SDC-92-291

SDC
SOLENOIDAL DETECTOR NOTES

FIBER SPUTTERING AND PAINTING

July 17, 1992

E. Hernandez, E. Bartosz, M. Bertoldi, V. Hagopian, K. Hu,
C. Immer, A. Kleinhammes and J. Thomaston
Florida State University

FIBER SPUTTERING AND PAINTING.

E. HERNANDEZ, E. BARTOSZ, M. BERTOLDI V. HAGOPIAN,
K. HU, C. IMMER, A. KLEINHAMMES, J. THOMASTON.

High Energy Physics, Florida State University,
Tallahassee, FL 32303.

ABSTRACT

The selection of the sigma design for the plate-fiber modules of the SSC calorimeter has reduced by a factor of two the number of fiber ends that will be read directly by photomultiplier tubes. With this design, only one of the ends of a fiber will be connected to a readout channel. In order to avoid wasting the light coming from the other end of the fiber inside the plate, mirroring techniques such as sputtering and painting are being studied. The sputtering and/or painting of optical fibers such as BCF91A considerably increases the light output of the plate-fiber system.

KEYWORDS

Sputtering; diamond cut; fiber.

FIBER SPUTTERING: SILVER AND ALUMINUM.

We began our studies on the sputtering of fibers by first measuring the light output of BCF91A fibers (75 cm long) in our "Black Box" set up. As fig. 1 shows, the interior of this set up consists of a hollow square track with a groove. The inside of the track is kept under a vacuum so that when the fiber is placed along the groove, it is held in place by the suction. A computer controls a movable blue light head by using a stepping motor that travels along the length of the fiber, and the light output is read by a phototube as the blue light head moves down the fiber. The sputtering of the fibers was done at FSU by the Materials Science Research group. The sputtering was done in argon at a vacuum of 4.1 X 10 $^{-3}$ Torr. The calculated deposition of aluminum was approximately 680 nm thick on each fiber end.

Diamond-Cutting

Diamond-cutting the ends of a fiber before sputtering offers an advantage over just placing the fiber in our specially designed fiber holder and shaving it with a razor blade. When a fiber is diamond-cut, a flat surface is created at right angles with respect to the fiber length. The fibers were measured in the previously described set up after being sputtered. These results are shown in fig. 2. As seen in fig. 2, the improvement in the light output at the sputtered end of the fibers over the plain fibers was approximately 66% or better. Also, the diamond-cut fibers sputtered with aluminum and silver provide similar light outputs. On the basis of these results, all subsequent sputtering was done with aluminum. Upon handling the fibers to make different light ouput measurements, we discovered that the sputtered material came off very easily, especially in the perimeter, thus reducing the increment in light output.

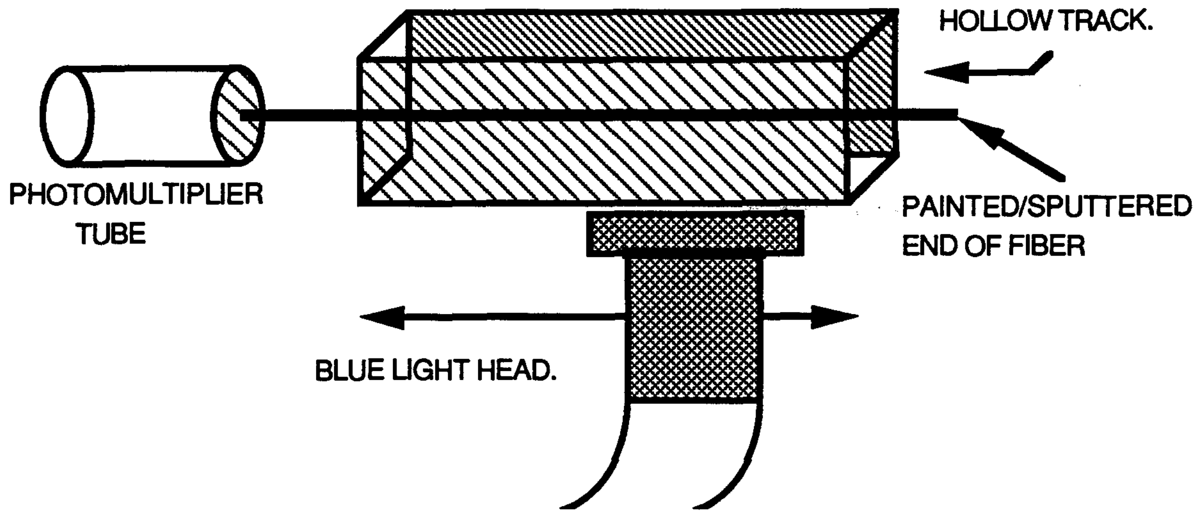

Fig. 1.- Inside of fiber scanning device at Florida state university.

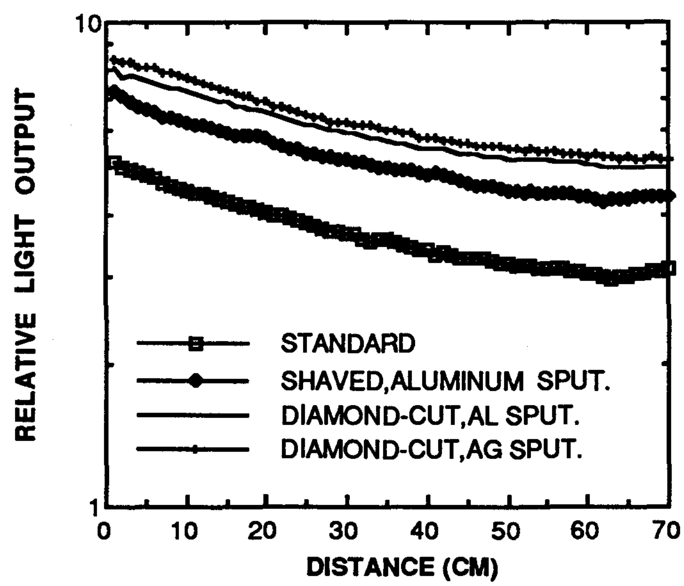

Fig. 2.- Aluminum and silver sputtering results (8 KeV X ray excitation).

FIBER PAINTING

Another way to achieve partial light reflection is to paint one of the ends of the fiber with white titanium dioxide paint. This method proved to be faster and simpler than sputtering. All that is required for this quick procedure is to diamond-cut the fiber and dip one of the ends into a very shallow (1 mm) paint container. The paint takes approximately 10 minutes to dry once it is on the fiber. When a fiber end is painted with this white, water-based paint, we obtain similar results to those of a sputtered fiber; namely, an increase in light output. However, if we compare the percentage of light output increase from fig.2 with that of fig. 3, we note that the sputtered fibers do provide a greater increase.

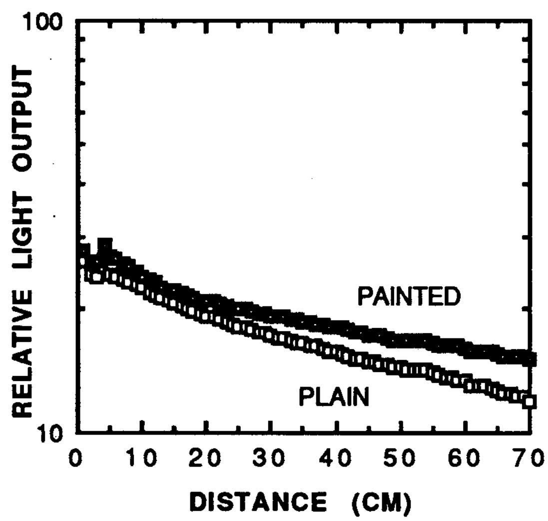

Fig. 3.- Light output from a plain and a painted fiber (Blue light excitation).

After seeing the results from painted and sputtered fibers, we took these fibers and placed them inside a plate with the sigma groove design to make light output measurements. This measurements also took place in our "Black box" but with a different set up (V. Hagopian et al. conference proceedings). As fig. 4 shows, the uniformity of the light output from the sputtered and painted fibers in comparison to the plain fiber was almost identical. It should be noted that even though a single sputtered fiber when measured by itself shows a 66% increase in light output, once inside a plate this increase reduces to only about 40%.

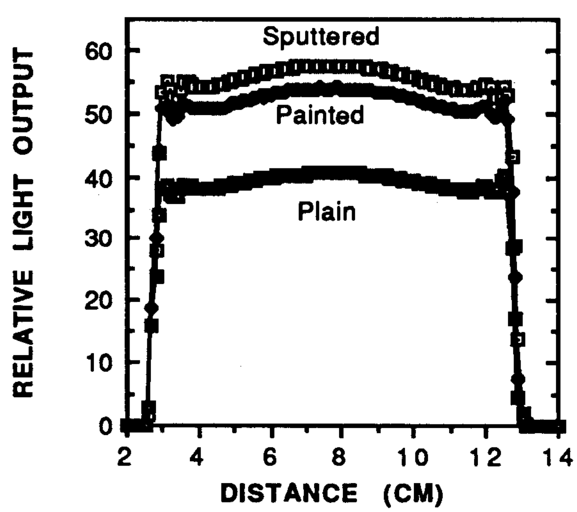

Fig. 4.- Light output of a BC499-27 plate with BCF91A fibers.

RESEARCH CONTINUATION AND RECENT RESULTS

Since the presentation of this data at the conference, further results have been obtained. Recent sputering samples show from 96 to 100% reflectivity. This was achieved by following Fermilab's Eillen Hahn's advice of cleaning of the ends of the fibers with ethyl alcohol and sputtering a thinner coat. Figure 5 shows our most recent and best results . This batch of diamond-cut BCF91A fibers received a coat of approximately 2000 Å.

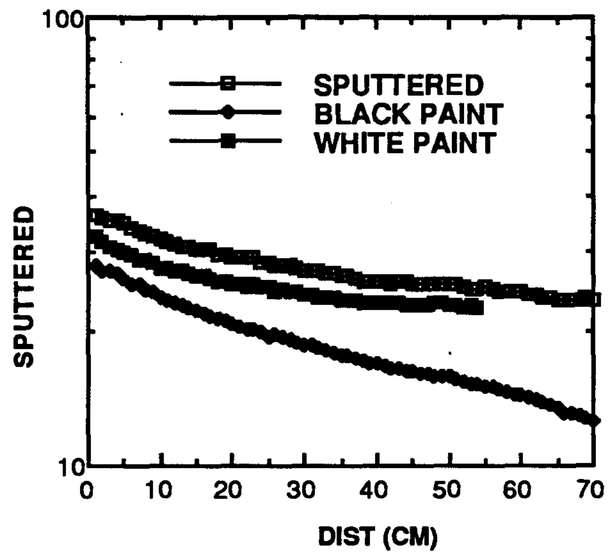

Fig. 5.- Light output of a sputtered BCF91A fiber. (Blue light excitation).

CONCLUSIONS:

The sputtering of fibers increases the light output from the plate-fiber system with the sigma design. After sputtering several fiber ends with aluminum and silver, we concluded that they have similar reflectance. The sputtering of a diamond-cut fiber, as shown in fig.2, increases the light output by about 66%. We have discovered that the delicate sputtered material comes off very easily, especially in the perimeter, thus reducing the reflectivity. Recent results show that proper cleaning of the fiber and a thinner coat increases the reflectivity of the fiber end. The use of titanium dioxide paint instead of sputtering increases the light output by only about 30% but offers a more durable surface. When we placed the painted and sputtered fibers in a BC499-27 plate with the sigma design, definite increases in light output were observed. Most importantly, neither the sputtering nor painting of fibers affects the uniformity of the light output of the plate-fiber system.

This research was partially funded by the U.S. Department of Energy and by the Texas National Research Laboratory Commission Fund.

REFERENCES:

1) Hagopian, V. et al. (1992). Single tile-fiber unit of SDC calorimeter. In: RADDAM 92 proceedings. Pergamon Press, Oxford.