38641 - 2002

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SIMPLE UHV PHOTODIODE BEAM POSITION MONITOR AT THE DARESBURY SRS

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SEPTEMBER, 1986

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Abract

Details of the construction and performance of a UHV photodiode beam position monitor are given.

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Introduction

Synchrotron radiation is highly collimated and its position and direction are critical to the operation of experiments on beamlines using this radiation. Generally the vertical beam position and direction are the most critical because most monochromators on beamlines disperse in the vertical plane. The effect of beam movement on monochromators is to change intensity and calibration. Intensity changes occur because the beam is usually aimed down a small aperture. The calibration change is most prominent for those monochromators that use the source as the entrance slit. For example, the SX700 type monochromator [1] installed on the undulator beamline uses the source as an entrance slit. A vertical movement of 1 mm by the electron beam results in a 0.35 eV calibration charge at 300 eV (0.12%). Typical experiments will be looking for energy shifts of this order so beam positional stability needs to be at least × 10 better.

The monitor described here was required to be simple, UHV compatible, able to go through a 70 mm conflat flange, able to measure the beam position to better than ± 0.1 mm and cope with being irradiated with white synchrotron radiation. We opted for a monitor that would move into the beam to measure its absolute position. This contrasts with split monitors that monitor the wings of the beam (see for example ref.[2]). These can suffer from non-linearity with beam current and cannot tell exactly where the beam centre is due to different detection efficiencies for the two halves.

Description

The monitor is shown in Fig.1. It is faced with an OFHC copper block that acts as a heat shield for the stainless body containing the photocathode. The heat shield is separated from the stainless body by thermally insulating ceramics. The copper block contains a 2 × 10 mm aperture covered by 60 μ thick beryllium foil (3 × 20 μ beryllium foils). This filters out the higher divergent UV from the low divergent x-rays. The x-rays passing the foil see a 0.5 mm wide slot in the stainless steel body. This is the angular defining aperture. Behind the slot is an aluminium photocathode. This is shaped so there is no direct line of sight between the photoemitting surface and the insulating ceramics. Experience indicated that failure to do this resulted in contamination of the ceramics due to photodesorbtion and consequent electrical leakage. The photocathode is entirely enclosed except for the slot. This prevents any scattered x-rays, electrons or ions from other parts of the beamline from interferring with the photocurrent measured. Standard UHV PTFE coated wire [3] connects the photocathode to a BNC vacuum feedthrough. This wire is screened with stainless steel tube because the large amount of scattered radiation in the beamline degrades the PTFE to what appears to be carbon in a matter of weeks. The whole assembly is externally coated in aquadag to aid thermal radiation. The monitor can be attached to a standard linear motion drive and can be raised or lowered into the beam. Generally a horizontal beamport is arranged in the beamline so the monitor can be surveyed into position in-situ.

Aluminium was chosen as the photocathode simply because its photoemission efficiency has been measured [4]. Combining this with the transmission curve of the 60 μ beryllium foil [5] gives the response curve of the monitor. This is shown in Fig.2. The peak response of the monitor is for 3 keV radiation which has an FWHM vertical opening angle of 0.45 mrad at 2.0 GeV [6].

Performance

The output of the monitor as it was vertically scanned through the beam is shown in Fig.3. The photocurrent was measured with current amplifier. No bias voltage was found to be necessary.

The monitor is positioned 10 m from the target point on beamline 6. By means of centroid averaging the beam position can be established to ± 0.1 mm, equivalent to ± 0.01 mrad (± 2.06 arc sec). For the monochromators in beamline 6, acceptance apertures are greater than 1 mm so a steering accuracy of ~ ± 0.2 mm is adequate.

In practice this monitor is left permanently in the white beam on orbit height and steering is accomplished by adjusting the beam bump for maximum output from the monitor. A steering accuracy of ~ ± 0.02 mrad is usually obtained. The power output from the SRS at 2 GeV, 300 mA is 12 watts/mrad horizontal. For this monitor subtending 2.5 mrads horizontally the thermal input of 30 watts raises its temperature considerably such that the front copper heat shield attains temperatures of ~ 400°C for a newly injected beam of 300 mA. The temperature of the stainless steel body is somewhat lower ~ 200°C. This causes a drift of the output of monitor of $\lesssim$ 10% in 30 minutes. As beam steering usually takes only a few seconds per beamline this drift is tolerable.

Two monitors have been in operation for some 18 months now. Satisfactory operation has been obtained from them for up to 12 months. After this time the original 20 μ thick beryllium filter appears to have melted or sublimed such that they become increasingly more sensitive to UV radiation. As UV radiation has a higher divergence and a greater photoyield the monitor becomes increasingly less sensitive to vertical beam steering. As a temporary measure three 20 μ beryllium filters are now installed but future developments should include cooling of the copper heat shield and the motorising of the linear motion drive.

References

[1] H. Peterson, Optics Commun. 40 (1982) 402.

[2] S.M. Heald, Nucl. Instrum. Meth. A246 (1986) 411, and references therein.

[3] Habia Cable Ltd., Thornbury Industrial Estate, Short Way, Bristol BS2 4UT.

[4] B.L. Henke, J.P. Krauer, K. Premaratne, J. Appl. Phys. 52 (1981) 1509.

[5] W.M.J. Veigele, At. Dat. Tables 5 (1973) 51.

[6] G.N. Greaves, P.J. Duke and R.S. Holt, Daresbury Internal Report, DL/SCI/TM27E (1981).

Figure captions

Figure 1	Schematic drawing of the photodiode detector.
Figure 2	Spectral response of the photodiode detector.
Figure 3	Output of the monitor as it is scanned vertically through the white beam. Monitor position - 10 m from target point. The SRS was operating at 260 mA, 2 GeV.

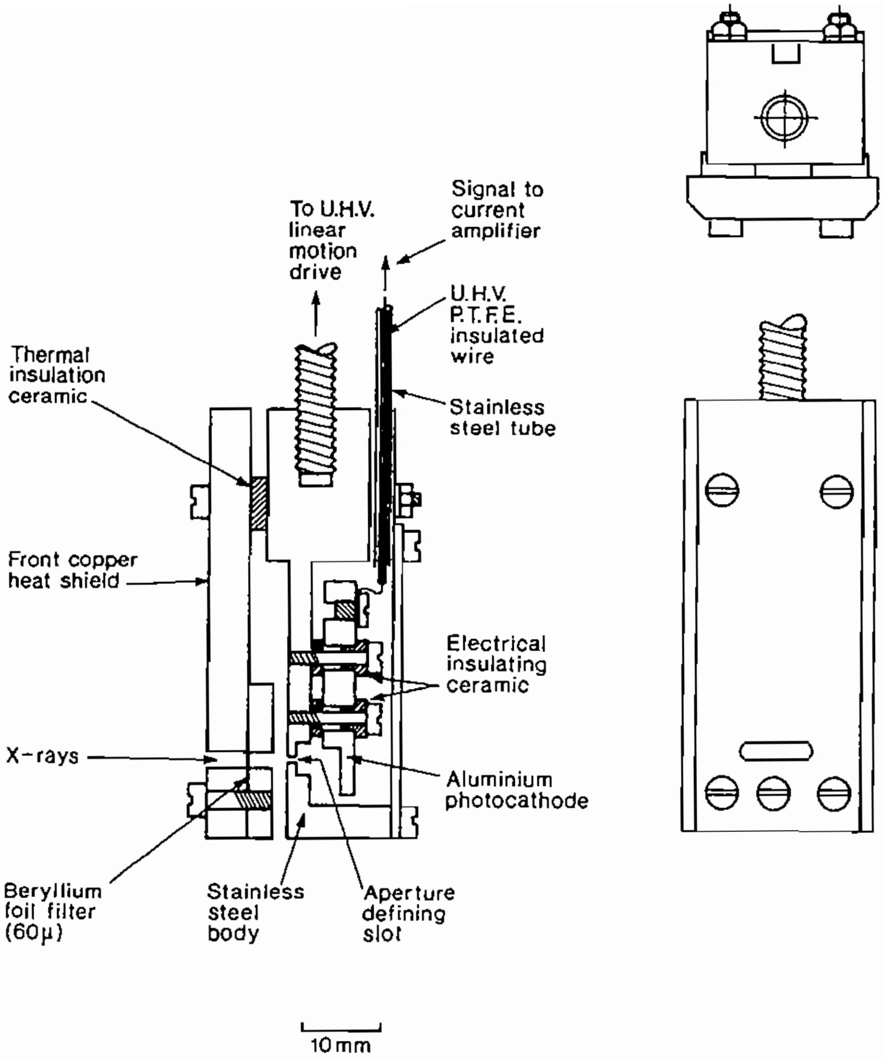
To U.H.V. linear motion drive
Signal to current amplifier
U.H.V. P.T.F.E. insulated wire
Stainless steel tube
Thermal insulation ceramic
Front copper heat shield
Electrical insulating ceramic
X-rays
Aluminium photocathode
Beryllium foil filter (60μ)
Stainless steel body
Aperture defining slot
10 mm

Fig. 1

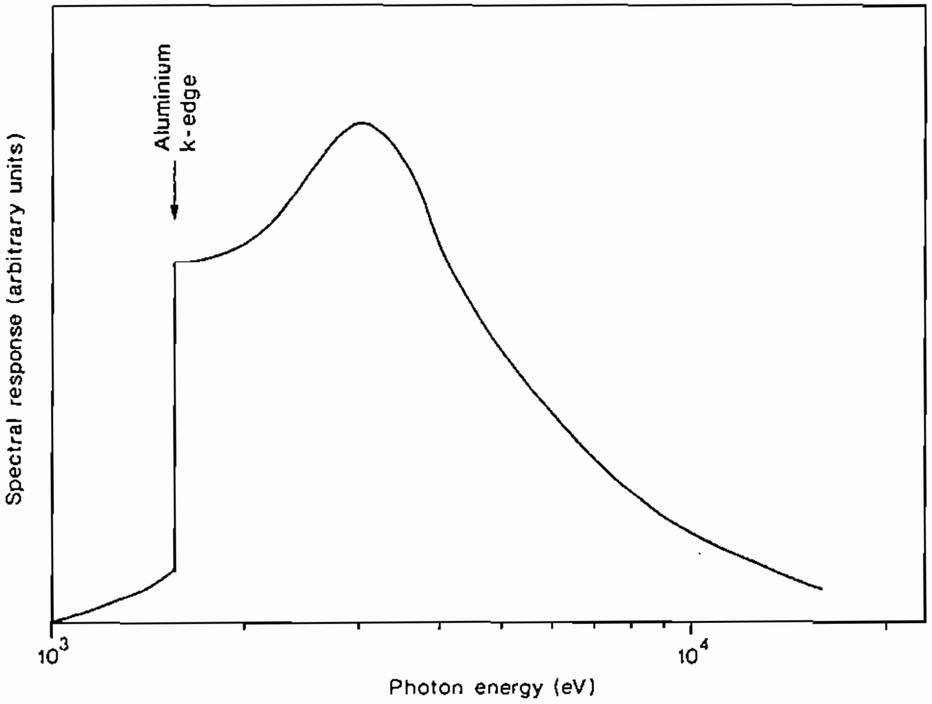
Spectral response (arbitrary units)
Aluminium k-edge
10^3
10^4
Photon energy (eV)

Fig. 2

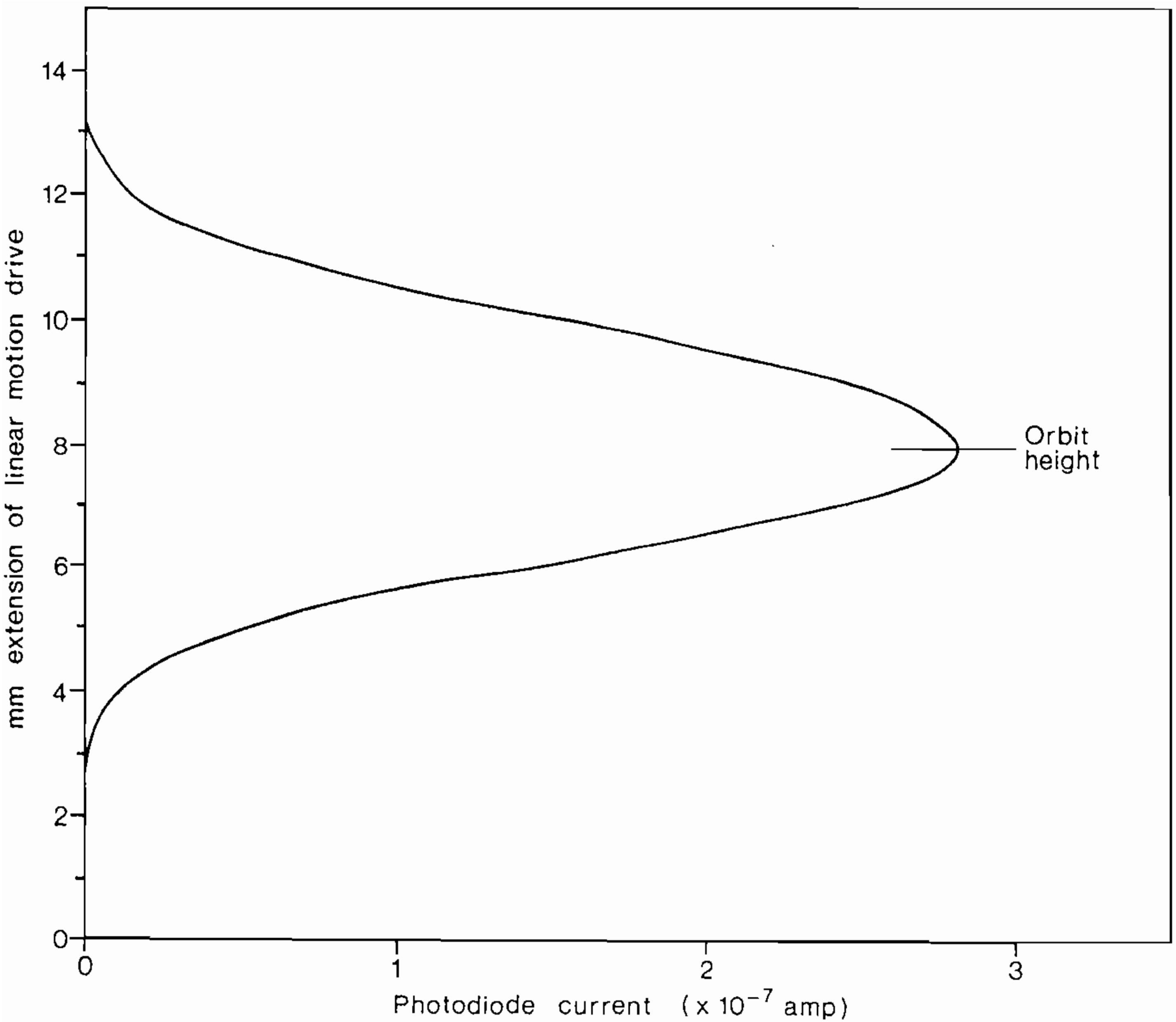
mm extension of linear motion drive
0
2
4
6
8
10
12
14
Orbit height
0
1
2
3
Photodiode current ($\times 10^{-7}$ amp)

Fig. 3