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Measurement of Radiation Damage on an Epoxy-based Optical Glue^{*}

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Abstract

We measured the radiation damage on an optical glue called Eccobond-24 which is a candidate for CsI and BGO crystal calorimeters of the BELLE detector of the KEK B-factory. Absorption spectrophotometry in the range 300–800 nm was used to monitor the radiation damage. Maximum equivalent dose was 1.64 MRad. The glue shows effects of damage, but is acceptable for the radiation level at the above-mentioned experiment.

1 Introduction

Optical glues have been extensively used in high energy physics experiments for the purpose of optical interfacing of two media of different refractive indices. Interfacing a photodiode with a scintillating crystal is one of its applications. For example, calorimeters EFC[1] and ECL at the BELLE detector of KEK B-factory[2], are proposed to be built of Bismuth Germanate(BGO) and Thallium-doped Cesium Iodide(CsI) crystals, respectively with photodiode read-out.

We have been experimenting with a certain kind of *epoxy-based* optical glue, which would interface the crystals with the photodiodes. Glues based on epoxy resins are normally stronger adhesives, endure greater mechanical and thermal stress and have better resistance to oils and solvent chemicals, compared to their acrylic, silicone or inorganic counterparts. Hence it is tempting to use such glues when one wants to make a maintenance-free detector.

One problem, however, is because of its proximity to the beamline, EFC gets a very high dose of irradiation from physics and background events. It has been estimated to be of the order of 100 kRad/year including accidental beam dumps. The optical glue receives a dose of 10 Rad/year to 100 Rad/year depending on the location. It is therefore important to know the radiation hardness of optical glues before we use them in our detector.

Tests of radiation damage of several kinds of optical glues have been performed[3]. Here we report the results of a radiation damage test on a certain kind of optical glue called Eccobond-24[4], which is known for its

transparency, quick curing, mechanical and thermal stability. The components of the glue are *Bis-phenol A diglycidyl ether* and *Diethyleneeglycol bis-(3-aminopropyl) ether*, mixed in a ratio of 100:30. Curing time of the glue is 3 hours at 25°, strength 130 kg/cm², specific gravity 1.1, and refractive index 1.51 at Na-D line(589.3 nm).

This glue is a candidate material for CsI and BGO calorimeters of the BELLE experiment.

2 Experimental Setup

The glue was prepared according to the instructions, and was filled into transparent plastic cuvettes used for absorption spectrophotometry. Special care was taken not to let any air bubble in the glue volume. Thickness of glue inside the cuvette was 5mm.

Nine such cuvettes were prepared and their transmittances were measured with an absorption spectrophotometer[5]. Then they were placed in front of a ⁶⁰Co source for irradiation. We used the irradiation facility of the National Tsing Hua University in Taiwan. By varying the distance of the cuvette from the source, the amount of dose could be controlled.

The glue started to look yellowish after about 100 kRad of equivalent doses[§], and grew gradually darker with higher irradiation, turning brown above 1 MRad.

After irradiation, the samples were subjected to another transmittance

[§]We define the *equivalent dose* as the amount of dose that would have been absorbed by water if placed at the same position as the sample. *Absolute dose* absorbed by the glue is estimated to be about the same as the equivalent dose.

measurement, and the values were normalized to the transmittance prior to irradiation. A slight correction (about 1%) due to loss in transparency (only in very short wavelength region of $\lambda < 400$ nm) of the plastic cuvette was applied.

Relative transmittance as a function of wavelength (from 300 to 800 nm) was measured by the absorption spectrophotometer for samples irradiated to different doses. From this measurement, spectral transmittance of the glue as a function of equivalent dose could also be calculated.

3 Results

In Fig. 1 we show the relative transmittance of samples irradiated to different doses as a function of wavelength of incident light. The contours are marked by the corresponding equivalent radiation dose on the plot.

Strong absorption is seen for wavelengths of 400 nm or less for doses of 2 kRad or more.

4 Conclusion

The epoxy-based optical glue Eccobond-24 has been subjected to a radiation hardness test. The glue shows strong absorption above the equivalent dose of 2 kRad. This optical glue is still safe for application in EFC and ECL calorimeters at B-factories, since the equivalent dose on the glue would be less than 100 Rad/year.

Epoxy glues of better radiation hardness, however, have been reported in Ref. [3].

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Figure 1: Relative transmittance of samples of glue as a function of wavelength for different equivalent doses