

Electron Multipliers for Mass Spectrometry



ETP electron
multipliers
From Restek

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Innovative Chromatography Solutions

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The ETP Electron Multiplier Advantage:

- The multi-dynode approach of all ETP electron multipliers results in longer lifetimes—and better sensitivity—compared with channel electron multipliers (CEM) or continuous-dynode multipliers.
- Optimized ion and electronic optics for maximum performance.
- Increased surface area for enhanced sensitivity and extended operational life.

Figure 1: Components of mass spectrometry. The general layout of a mass spectrometer consists of the following elements: sample introduction and separation system, ion source, mass analyzer, ion detection system, and data processing.

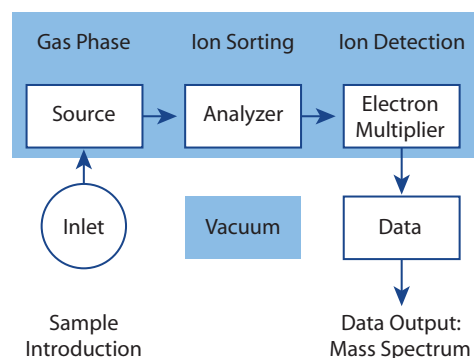
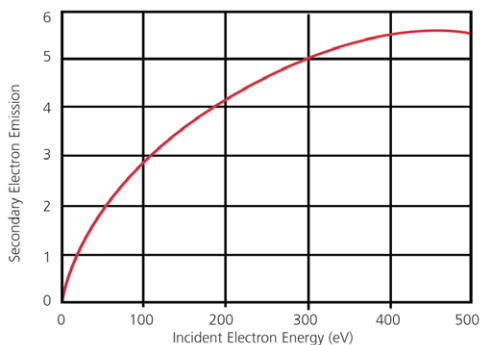


Figure 2: Secondary electron emission. The average number of secondary electrons emitted from the surface of an ETP electron multiplier plotted against the energy of the incident primary electron.



How Electron Multipliers Work

An electron multiplier is used to detect the presence of ion signals emerging from the mass analyzer of a mass spectrometer. It is essentially the “eyes” of the instrument (Figure 1). The task of the electron multiplier is to detect every ion of the selected mass passed by the mass filter. How efficiently the electron multiplier carries out this task represents a potentially limiting factor on the overall system sensitivity. Consequently, the performance of the electron multiplier can have a major influence on the overall performance of the mass spectrometer.

The basic physical process that allows an electron multiplier to operate is called secondary electron emission. When a charged particle (ion or electron) strikes a surface, it causes secondary electrons to be released from atoms in the surface layer. The number of secondary electrons released depends on the type of incident primary particle, its energy and characteristic of the incident surface (Figure 2).

There are two basic forms of electron multipliers that are commonly used in mass spectrometry: the discrete-dynode electron multiplier and the continuous-dynode electron multiplier (often referred to as a channel electron multiplier or CEM). All ETP electron multipliers are of the discrete-dynode type (Figure 3).

A typical discrete-dynode electron multiplier has between 12 and 24 dynodes and is used with an operating gain of between 10^4 and 10^8 , depending on the application. In GC-MS applications, for example, the electron multiplier is typically operated in analog mode with a gain of around 10^5 . For a new electron multiplier, this gain is typically achieved with an applied high voltage of ~1400 volts.

Improved Linearity of the Agilent 5973 with the ETP Electron Multiplier

The exceptional sensitivity of the Agilent 5973 MSD system often results in reduced system linearity due to the limitation of the electron multiplier supplied as original equipment. The ETP (Restek® cat.# 23074) detector system overcomes this limitation as demonstrated in identical performance comparisons undertaken at independent laboratories.



Detector Design

The ETP detector combines innovations in both ion optics and dynode materials to enhance sensitivity and linear system response. The 5973 MSD incorporates a high-energy conversion dynode (HED) to convert incoming ions to electrons. Electrons are then input to the detector for further amplification.

Detailed analysis reveals that conventional HED systems do not take full advantage of the technology. For example, ion detection efficiencies for 500 amu ions are typically limited to between 45% and 70%. Sophisticated ion optics modeling has been used to develop a focused conversion dynode for more efficient collection of incoming ions and subsequent transfer of secondary electrons to the electron multiplier. Figure 4 illustrates the ion optical design of the new detector.

Discrete-dynode technology allows fabrication of dynodes incorporating different materials depending upon anticipated electron flux exposure. This, in turn, allows a detector to be designed for maximum output current linearity while also improving detection efficiency and operational lifetime. The ETP detector incorporates several different materials along the dynode chain, which has resulted in significantly improved performance.

Performance Comparison

EPA Method 8270 was used to compare the performance of the original manufacturer-supplied detector with the ETP multiplier (Restek® cat. # 23074). Figure 5 displays data taken for tetrachlorophenol. As shown, linearity improvement greater than 250% over the original detector was achieved. Similar results were obtained with other compounds using the same methodology.

ETP's electron detector for the Agilent 5973 MSD significantly improves system performance for high-concentration samples. The combination of a focused HED and multiple dynode materials improves both efficiency and operational lifetime.

Figure 3: Ion-optics of an ETP discrete-dynode electron multiplier showing the electron gain at each successive dynode. The electron cascading process results in gains up to 10^8 being achieved with ~21 dynodes.

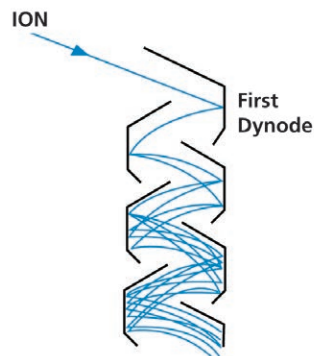


Figure 4: Ion/electron optical design of the ETP (Restek® cat. # 23074) electron multiplier detector.

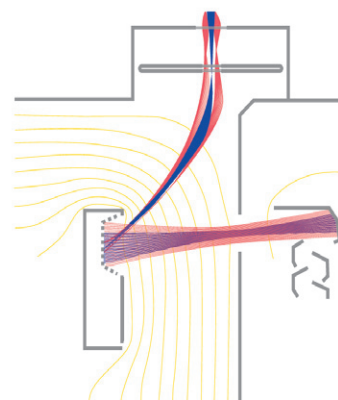
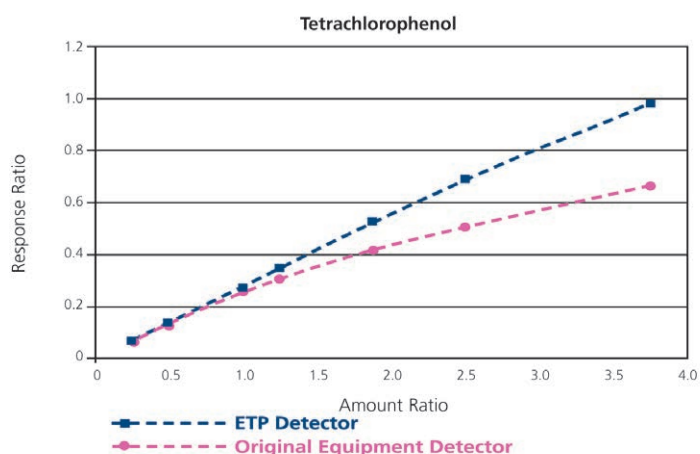
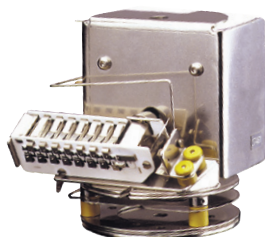


Figure 5: Detector response comparison for tetrachlorophenol.





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- Increased surface area for enhanced sensitivity and extended operational life.

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ETP Electron Multipliers for Mass Spectrometry

- Proprietary specialized surface material resulting in very high secondary electron emission.
- Air stable.
- 2-year shelf life guarantee.
- Discrete dynode design results in extended operating life.

The electron multipliers manufactured by ETP use a proprietary dynode material. This material has a number of properties that make it very suitable for use in an electron multiplier. It has very high secondary electron emission, which allows exceptional gain to be achieved from each dynode. This material is also very stable in air. In fact, an ETP multiplier can be stored for years before being used. As a direct result of the high stability of the active materials used in ETP multipliers, they come with a 2-year shelf life warranty (stored in original sealed package). Many testing laboratories take advantage of this long shelf life by keeping a replacement ETP multiplier on hand, ready for immediate installation. This keeps instrument downtime to a minimum.

For a typical ETP electron multiplier for GC-MS, the total active dynode surface area is ~1,000 mm². This can be compared to a standard continuous dynode multiplier that has a total channel surface area of only around 160 mm² (for a channel with 1 mm diameter and 50 mm length). This increased surface area spreads out the workload of the electron multiplication process over a larger area, effectively slowing the aging process and improving operating life and gain stability.

Description	qty.	cat.#
Electron Multipliers for Agilent GC-MS and LC-MS		
For Agilent 5970 GC-MS	ea.	23072
For Agilent 5971, 5972, GC GC-MS	ea.	23073
For Agilent 5973 & 5975 GC-MS (includes mount for initial installation)*†	ea.	23074
For Agilent 5973 & 5975 GC-MS and LC-MSD (Replacement Multiplier)*†	ea.	23075

*Note: The electron multipliers have been specifically developed to retrofit the original manufacturer's equipment. The detector incorporates a modular design to facilitate ease of replacement and additional innovations intended to enhance performance. First-time installation requires a mount that includes the mechanical housing. After initial installation, only the replacement electron multiplier is required.

†This unit is designed for use in the 5975, 5973 GC, and the LC-MSD (not for 5975C Triple Axis Detector).

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