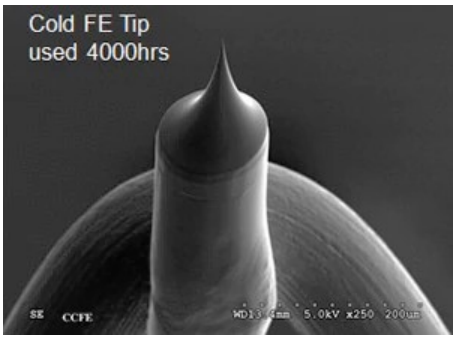
Hitachi's Coherent Cold-Field-Emission Source

Cold-Field-Emission Technology

Field Emission, or FE, refers to a phenomenon where high-density electrons are emitted when a strong electric field is applied to a cathode (an electron emission element) with a sharpened tip. At room temperature, FE technology provides an electron beam that is approximately 1,000 times higher in electron density than conventional thermionic electron cathodes (Tungsten hairpin filament).



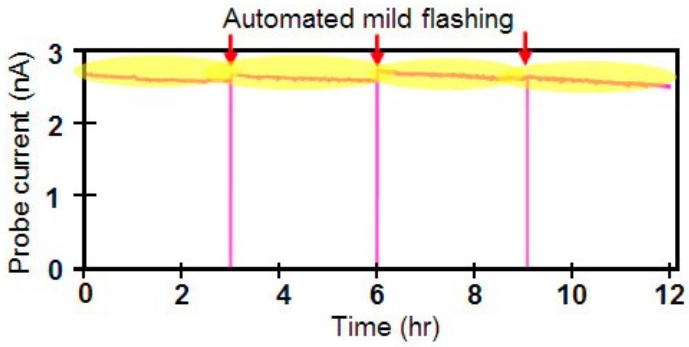
Small source size—fine beam
Small energy spread: 0.2 - 0.3 eV
Higher brightness and resolution

The FE technology has been applied to the development of an electron source for ultra-high-resolution scanning electron microscopes. The key to its practical usability is to stabilize emissions. Since the first practical implementation of cold-field-emission technology in a commercial SEM in 1972, Hitachi has rigorously investigated and applied ultra-high-vacuum technology to house the field emitter and has thus managed to make cold field emission usable for ultra-high-resolution imaging in today's most advanced SEMs, such as the SU8200 series and the SU9000.

New Steady-State Cold-Field-Emission Source

As a result of these efforts, in the latest generation of CFE source SEMs (the SU8200 series and the SU9000), Hitachi has further improved the ultra-high-vacuum condition of the electron gun. This improvement has resulted in stable emission current at higher levels since the amount of gas molecules adsorbed around the FE tip is greatly reduced. Other benefits of the Steady-State Cold-Field-Emission Source include virtually eliminating the need for virtual source drift correction and realignment of focus over several hours of operation.

In addition, Hitachi has developed a patented "Mild flashing®" technology. This technology is executed automatically in the background to gently clean the FE source at regular intervals while maintaining a high voltage. Mild flashing enables stable and continuous operation of the new cold-FE source.



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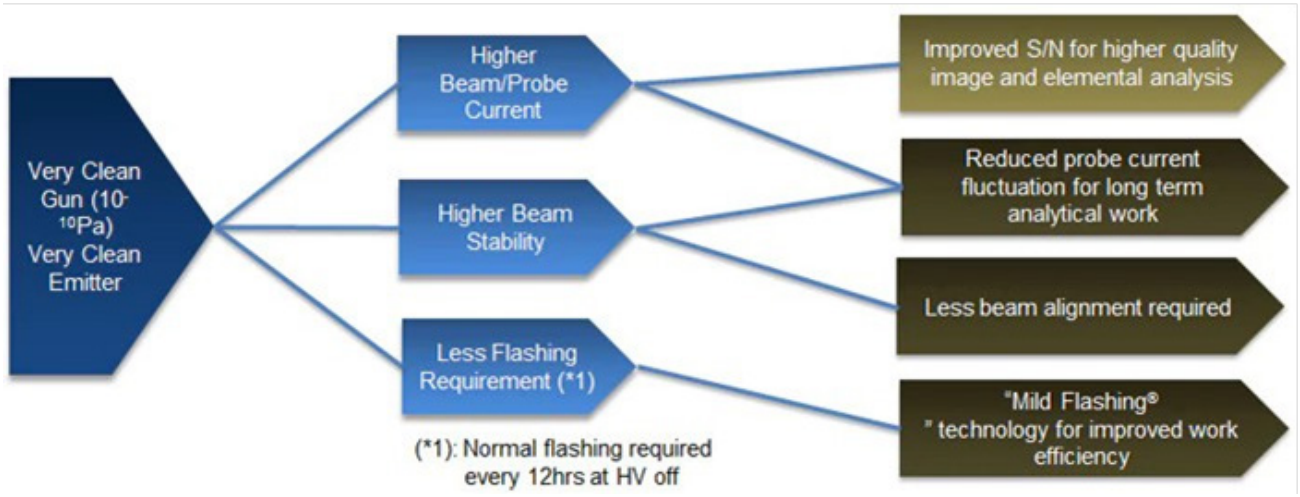
Mild flashing

Automated Mild flashing sequence executed with HV-on in the background. Summary of the advantages of Hitachi's steady-state cold field emitter:

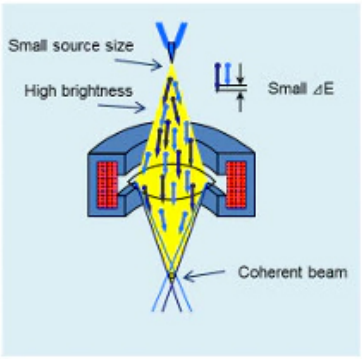


Advantages over Schottky Emitters

Currently, two different FE sources have been established in the marketplace: coherent-beam cold-field emitters and Schottky emitters. Schottky emitters, typically operated at high temperatures of 1,700K, are an excellent choice for general applications focused on analytical work using large, very stable probe currents. However, their effective electron source size and the large energy spread of the emitted electrons severely limit the achievable resolution. Furthermore, the need to exchange Schottky emitters annually is also a considerable cost factor for FE-SEM operation.

Optical Properties of FE source

	Coherent beam Cold FE Gun	Schottky FE
Cathode	Cold cathode	Thermal cathode
Energy spread(⊿E)	**0.2~0.3eV**	0.6~0.8eV
Source size	**< 5nm**	< 30nm
Brightness	**2×10^9 A/cm²sr**	2×10^8 A/cm²sr
Flashing	Required in some way	Flash free



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Ultra-high Resolution Scanning Electron Microscope SU8200 Series
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