CASE STUDY

EP30LTE-LO: Used in Composite Conical Reflector on the International Space Station

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Overview of EP30LTE-LO

Master Bond EP30LTE-LO is a specialty epoxy system featuring a low coefficient of thermal expansion (CTE) and is cryogenically serviceable with a temperature range of 4K to +250°F. It passes NASA's low outgassing test,[1] allowing it to be used in high-vacuum applications such as those in outer space. In fact, EP30LTE-LO has been used to produce a composite conical reflector for use on the International Space Station (ISS) as part of its ongoing efforts to probe fundamental physics in outer space.

Application

The Alpha Magnetic Spectrometer (AMS) is a particle physics experiment module mounted on the ISS and is dedicated to probing fundamental physics in space. To study topics in astroparticle physics such as the existence of antimatter or the relative abundances of light isotopes and charged nuclei, it is necessary to precisely determine the masses of charged particles. To do this, the authors designed a Ring Imaging Cerenkov Detector (RICH) that could measure the velocity of particles in space with sufficient accuracy based on the Cerenkov effect. The top of the RICH was a dielectric material, so when a charged particle crossed the radiator, it created a cone of Cerenkov radiation. However, only about 30% of the Cerenkov photons emerging from the radiator were directed at the Cerenkov photon detector array, so the authors designed a conical reflector to help collect them.

The reflector was produced in 120-degree composite segments that were framed with composite ribs along the entire perimeter of the mirror. They used a BRYTE EX-1515/M55J Laminate with Unidirectional Prepreg composite and adhered it with Master Bond EP30LTE-LO.

Key Parameters and Requirements

To create the conical reflector, the authors adhered three 120-degree cyanate ester composite segments together using Master Bond EP30LTE-LO. The authors constructed the reflector by a replica technique, beginning with a mandrel on which the carbon fiber-reinforced composite (CFRC) was plied, which served as the lateral surface of the reflector. Doing this helped properly position the composite before oven curing under vacuum before beginning the surfacing process to ensure sufficient reflectivity. The authors used a patented AMS-02/RICH2-105 technique to apply a thin layer of resin (~ 0.1 mm) between the CFRC and the mandrel, followed by a second cure.

The authors needed a mandrel with the exact shape, dimensions, and roughness of the reflector to be produced. The flanges and ribs were adhered to the lateral surface using EP30LTE-LO using the mandrel as a geometrical reference. Following this procedure, the three separate sections were produced and then assembled by gluing the vertical ribs using the mandrel as a jig (**Figure 1**). Once all pieces were glued into place, the authors produced a reflective coating by vacuum-depositing a 100 nm layer of aluminum and a 300 nm layer of SiO_2 to ensure a reflectivity >85% at 420 nm.

Results

To collect the Cerenkov radiation emerging from the radiator, the conical reflector was required to have a reflectivity of >85% at a wavelength of 420 nm. To create a reflective surface, the authors used a reflective coating composed of 100 nm aluminum and 300 nm SiO_2 particles. Two samples of the reflector showed a surface roughness of less than 5.3 nm and a reflectivity greater than 85% at 420 nm.

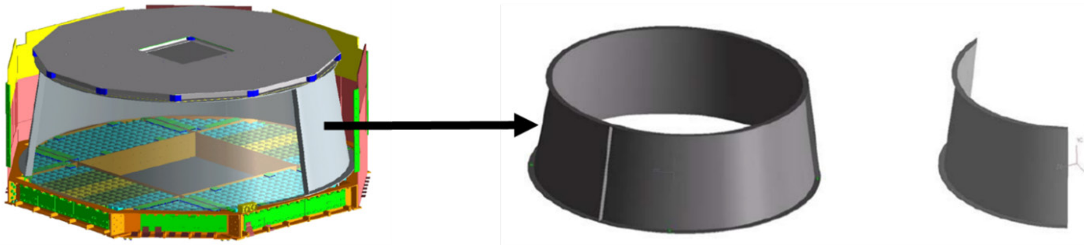

Figure 1. Diagram of the conical Cerenkov reflector, wherein Master Bond EP30LTE-LO was used to adhere the composite ribs to the reflector.

To validate the design of the AMS-02 RICH, the authors constructed a prototype with an array of 9 x 11 cells similar to those of the final model. Because the AMS detector was so complex, to verify the performance of the experiment and its thermal control hardware under thermal vacuum conditions and ensure that no degradation would occur during or after the test, the authors performed a thermal vacuum and thermal balance test after integration at The Large Space Simulator (LSS) at ESTEC. The AMS-02 was launched in May 2011 and has since collected information from over 246 billion cosmic ray events.[2,3]

References

[1] NASA Low Outgassing | MasterBond.com. https://www.masterbond.com/certifications/nasa-low-outgassing (accessed 2025-02-14).

[2] AMS-02 | The Alpha Magnetic Spectrometer Experiment. https://ams02.space/ (accessed 2025-02-11).

[3] Chung, C.H. et al. The AMS Collaboration. AMS on ISS Construction of a particle physics detector on the International Space Station. https://www1b.physik.rwth-aachen.de/~schael/AMS_files/2004_ams_nim_paper_draft.pdf