A.6: Development of 20 keV, 2 kW DC strip type electron gun system for photon absorber testing

Photon absorbers, also called crotches, are used to absorb unused synchrotron radiation (SR) emanating from bending magnets in synchrotron radiation sources (SRSs). In next generation SRSs, the SR power density required to be absorbed by such crotches is in the range of 10-100 W/mm^2. Such photon absorbers, being designed indigenously, need to be tested with an alternative power source simulating identical power density in vacuum environment. To meet this requirement, an electron gun based test set-up was designed and developed with specifications as mentioned in Table A.6.1.

Table A.6.1: Specifications of electron gun.

Type of electron gun	DC Triode (Strip Type)
Mode of heating	Direct heating
Cathode material	Pure Tungsten
Beam foot print at the photon absorber	(55 mm ± 0.5 mm) x (2.5 mm ± 0.5 mm)
Beam energy	20 keV
Beam power	2 kW @ 100 mA (settable)
Average power density on photon absorber	14.5 W/mm^2
Operating pressure	<1x10^{-06} mbar
Cooling of crotch	Chilled water cooling

Physics design and simulation studies of the electron gun were carried by Accelerator & Beam Physics Section. Based on these studies, Ultra High Vacuum Technology Section carried out design, fabrication of all the components including precision mechanical components such as Wehnelt, anode with machining accuracy of ±20 µm and assembled them within ±100 µm of positional accuracy.

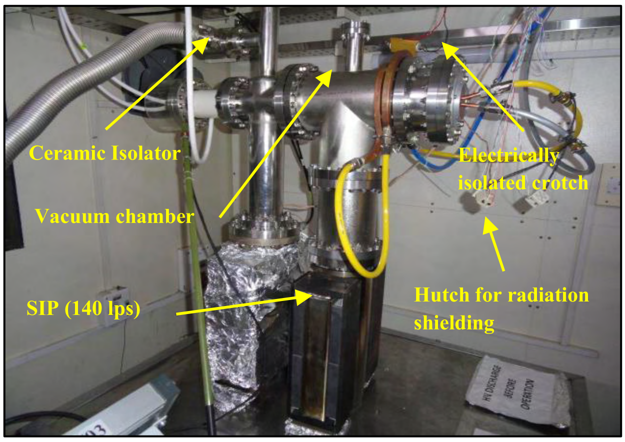
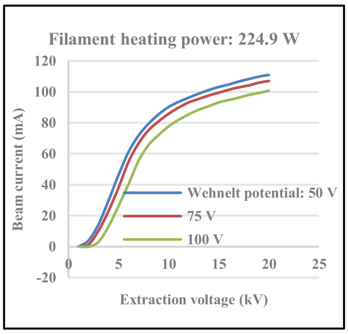
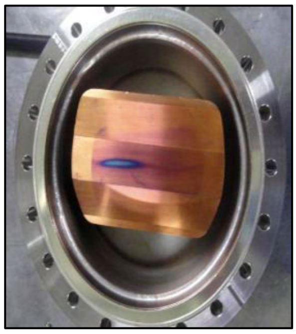


Fig. A.6.1: 20 keV, 2 kW DC strip type triode electron gun test setup.

To provide electrical isolation between HV feedthrough end flange and grounded anode, alumina ceramic chamber was utilized. Kovar end sleeves of this ceramic chamber are welded to DN100CF end flanges by Nd:YAG laser welding process with helium leak tightness better than 1x10^{-10} mbar.litre/s. The entire gun test setup is installed in a radiation shielded hutch, which is designed & fabricated for this purpose as per the recommendations of Health Physics Unit (HPU), RRCAT. Complete test set up is shown in Figure A.6.1. Pure annealed tungsten wire of 0.7 mm diameter and 20 mm length is used as cathode. To meet instrumentation requirements, various power supplies were installed such as 20 kV HVPS for acceleration of beam, HV deck for housing both cathode heating and Wehnelt power supplies, which are floated at -20 kV. Initially, filament is degassed with the help of a TMP station, whereas HV conditioning of entire setup is carried out with and without beam at various Wehnelt voltages using SIPs installed at cathode and crotch. The electron beam is extracted at different cathode heating currents and Wehnelt voltages and by gradually increasing the gun voltage to full HV. In triode mode of operation, the extraction of beam current can be controlled by Wehnelt potential as shown in Figure A.6.2(a). Figure A.6.2(b) shows specimen crotch exposed to 20 keV, 80 mA of electron beam. The DC electron beam current is measured by isolating the crotch, which is mounted on DN160CF end flange using glass epoxy bushes as shown in Figure A.6.1. At cathode heating power of 224.9 W and Wehnelt voltage of 100 V, beam current of 100 mA at 20 kV (2 kW) falling on the photon absorber was measured and temperature of crotch was found to be 38 °C at 20 °C chilled water flow at a rate of 8 lpm. During these beam trials at rated beam power, radiation survey was also conducted by HPU. The radiation level was found to be close to background level inside as well as outside the hutch.



(a)



(b)

Fig. A.6.2: (a) Plot depicting the electron beam extraction at different Wehnelt voltages, (b) specimen crotch exposed to 20 keV, 80 mA of electron beam.

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