MASTERBOND®
CASE STUDY

UV10TKLO-2: Used to Adhere Mirrors in a Kirkpatrick-Baez Microscope to Image X-ray Emissions During Deuterium-Tritium Implosions

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Overview

Master Bond UV10TKLO-2 is a one-component UV-curable system for high-performance bonding, sealing, and encapsulation applications. It meets NASA's specifications (ASTM E-595) for low outgassing and can be readily cured using UV light at room temperature. Due to its low outgassing, UV10TKLO-2 is suitable for use in applications that involve the use of a vacuum, including optical equipment such as Kirkpatrick–Baez (KB)–type X-ray microscopes to measure the performance of a fuel used in nuclear fusion.[1]

Application

Thermonuclear fusion generates enormous amounts of energy and occurs when two nuclei, such as deuterium and tritium, combine to form nuclei with a higher molecular weight, such as helium. Deuterium-tritium (DT) is a fuel used in thermonuclear fusion reactions that is imploded to initiate fusion, self-heating, and ultimately ignition. Thus, the implosion step is critical to obtaining a self-sustaining nuclear fusion reaction. During this process, DT emits X-ray radiation that can be used to measure its implosion performance, providing valuable information about the performance of this fuel. Researchers at the Laboratory for Laser Energetics at the University of Rochester have developed a Kirkpatrick–Baez (KB)–type X-ray microscope that can image X-ray emissions from laser-generated plasmas from DT. The microscope consisted of compact KB mirrors and was coupled to a high-speed camera to measure the hotspot evolution of cryogenically-cooled DT implosions. The experiment was performed on the University of Rochester's OMEGA Laser System, which delivers laser pulses to targets and then measures the resulting nuclear and fluid dynamic events.

Key Parameters and Requirements

KB mirror pairs were used because they can provide focus with a minimal loss in intensity after being properly aligned, which was necessary for obtaining a correct focus. Therefore, the researchers needed a high-quality, vacuum-qualified, UV-curable adhesive to ensure long-term adhesion. Master Bond UV10TKLO-2 satisfied these requirements because it can be UV cured and meets NASA low outgassing requirements. The mirrors of the KB microscope were held in place by applying an adhesive to their optic base and then UV-curing them into place. The adhesive itself acted as a tilted interface to the flat optical base. According to the researchers themselves, UV10TKLO-2 was chosen because it "is the one of highest-quality-known, vacuum qualified, UV-curable" adhesives. At Master Bond, we recommend curing UV10TKLO-2 at 320–365 nm with a minimum intensity of 20–40 mW/cm^2.

Results

The researchers successfully designed a KB microscope and coupled it to a high-speed camera to obtain images of X-rays emitted from laser-generated plasmas of DT targets. To achieve this, they properly aligned the mirrors of the camera to capture all X-ray emissions from the DT fuel during its implosion. The researchers used UV10TKLO-2 to hold the KB mirrors in place to obtain the optimal mirror alignment and focus. Master Bond UV10TKLO-2 has successfully held the mirrors in place for more than two years since they were first installed, with no observable changes in image position. The resulting instrument, called KBFRAMED, was used to obtain a spatial resolution of 6 **μm** and a time resolution of 30 picoseconds when used to measure the hot spot of cryogenically-cooled DT target explosions. Ultimately, this instrument is useful for obtaining time-resolved changes in the shape and size of these hotspots, providing valuable information about the performance of DT fuel.

References

[1] Marshall FJ, Bahr RE, Goncharov VN, Glebov VY, Peng B, Regan SP, Sangster TC, Stoeckl C. A framed, 16-image Kirkpatrick-Baez x-ray microscope. Rev Sci Instrum. 2017 Sep;88(9):093702. doi: 10.1063/1.5000737. PMID: 28964245.