A modular 100 keV vacuum sealed FEG

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A modular and ultra-high vacuum (UHV) sealed field emission electron gun (FEG) that is operational in the energy range of 30-100 keV has been developed, where all the electron optical elements (electrodes) of the FEG are under UHV. The modular design of this FEG includes a manual isolation valve on the FEG's optical axis and a differential pumping aperture that can stand off a pressure differential of $>10^{-2}$mbar. This design lends itself to integration onto existing high voltage electron columns, such as upgrading thermionically operated transmission electron microscopes (TEMs) or electron beam lithography (EBL) systems into FEG operation as well as using it in R & D applications. The system occupies a physical envelope of approximately 200mm diameter and about 315mm height (in addition to the high voltage plug). In its current configuration, it has a spherical and chromatic aberration coefficients (C_s and C_c) in the range of C_s = 45-55mm and C_c = 25-27mm, respectively, over a range of working distances at 100 keV of 10mm to 60mm from the exit plane of the unit.

For stable operation of a field emission electron optical system, all the electrodes require stable voltage supplies, where a stand-alone 100kV Power Supply Unit (PSU) together with a plug and cable and a vacuum feedthrough have also been developed to operate the present FEG. The PSU has high stability for all its outputs with voltage ripples of less than 100mV on the beam potential at 100kV, which is a requirement for high resolution field electron emission based optics. An advantageous feature of this development is that the FEG, the feedthrough and the high voltage plug assembly do not require the use of SF_6 gas, as it is customary the practice for High Voltage FEGs used on TEMs. This allows an easier 'Hot Swap' transition for emitter exchange; thus, negating the need to bake the FEG chamber on site to achieve UHV base pressure following an emitter exchange, but equally important this reduces the time taken to exchange a spent emitter.

Operation of the FEG has been demonstrated on a Tecnai 12 TEM, whereby the original thermionic hairpin electron source, the electron gun chamber and EHT unit were replaced with the 'present FEG unit. The sealed FEG chamber is transported under a base pressure in the range of low E^{-10}mbar. To maintain UHV base pressure during operation, an intermediate vacuum chamber evacuated with an IGP to achieve a base pressure in the range of E^{-8}mbar is added to interface between the FEG chamber and the microscope column.

Electron beam current stability of < 1% drift over 24hrs and <0.5% over 1 minute is achieved and operation in the voltage range of 30-100kV has been demonstrated. Graphitic carbon as well as gold particles have been resolved confirming a resolution limit of better than 0.24nm at 60-100 keV. The source brightness for this FEG has been estimated for an emitter operated at an angular current intensity of the order of 250-300μA/ster to be of the order of x150 with respect to the W hairpin source.