Conceptual Design on an Interlock X-ray Monitor

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1. Introduction

The direction of the synchrotron radiation (SR) beam from the insertion device (ID) might be changed by missteering the electron beam in the SPring-8 Storage Ring. In these cases, the SR beam will hit the beam pipes or the other components which do not have heatproof structures. Therefore the front-end should have an interlock system in order to abort the electron beam in the Storage Ring immediately. The interlock X-ray monitor is designed to detect missteering of the SR beam excess the acceptance and send a interlock signal to the module of network loop in a few msec. We consider that prior requirements of this monitor are reliability, quick response and stability under the sever condition of heat load.

2. Design

The following are the key properties of the interlock X-ray monitor; (1) size of acceptance: The diameter of the acceptance would be about 15mm for undulator beam line components, for example, which corresponds to the entrance aperture of the fixed mask. The aim is to protect beam lines that the fixed mask does not cover. (2) response time: The required response time is less than 1 msec, because metal is supposed to be melted in a few msec in the most pessimistic case that the ID beam hits it at a right angle. (3) installation: The monitor is installed at about 20m distance from the center of the ID, and it is before the fixed mask. We think that it is proper for the monitor to be installed as closer to the ID as possible.

2-1 Probe

We are considering two types of detector heads. They are a graphite type and a diamond type. Typical properties of carbon are shown in Table 1. Especially a high thermal conductivity and a high transmission rate of the X-ray are significant. The former type is made of highly oriented graphite sheet [3] as shown in Fig.1.a. This sheet has a hole in the center, and it is placed on the beam axis. Normally the beam passes through this hole. When the beam hits the sheet by missteering the beam, the signal of photoelectrons is detected. The aperture of the hole is equivalent to the acceptance. The good point of this type is a simple structure. The latter is made of four detector elements which are made of diamond as shown in Fig. 1.b. Each element has an active area at the edge of it, where a pair of electrodes is mounted. The signal of photoconduction from this set of elements gives a position information of the beam at all times [4]. The interlock signal is sent once the beam comes off from the aperture. We think that the good point of this monitor is that further reliability can be added by catching the beam position constantly.

2-2 Chamber

The schematic view of the monitor chamber is shown in fig.2. The monitor chamber is design to have; (1) cooling water lines and good heat contact of the probe, (2) signal read out lines, (3) thermal couple near the probe, (4) bakable structure at 150℃ ($\sim 10^{-9}$ Torr during operation), (5) linear motion to pull out the probe fully from the beam axis and so on. The details are now being designed.

References

[1] manufactured by Matsushita Electric Industrial Co.,Ltd.

[2] manufactured by Sumitomo Electric Industries

[3] The simulation study of heat load and the heating test using test pieces support a feasibility of this type. The results are presented in the SPring-8 Engineering Note FE-005-94 and FE-004-95.

[4] The demonstration of the operation of photo-conductive mode is presented in this issue of the SPring-8 Annual Report.

Table 1. Properties of graphite[1] and diamond[2]

Properties	Units	Graphite		Diamond
Density	[g/cm^3]		2.24~2.25	3.52
Thermal Conductivity	[W/m℃]	(in the a-b plane)	>1000	1000
		(along the c-axis)	5	
Thermal Expansion Coefficient	[℃$^{-1}$]	(in the a-b plane)	-1.0×10^{-6}	2.3×10^{-6}
		(along the c-axis)	27×10^{-6}	
Electrical Conductivity	[Ωcm]$^{-1}$	(in the a-b plane)	$(20\sim23)\times10^{3}$	2×10^{-10}
		(along the c-axis)	5~6	

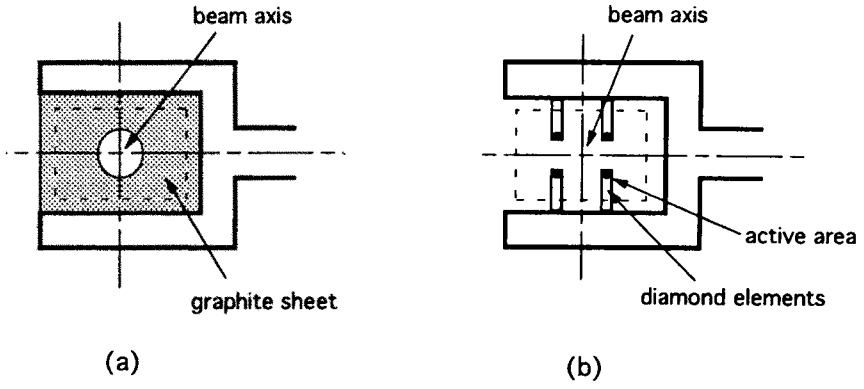

Fig. 1 Schematic view of the detector head (a) using a graphite sheet with a hole in the center and (b) using diamond elements to give the position information.

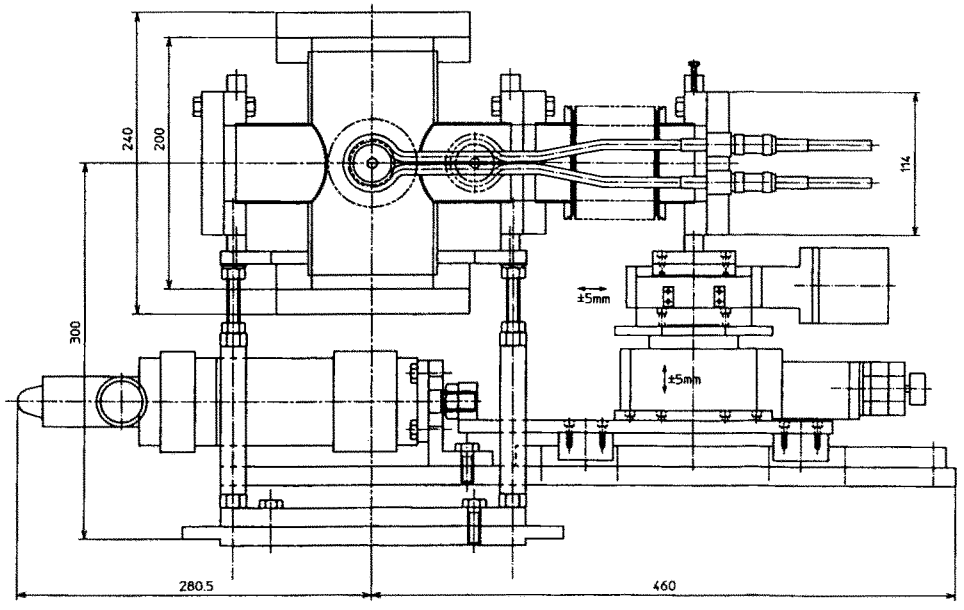

Fig. 2 Schematic view of the monitor chamber.