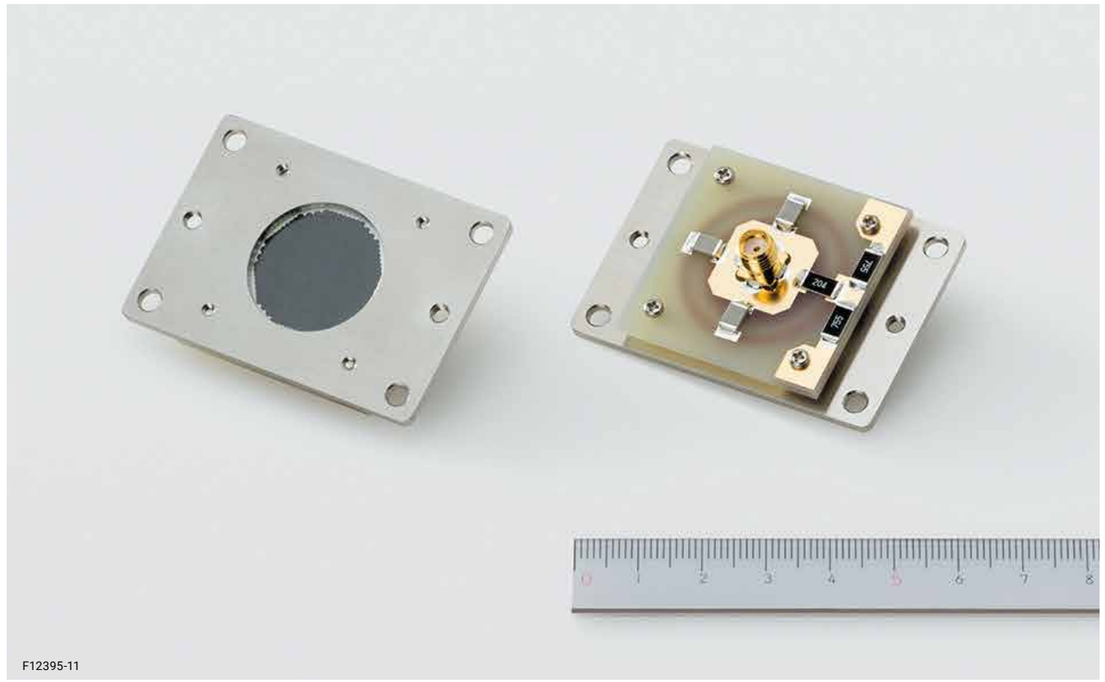
● F13447-11



Front view　　Side view　　Rear view

* When using, be sure to connect the GND line of the SMA connector to GND.

F12334-11 / F12395-11 / F12396-11



Features

- Thin and lightweight
- Fast response

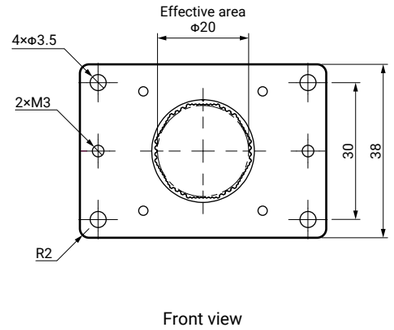
Specifications

Items		F12334-11	F12395-11	F12396-11	Unit
Number of MCPs		2			–
Effective area		Φ20	Φ27	Φ42	mm
Signal readout		Single anode			–
Channel diameter		12			μm
Pulse width (FWHM) *1		1500			ps
Gain *2	Min.	1×10^6			–
Pulse height resolution *2	Max.	–			%
Dark count *2	Max.	3			$S^{-1} \cdot cm^2$
MCP supply voltage *3 *4		-2.0			kV
MCP-OUT to anode supply voltage *3		0.1			kV

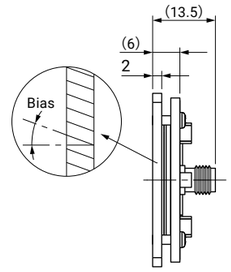
*1: FWHM at output peak value 20 mV, 50 Ω input
*2: Supply voltage: 1.0 kV/MCP, vacuum: 1.3×10^{-4} Pa, operating ambient temperature: +25 °C
*3: Vacuum: 1.3×10^{-4} Pa
*4: When supplying a maximum of -2.1 kV to the HV electrode

Dimensional outline (Unit:mm)

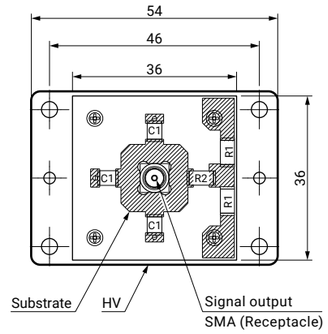
● F12334-11



Front view

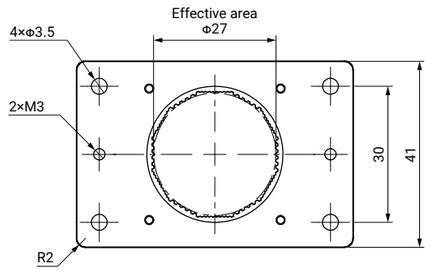


Side view

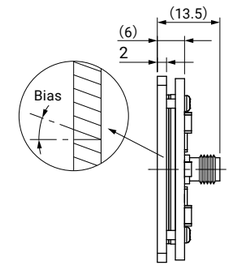


Rear view

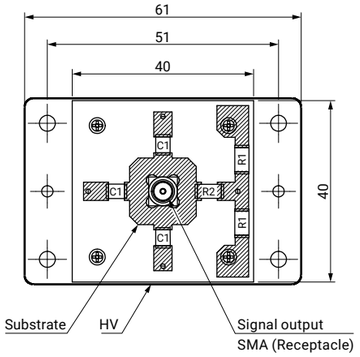
● F12395-11



Front view

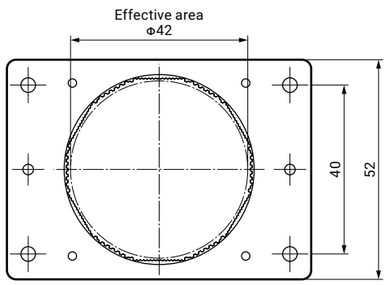


Side view

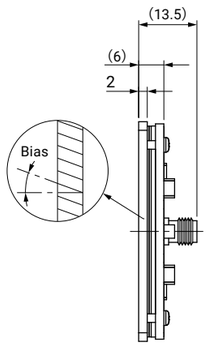


Rear view

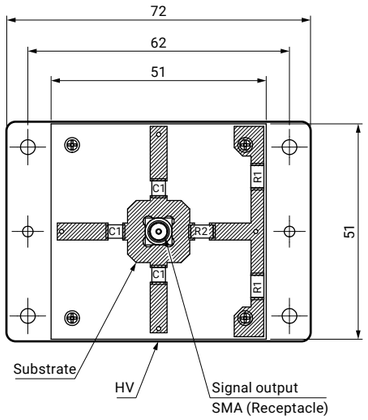
● F12396-11



Front view



Side view



Rear view

F2225-11 / F2225-21 / F2225-21PGF

F2225-21PGF

Features

● Vacuum flange integrated：F2225-21PGF

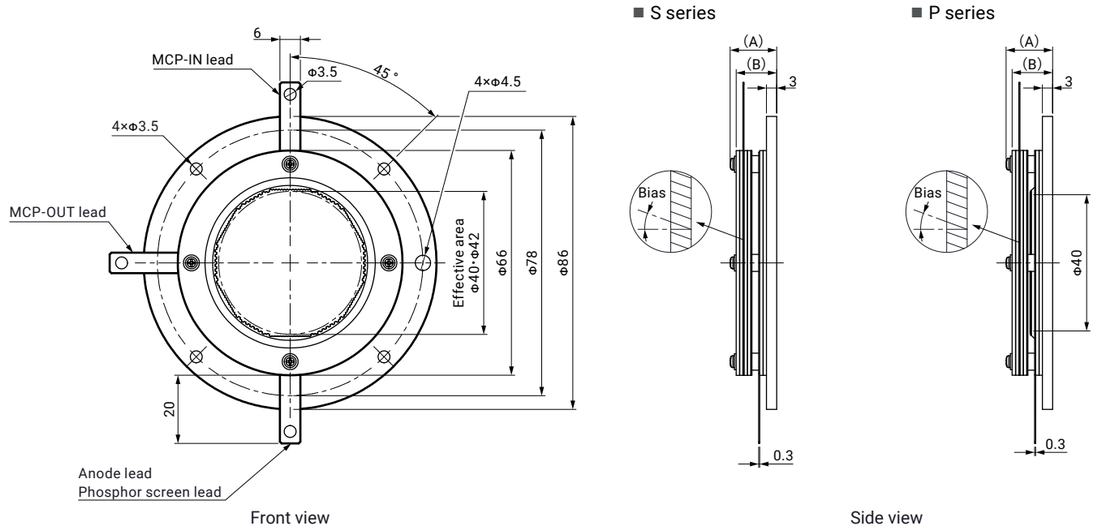
Specifications

Items		F2225-11S	F2225-11P	F2225-21S	F2225-21P	F2225-21PGF	Unit
Number of MCPs		1		2		2	–
Effective area		Φ42	Φ40	Φ42	Φ40	Φ40	mm
Signal readout		Single anode	Phosphor screen	Single anode	Phosphor screen	Phosphor screen	–
Channel diameter		12				12	μm
Pulse width (FWHM)		–				–	ps
Gain	Min.	1×10^4		1×10^6		1×10^6	–
Pulse height resolution *1	Max.	–		120		120	%
Dark count *1	Max.	–		3		3	$S^{-1} \cdot cm^2$
MCP supply voltage *2		1.0		2.0		2.0	kV
MCP-OUT to anode supply voltage *2		0.5	3.0 to 4.0	0.5	3.0 to 4.0	3.0 to 4.0	kV

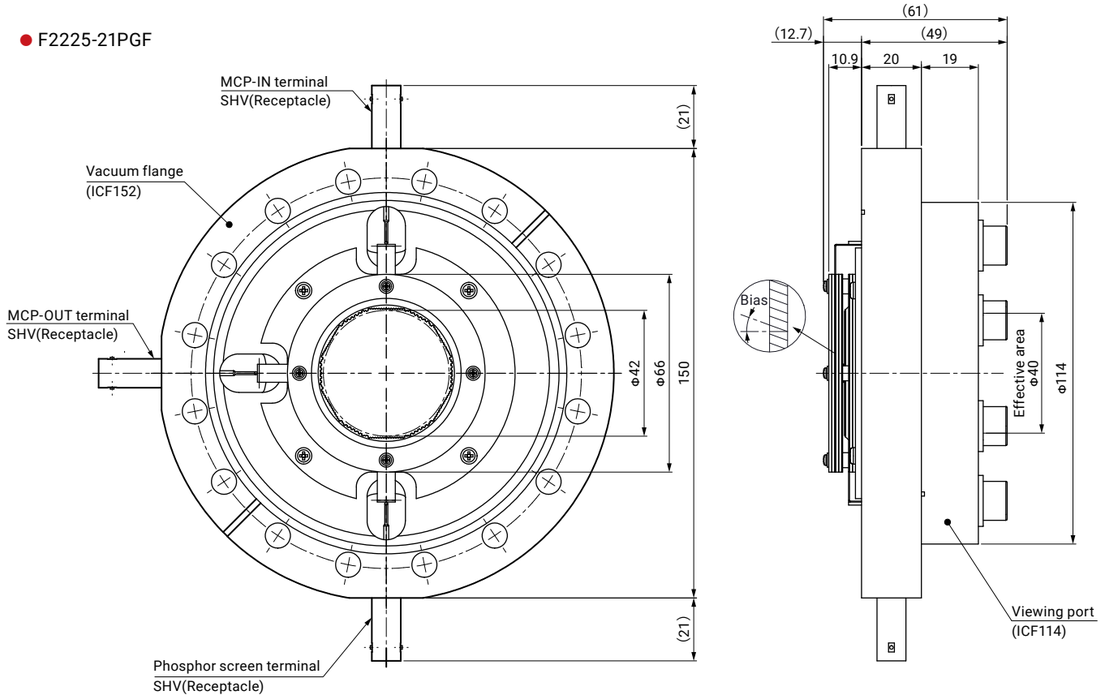
*1: Supply voltage: 1.0 kV/MCP, vacuum: 1.3×10^{-4} Pa, operating ambient temperature: +25 °C
*2: Vacuum: 1.3×10^{-4} Pa

Dimensional outline (Unit:mm)

● F2225series



● F2225-21PGF



Perform the vacuum baking under 150 °C while keeping the evacuation system at a vacuum pressure below 1.3×10^{-4} Pa.

F2226-14 / F2226-24

Features

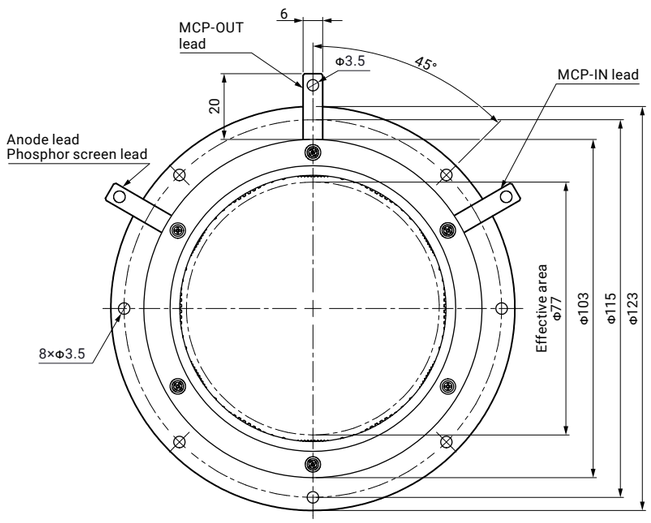
- Channel diameter 25 µm

Specifications

Items		F2226-14S	F2226-14P	F2226-24S	F2226-24P	Unit
Number of MCPs		1		2		–
Effective area		Φ77				mm
Signal readout		Single anode	Phosphor screen	Single anode	Phosphor screen	–
Channel diameter		25				µm
Pulse width (FWHM)		–				ps
Gain	Min.	1×10^4		1×10^6		–
Pulse height resolution *1	Max.	–		120		%
Dark count *1	Max.	–		3		$S^{-1} \cdot cm^2$
MCP supply voltage *2		1.0		2.0		kV
MCP-OUT to anode supply voltage *2		0.5	3.0 to 4.0	0.5	3.0 to 4.0	kV

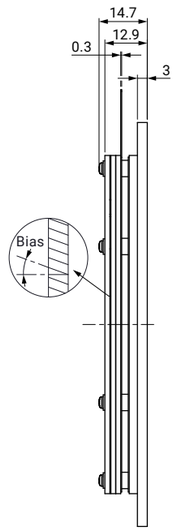
*1: Supply voltage: 1.0 kV/MCP, vacuum: 1.3 × 10-4 Pa, operating ambient temperature: +25 °C
*2: Vacuum: 1.3 × 10^{-4} Pa

Dimensional outline (Unit:mm)

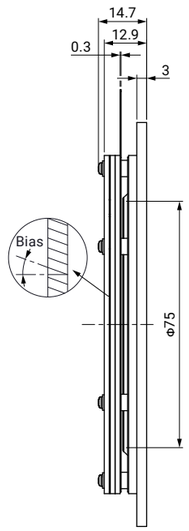


Front view

■ S series



■ P series

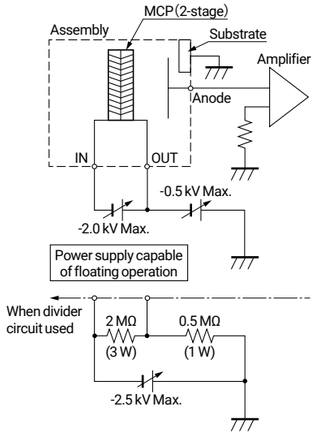


Side view

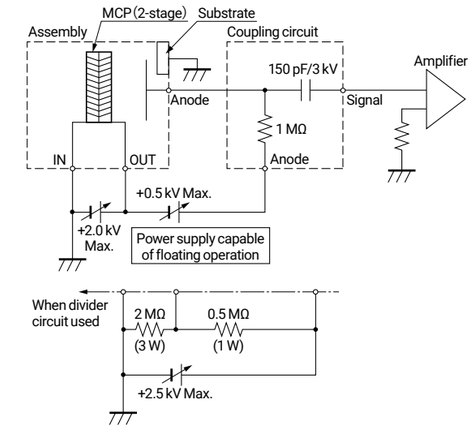
MCP assembly wiring example

Signal measurement

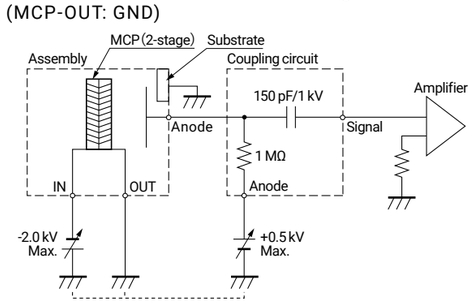
- Positive ion detection: Anode grounded



- Electron or negative ion detection: Anode floating (MCP-IN: GND)

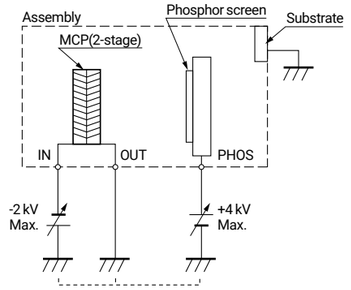


- Positive ion detection: Anode floating (MCP-OUT: GND)

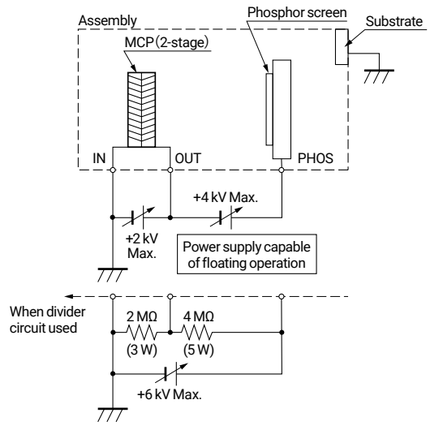


two-dimensional detection

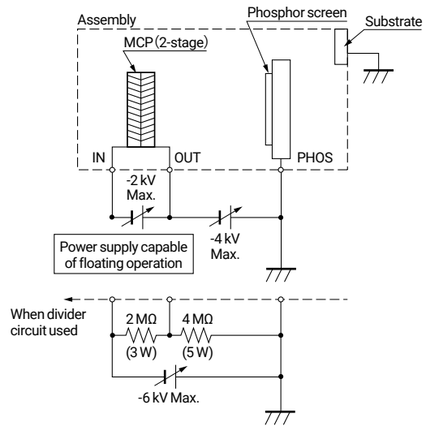
- Positive ion detection(MCP-OUT: GND)



- Electron or positive ion detection(MCP-IN: GND)



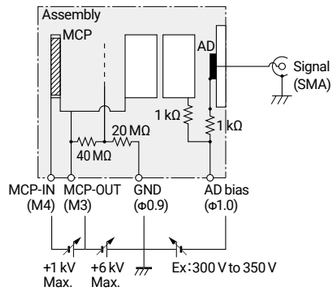
- Positive ion detection(Phosphor screen: GND)



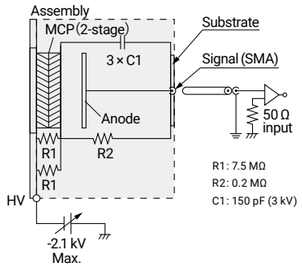
Using multiple high-voltage power supplies has the advantage that the MCP gain can be independently adjusted. Using the divider circuit with a single high-voltage power supply offers low cost, but there is a disadvantage that the MCP gain varies as the power supply voltage varies. There can be some exceptions.

MCP assembly wiring example

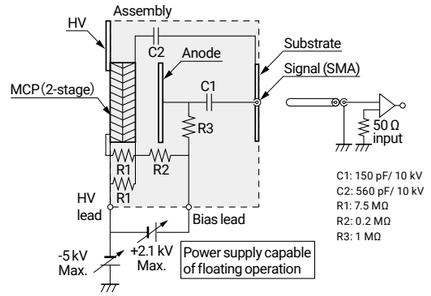
● F14845-11



● F12334-11, F12395-11, F12396-11



● F13446-11, F13447-11



Notes

How to handle

1. Storage
   MCP and MCP assembly are shipped in packages that are evacuated to a vacuum or filled with dry nitrogen. These packages are intended for use during shipping and not suited for long-term storage. When storing the MCP and MCP assemblies, take them out of their packages and keep them in a clean case under either a) or b) of the following conditions.
   a) At vacuum pressure below 13 Pa and no oil diffusion.
   b) Under gentle constant flow of dry nitrogen passed through a 0.45 µm or smaller filter (humidity: 20 % or less).

2. Handling
   Avoid touching the MCP and the MCP assembly with bare hands. If handled with bare hands, they might be contaminated by oil and salt, causing an increase in dark current, a loss of gain, and an electrical discharge. When handling them, always wear clean vinyl or polyethylene gloves. Even when wearing gloves, never touch the effective area of the MCP and the MCP assembly.

3. Environments
   The MCP surface is processed to be electrically active and the components used for the assembly are also processed for high vacuum use. So as much as possible, handle them in an environment conforming to clean-room (dust-proof room) specifications where oily vapor, moisture, and dust are minimized.
   If dust or debris gets on the MCP surface, blow it off with dry clean air or nitrogen gas. When doing this, check the pressure and surrounding area so as not to blow other dust into the air. Never use your own breath to blow off dust from the MCP surface.

4. Degassing before use
   Gas adsorption usually occurs on the surface of an MCP which has not yet been used after delivery or has been stored after use. The MCP must be evacuated in a high vacuum below 1.3 × 10^{-4} Pa for more than 24 h to perform degassing before using it (before supplying a voltage).

5. Vacuum baking
   Vacuum baking is effective in degassing when the MCP or the MCP assembly is to be used in a high vacuum. Perform the vacuum baking at under 150 °C while keeping the vacuum pressure below 1.3 × 10^{-4} Pa. Vacuum baking cannot be performed on some types of MCP assembly. Please consult us for details.

6. Supply voltage
   Always maintain the MCP and the MCP assembly high vacuum condition below 1.3 × 10^{-4} Pa in operation. (1 Pa or less for the F14844 series) When supplying a voltage to the MCP or MCP assembly and to the output signal readout device (anode, phosphor screen), slowly increase it in 100 V steps (approx. 5 sec per 100 V).

7. Measurement of MCP resistance
   Because standard specification MCPs listed in the catalog are made of lead glass, a correct value cannot be obtained if the MCP resistance is measured in the atmosphere as it is easily affected by humidity. To measure the resistance correctly, the MCP must be placed in a vacuum and its electrodes must be securely in contact with the measuring device. The MCP resistance has negative temperature characteristics (resistance deceases as temperature increases), so it may take several minutes for the resistance value to become stable.

Warranty

This product is warranted for one year after delivery. If you find any failure or defect in the workmanship and notify us within this warranty period, we will repair or replace it free of charge. The warranty is limited to replacement of the defective product.
Even if within the warranty period, this warranty shall not apply to failure or damage that was caused by the product reaching the end of its service life, natural disasters, negligence, or incorrect operation including modification.

Disposal method

The materials in standard specification MCPs listed in the catalog contain lead and its compounds. When disposing of this product, please dispose of it properly by yourself in accordance with the Act on Waste Management and Public Cleaning or entrust the disposal to an appropriate licensed industrial waste disposal company. Please follow the applicable regulations regarding disposal of hazardous materials and industrial wastes in your country, state, region, or province.

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