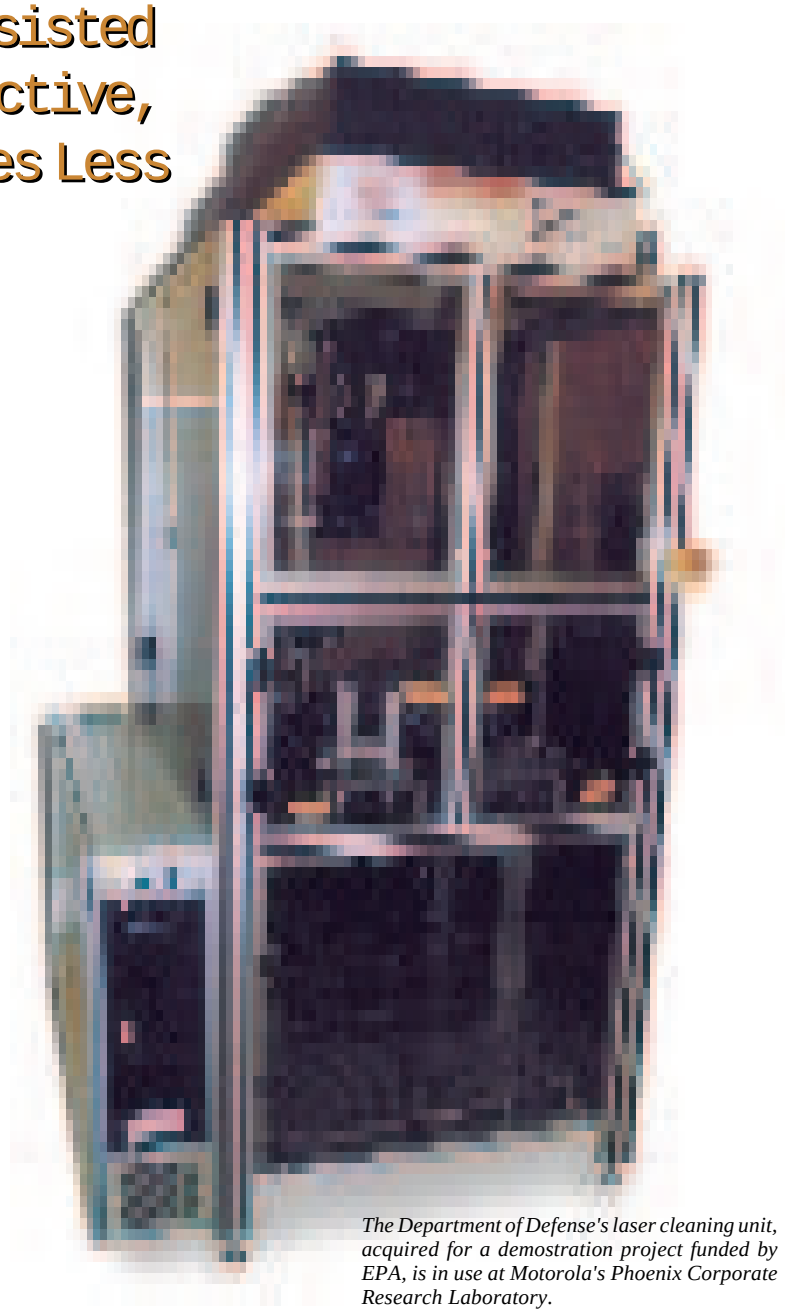
Affordable, Laser-assisted Chip Cleaning Is Effective, Saves Water, Pollutes Less

Laser-assisted cleaning was discovered by accident in 1988 by two doctoral students (Audrey C. Engelsberg and Joseph A. Dehais) at Rensselaer Polytechnic Institute, Troy, NY. It is now a patented process* that utilizes laser light and flowing inert gas to remove contaminants from surfaces. The process is currently being developed for cleaning semi- conductor wafers, which require large volumes of water to process. It is also being used for cleaning in a number of other applications, including integrated circuits, precision tooling and optics.



The Department of Defense's laser cleaning unit, acquired for a demostration project funded by EPA, is in use at Motorola's Phoenix Corporate Research Laboratory.

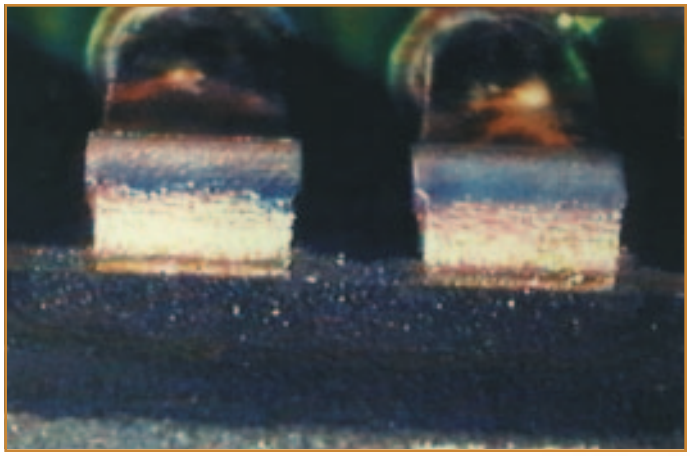
The laser-assisted cleaning process uses a pulsed laser and an inert gas stream to dissociate chemical bonds in light contamination films and particles on surfaces without affecting the base material. It removes particles in sizes from 80 µm to below 0.1 µm, as well as metallic ions, organic films and oxides. It operates at room temperature and ambient pressure, and causes no melting, annealing, vaporization or microroughing. After discovering the technique, Engelsberg and Dehais teamed-up with lawyer Ralph Benko to found Radiance Services Company. Benko recruited Donna Bethell to join the partner-ship. She serves as president and CEO of the company, while Engelsberg currently serves as vice president and chief technical officer. The firm holds 29 patents internationally on the process and has ongoing demonstration projects with a number of industries.

Donna Bethell, president of Radiance, holds a silicon wafer in front of 400 five-gal water bottles (2,000 gal). This represents half the amount needed to clean the wafer she is holding. Her company's patented laser-assisted cleaning system is a dry method.

The process has potential to be used in hundreds of situations for thousand of products,according to Engelsberg. "It really has a lot of potential in industries producing devices or materials to µm or smaller dimensions, especially films and coatings, micromachines and microactuators, and products of microlithography, chemical vapor deposition, physical vapor deposition and advanced thin film methods," she said.

This unique cleaning method can help chip manufacturers prepare surfaces between deposition steps during fabrication. It can also prepare precision micro-optical structures for coating or coupling to other devices. The process can also be useful for

*Radiance Process℠, Radiance Services, Bethesda, MD



The laser process removes oxide and dirt from printed circuit board pins, as shown in this photo.

The swatches on this antique metal plate were made by cleaning with varying amounts of laser power and flux levels.

high-value tools, dies and artifacts. Engelsberg says the process uses no water, solvents, chlorofluorocarbons or any other chemicals, so it does not leave residues and it produces no new particles. Because there is nothing hazardous involved, it does not create a waste disposal problem.

Advantages of Laser-assisted Cleaning

Potential cost savings vary by application and industry, Engelsberg says. A major savings will be in hazardous waste disposal. In California it costs about $450,000 per 100,000 gal to dispose of fluoride-ion-contaminated liquids. Chemical recycling is not cost effective unless there is sufficient volume to warrant it (typically, only sulfuric and hydrofluoric acids are recyclable).

The costs of water use and disposal are continuing to climb, and in some areas of the country, water is scarce. Full use of such a non-liquid cleaning technology can save up to 2.25 million gal of water per year at a semiconductor fabricating facility.

Conversion to this type of technology can yield as much as a 60 percent reduction in capital equipment costs, and an 80 percent reduction in operating costs for semiconductor manufacturing. Engelsberg says similar cost savings and impact on the environment can be accomplished in other industries with this method.

Estimates of the cost reduction for using the laser-assisted technology are about two-thirds or more of current cleaning costs. It could save about $7.35 per 150 mm wafer.

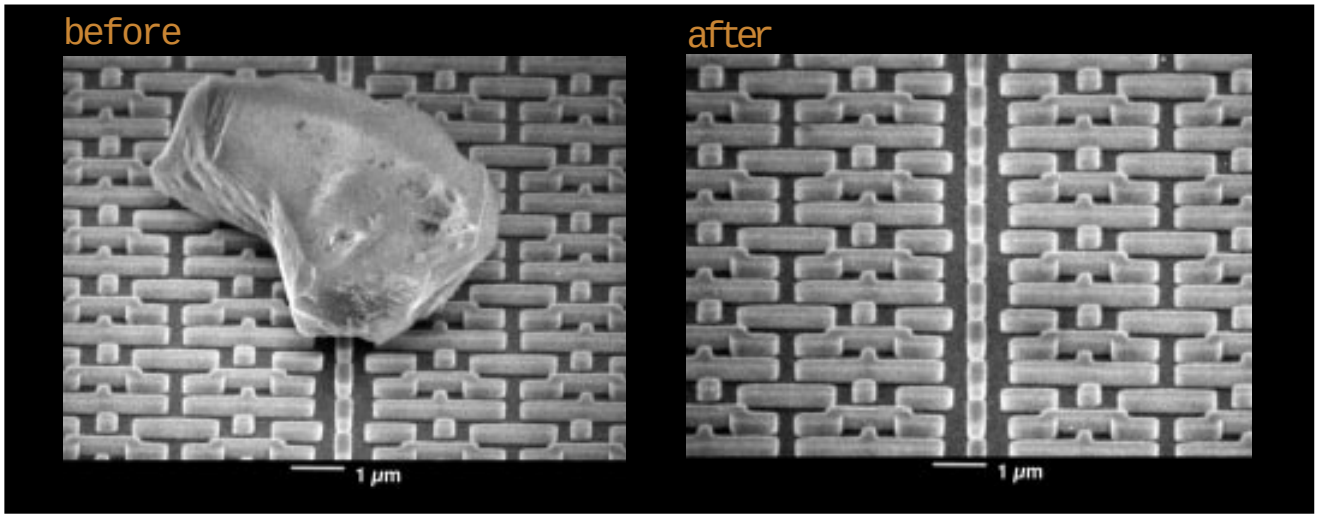
How It's Being Used

The U.S. Environmental Protection Agency (EPA) recently provided $335,000 in funding to acquire a laser-assisted cleaning system** for a demonstration project. The system is operating at Motorola's Phoenix Corporate Research Laboratory. The Microelectronics Research Laboratory (MRL) of the Department of Defense purchased the tool to carry out a joint demonstration for cleaning silicon wafers, photomasks and substrates for flat panel displays.

Funded under an Environmental Technology Initiative grant, the project is being co-managed by the MRL through the National Risk Management Research Laboratory.

"This is an unusual cooperative project to demonstrate the benefits of a new technology," said Dr. William Bandy, director of the MRL. "All of the parties are seeking an improved, environmentally benign, economical means of cleaning semiconductor wafers and other electronics products."

**Neuman Micro Technologies, Inc., Concord, NH



These photos show a before-and-after view of the removal of a 6–7 micron, non-repairable foreign material defect from an X-ray photomask.

The right side of this tire mold shows how the laser-assisted process cleans the recessed areas.

"We expect that the process can greatly reduce both capital and operating costs for semiconductor fabs," said Bethell. "Its greatest benefit may well be in yield improvements," she said, "because chemical cleaning is reaching its limit at 0.2 micron." Laser-assisted cleaning removes particles below 0.1 micron, down to parts of molecular size, she pointed out.

Bethell also noted that you can find out how well the method works without investing a lot of money.

Another demonstration project using the technology is currently underway at the Central Microstructures Facility of the Rutherford Appleton Laboratory (RAL), Chilton, U.K. The system*** here employs the same patented technology for cleaning bare and processed silicon wafers, photo masks, hard disks, flat panel display substrates, and other microelectronics and industrial products.

A system is even being tested for cleaning tire molds. A U.S. manufacturer** is licensed to make tooling and is demonstrating it to one of the top 10 U.S. tire makers. Traditionally, the method for cleaning tire molds involves scouring the molds with glass beads applied at high pressure. Molds for high-end tires with details on the sidewalls have to be cleaned every two or three weeks. Molds for lower-end products are cleaned every few months. The traditional method is expensive, messy and can erode the surface of molds, resulting in lower-quality output, and eventually requiring the mold to be replaced.

This dry process removes only surface contaminants and causes no damage to the underlying surface. It does not rely on chemical or mechanical methods.

According to Bethell, "Radiance is working closely with several dozen companies that are actively considering adopting the process as a very appealing solution to their cleaning needs. It is less expensive, often more effective and an environmentally appealing process that can benefit many different industries." P&SF

***Exitech Ltd., Oxford, England