FIBER-OPTIC LASER TECHNOLOGY FOR DECONTAMINATING METALS

The laser, once a laboratory curiosity, has emerged as a powerful industrial tool. Millions of lasers have found their way into the marketplace ... from the supermarket register to the home stereo system. As larger, more powerful, laser systems have become available, a variety of industrial uses from cutting to welding have become commonplace. The ability to deliver energy remotely, precisely, and under computer control makes lasers the systems of choice for many industrial jobs.

In 1989 the U.S. Department of Energy identified, as a key mission, the remediation of facilities that were used for the production and use of special nuclear materials. Many of these facilities need to be decontaminated prior to decommissioning and contain many millions of pounds of valuable metals that could be recovered for industrial use. In the majority of instances, the contamination is restricted to a small layer close to the surface of the material and if that layer can be selectively removed from the bulk of the material, the vast majority of the metal would be potentially recyclable. However, traditional methods of surface cleaning (e.g., steel wool and soap solutions) are time and labor intensive and can require the use of liquids that become contaminated themselves, requiring special disposal. As a result of these problems most of these metals are not treated, are classified as radioactive wastes, and are buried in landfills. This depletes both landfill space and metal resources.

In 1990 a research team at the Ames Laboratory began work to test whether lasers could be used to selectively remove the surfaces of contaminated metals so that treated metals could be released for unrestricted use. By 1992 a test on a contaminated section of aluminum duct had demonstrated success. The treated material met all conditions for unrestricted release set by the Department of Energy. Virtually no secondary waste was generated during cleaning and the computer controlled laser permitted the operator to work far from the workpiece to prevent radiation exposure.

The Fiber-Optic Laser Technology for Decontaminating Metals was developed in 1995 as a result of a collaboration between the Ames Laboratory laser decontamination team and the Idaho National Environmental and Engineering Laboratory (INEEL). It improved upon the method developed in Ames by introducing a fiber optic delivery system that permits laser energy to be efficiently ported to remote locations where it can be used for surface cleaning.

INEEL has many materials that are highly radioactive and require isolation in glove boxes and hot cells. Porting laser energy from an industrial laser to materials within such environments posed several problems. The laser originally selected in Ames for decontamination work, an excimer laser operating in the ultraviolet portion of the optical spectrum, was incompatible with fibers that work best in the visible or near infrared portions of the spectrum. Conventional near infrared lasers had very short pulse lengths and repeatedly caused damage to fibers that could not be tolerated in an industrial system that needed to be reliable and rugged.

The solution was provided by an acousto-optic Q-switched laser that operates in a compatible part of the optical spectrum and has pulse widths sufficiently broad to preclude fiber damage. The surface cleaning efficiency obtained with this laser exceeded that demonstrated with any other laser system tested in Ames. Most importantly, the laser delivery fiber, optics head, and collection cell could be flexibly deployed using robotics end-effectors at remote locations. This system was patented in 1998 and was licensed to ZawTech International in that year.

The application of lasers to radioactive decontamination is only one of many that can be envisaged for this system. A focused laser beam that is sufficiently powerful to ablate microns from a stainless steel surface will destroy hazardous chemical or biological contamination on surfaces. The ability to conveniently direct that energy by fiber optics means that the cleaning operation can be conducted safely.

Contact: Martin Edelson • Ames Laboratory - Iowa State University • 130 Spedding Hall Ames • IA 50011
515-294-4987 • Fax 515-294-1230 • edelson@ameslab.gov or martine4@aol.com

FIBER-OPTIC LASER TECHNOLOGY FOR DECONTAMINATING METALS

The first demonstration of success in metal decontamination via laser cleaning was accomplished by showing how contaminated aluminum ductwork could be cleaned via excimer laser treatment. The key thing to note in the graph below is that useful decontamination could be accomplished at up to 2 m^2/hour. This answers the common question of how lasers, focused to small areas, can perform useful work on a "macroscopic" scale.

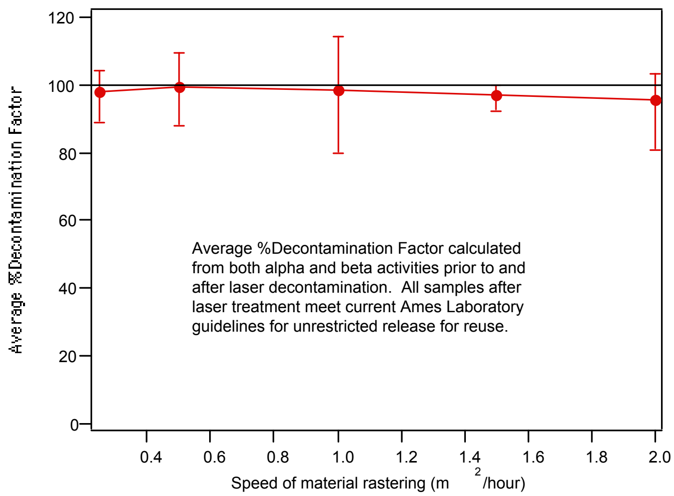
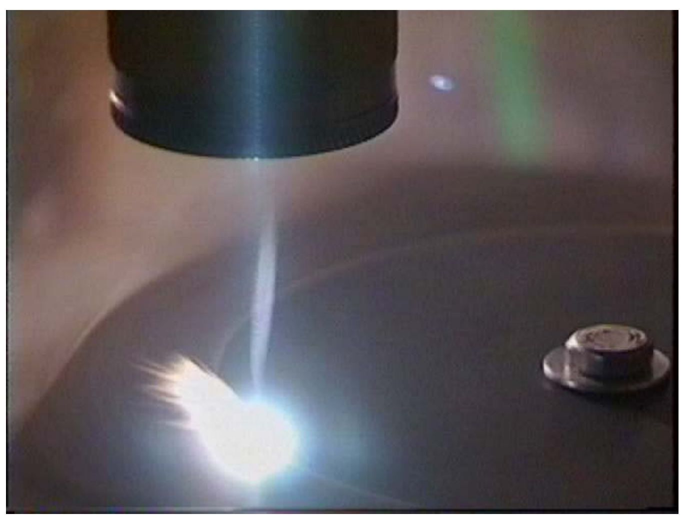


Fig. 1 Decontamination of aluminum ductwork using excimer laser

Results above were obtained by averaging the percentage alpha and beta decontamination achieved at five different material transport speeds. Percentage decontamination factor equals 100 for perfect de-contamination.

The fiber-optic laser system was tested against chemical decontamination methods on stainless steel coupons with simulated radioactive contamination (cesium (Cs) & Zirconium (Zr)). Results show that the laser, which produces little secondary waste, outperformed chemical cleaning. In lab tests the fiber-optic laser system outperformed the excimer laser system in speed and effectiveness.

Cleaning Agent	Cs-D_f	Zr-D_f
Fiber-optic laser	>1000	20.6
Turco 4502	5.5	(0)
Nitric Permanganate	2.8	1.1
Organic acids	3.1	1.6
Nitric/Oxalic	4.5	1.3
TUCS	4.8	3.3
Nitric (800 ppm HF)	6.1	13.8
Fluroboric acid	12.6	37.2



The decontamination factor (D_f) is computed by dividing the original concentration of the chemical on the surface of the coupon by the amount remaining. For example, a D_f of 15 is equivalent to removing 93.2% of a contaminant.