A major purpose of the Technical Information Center is to provide the broadest dissemination possible of information contained in DOE's Research and Development Reports to business industry, the academic community, and federal, state and local governments.

Although a small portion of this report is not reproducible, it is being made available to expedite the availability of information on the research discussed herein.
MASTER

TITLE USE OF LASERS AT THE LOS ALAMOS HOT-CELL FACILITY

AUTHORS Michael E. Lazarus

SUBMITTED TO Proceedings published by SPIE - Los Alamos National Laboratory Conference on Optics '83 Santa Fe, NM April 12, 1983

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes.

The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.
Use of Lasers at the Los Alamos Hot-Cell Facility

M. E. Lazarus

Los Alamos National Laboratory, Los Alamos, NM 87545

Abstract

An optical profilometer that uses a Techmet LaserMike scanning, focused, laser-beam, optical micrometer is installed in a remote alpha-gamma containment cell at the Los Alamos Hot-Cell Facility. A hot-cell extension chamber provides the nominal 30-cm (12-in.) working distance required by the LaserMike and, at the same time, keeps the LaserMike components outside the high-radiation-containment environment. This system provides measurement accuracy better than ±5 μm (0.0002 in.) on diameters between 2 and 13 mm (0.08 and 0.5 in.) at a rate of 33 measurements per second.

The Hot-Cell Facility also uses a Korad 20-J output ruby pulsed laser to drill a hole in reactor-fuel-element cladding to sample fission gas. The laser is then used to reweld the hole so that the fuel element will not be contaminated and may be stored without an alpha-containment barrier. The wall thickness of the fuel elements sampled varies from 0.25 to 0.50 mm (0.010 to 0.020 in.).

Introduction

At the Los Alamos Wing 9 Hot-Cell Facility, lasers provide a remote method for drilling and rewelding irradiated fuel elements and for making highly accurate, noncontacting, profile measurements of fuel elements.
The facility consists of 20 cells, each 3.4 m (11 ft.) high x 2 m (6 ft.) square, individually shielded with high-density [0.8-m (32-in.)-thick] concrete. The cells are used for remote examination of highly radioactive fuels and materials. Many of these examinations are done on experimental irradiated fuel elements that are between 1 and 1.5 m (39 and 60 in.) long. The reactor fuel is encased in a stainless steel tube that varies between 0.5 and 1.0 cm (0.2 and 0.4 in.) in diameter with a wall thickness between 0.25 and 0.5 mm (0.010 and 0.020 in.).

Equipment used for these examinations is placed outside the hot-cell whenever possible, for two reasons. (1) Equipment placed in the cell may become contaminated with fuel. Once contaminated, equipment must be calibrated or repaired remotely which can be difficult, and sometimes impossible. (2) Radiation levels in the cell can damage electronic equipment and optical components: transistors and other semiconductors are destroyed, plastics become brittle and cracked, and glass darkens.

Equipment

The profilometry system$^2$ makes accurate [better than \( \pm 5 \mu\text{m} \) (\( \pm 0.0002 \text{ in.} \))] diameter measurements on irradiated reactor fuel elements as a function of position along the length of the element, and also as a function of the element's radial orientation. It provides accurate indications of changes in diameter in less than 125 \( \mu\text{m} \) (0.005 in.) along the element length. This system uses a TechMet LaserMike$^3$ Model 501A focused, scanning laser beam that scans a fuel element 333 times per second at a velocity of about 200 m/s (7800 in./s). The scanning beam is created by reflecting the laser beam off of a rotating mirror. The fuel
element is placed between the beam and a photodetector, which measures the length of time that the beam is blocked by the fuel element. This time is directly proportional to the element diameter. The beam diameter at its focal plane is approximately 0.13 mm (0.005 in.).

Two laser beam systems, collimated and focused, are available from Techmet. The focused beam is smaller, providing greater resolution than the collimated beam, but accuracy is sacrificed by movement of the fuel element toward or away from the beam's focal plane.

The LaserMike requires a nominal working distance of 30 cm (12 in.), so depleted uranium was needed to provide sufficient radiation shielding under this constraint.

Figure 1 shows the profilometer equipment arrangement. Mirrors in the laserMike head reflect the laser beam toward the fuel element. The radiation beam emitted by the fuel element passes through the mirrors and is stopped by the port shields. This model LaserMike makes two simultaneous measurements 90° apart and can provide 666 scans per second. One set of measurements can be made every 0.025 mm (0.001 in.) along the length of a fuel element. The data are recorded by computer on magnetic tape as a series of longitudinal positions and diameters. Averages of each successive 10 diameters are taken to reduce the noise or scatter in the data and the averages are then plotted. The fuel element can be rotated in 1.8° increments and the measurements repeated. A three-dimensional surface plot can then be made of the element.

The laser fission gas sampling system uses a 20-J-output ruby pulsed laser to drill a hole in the fuel element cladding from which gas samples are taken. The hole is rewelded by laser and the fuel element can be stored without an alpha containment barrier. (If the hole were not sealed, the fuel element would have to be stored in a sealed stainless steel tube to prevent fuel particles escaping into the storage area.) Figure 2 shows the component arrangement.
The laser is mounted along the outer face of the cell wall and the beam is reflected 90° through the hole in the cell wall by a mirror. The beam is focused onto the surface of the fuel element using a 100-mm focal length acromat. The beam then passes through a quartz window, which maintains the vacuum around the fuel element, and then through a microscope slide, which is used as a spatter shield. The spatter shield is replaced after about three fuel elements are processed and the quartz window will probably require replacement approximately every 2 years. The viewing lamps become hot enough during operation to anneal any radiation darkening, and replacement is not normally required. The lens, darkened by radiation, must be replaced every 6 to 12 months.

Figure 2 shows an example of a hole and a weld made by this system. To reweld the hole, the laser power is increased by a factor of 4 to 8, the beam is defocused slightly to melt enough metal to fill the hole, and the laser pulse time is increased so that the metal is molten long enough to fill the hole. The lens has a viewing assembly so that both the hole and the weld can be examined visually. The released fission gas is expanded into three known volumes. The amount of gas and the empty volume inside the fuel element are determined from the known volumes and the gas pressures from each expansion. A sample of the gas is sent for mass spectrometric analysis.

References


Acknowledgments

I thank Warren T. Wood for his encouragement and suggestions. This work was supported by the U. S. Department of Energy.
Fig. 1. Hot-cell extension profilometer.
This system provides a method for quantitative sampling of fission gas for analysis and determining the void volume of reactor fuel pins.

Fig. 2: Laser fusion gas sampling system