Lasers and the Fine Art of Art Conservation

Daniel Dawes

Most museums in the United States are not entrusting their priceless paintings and statues to laser cleaning, but as lasers become cheaper, safer and more precise, art conservators may find them hard to ignore as replacements for more traditional cleansing techniques.

Research on analyzing and cleaning art with lasers has abounded in the United States since the early 1990s at universities such as Harvard, Duke and the University of California at San Diego. Still, only one major U.S. museum—the Los Angeles County Museum of Art—regularly uses the technology. John Miller, a laser scientist at Oak Ridge National Laboratory for 23 years and currently a grant review manager for the Department of Energy in Gaithersburg, Md., is among those who feel lasers offer great promise for the art conservation world.

"I believe that safe, effective techniques have been demonstrated and the time is ripe for laser ablation cleaning to be incorporated into the conservator's arsenal of tools," Miller said. "Lasers are now available in a growing variety of sizes, wavelength ranges and powers. Also, importantly, many are now 'turnkey' lasers that can be operated safely by those who are not Ph.D.-level [scientists]."

Although there has been sporadic research into laser cleaning since the birth of the laser in the 1960s, "the large spurt in research came when the Europeans began to provide [more] funding for cultural heritage type projects," Miller said. "The accumulated research into laser-materials interaction in the physics and chemistry communities also led to a large number of labs and scientists with the right experience to think about applications like art conservation."

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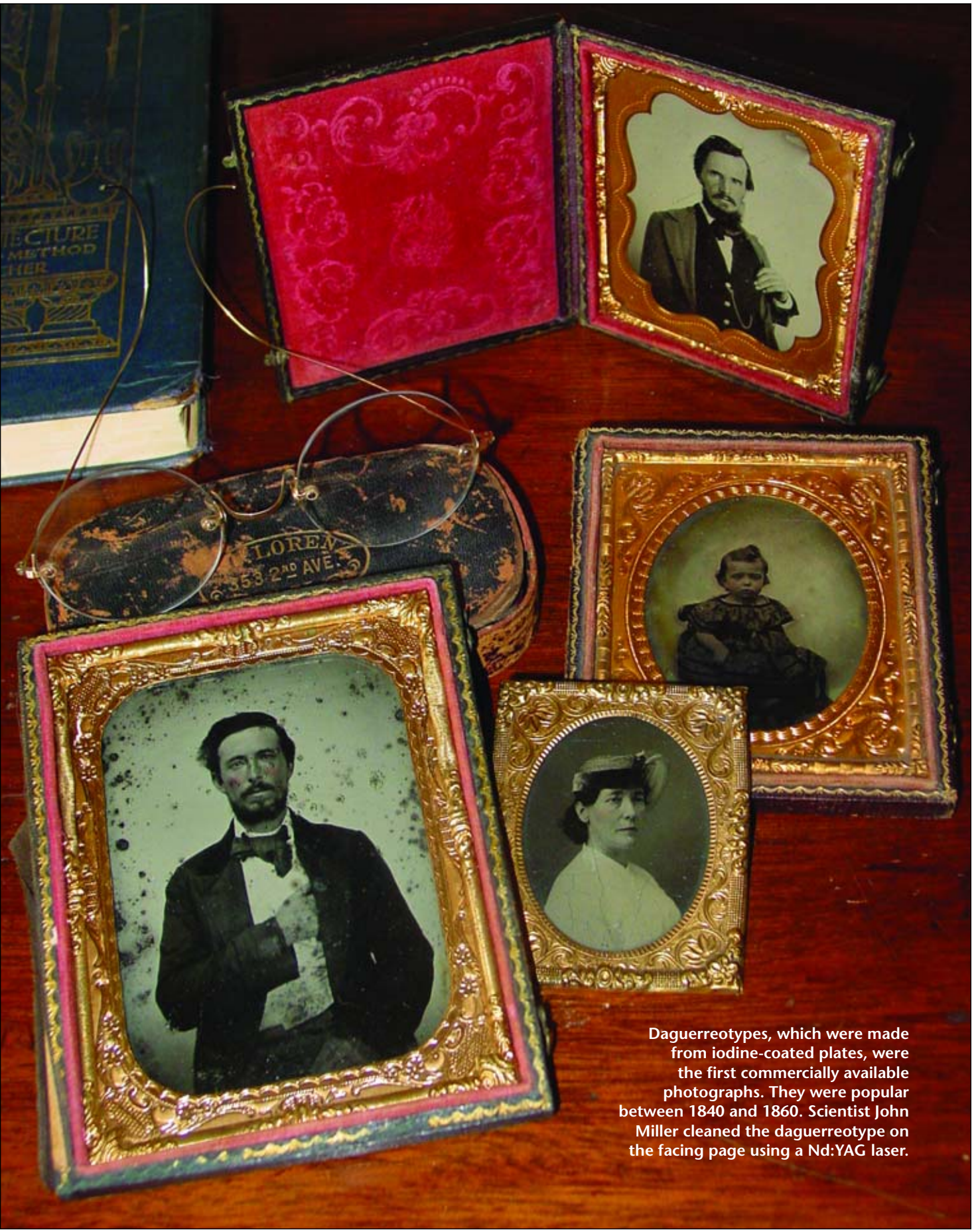


Daguerreotypes, which were made from iodine-coated plates, were the first commercially available photographs. They were popular between 1840 and 1860. Scientist John Miller cleaned the daguerreotype on the facing page using a Nd:YAG laser.

Daguerreotype of the south side of the White House, probably taken in the winter of 1846 during President James K. Polk's administration. [Library of Congress, Prints & Photographs Division; reproduction number DLC/PP-1972:R01.2; photographer: John Plumbe.]

Still, Miller understands why art conservators are wary of lasers. He has worked mostly with daguerreotypes, the first commercially made photographs, which were developed in the mid-1800s. If lasers aren't used carefully, they can do irreparable damage to an object.

"But so can conventional cleaning if done by inexperienced people," he said. "In earlier eras, daguerreotypes were cleaned quite effectively with chemicals. But after the passage of time the process turned out to have inflicted invisible damage that was only evident years later. I believe that the techniques of laser-ablation cleaning must be perfected and demonstrated on similar media first. Then a partnership between laser scientists and conservation professionals must guide the application."

The techniques

Laser researchers at American universities are experimenting with several different techniques for analyzing and cleaning art.

The methods include laser-induced fluorescence, where a low-intensity laser gives a fluorescence emission identifiable by its spectral features to analyze both organic and inorganic materials, such as paints and varnishes.

Laser-induced breakdown spectroscopy (LIBS) is a technique in which the spectrum of ionized material is analyzed and the encrustation on metal and stone is ablated. Only one-tenth of a nanogram of the material is burned off per pulse, and LIBS can give more selective, unambiguous results than laser-induced fluorescence.

Raman spectroscopy is a nondestructive laser-based technique in which a laser beam is reflected off a sample and the wavelengths that are different from that of the laser are measured. In this technique, the pigments under study are identified through matching of the wavelengths of their molecular chemical bonds.

While at Oak Ridge, Miller used LIBS to analyze daguerreotypes. A daguerreotype is an image exposed onto a mirror-polished copper plate in a box camera. The plate was light sensitized with iodine, placed in the camera, exposed to an image for one to two minutes, developed with mercury vapor, fixed with sodium thiosulfate and coated with gold chloride. The process was labor-intensive not only for the photographer but also for the subject: "Whenever you see daguerreotypes of children, you can almost hear dad in the background saying, 'You better not move, I paid $25 for this!'" Miller said.

Daguerreotypes were popular for about 20 years. They were replaced by cheaper and easier photographic techniques after 1860. Of the 20 million made between 1840 and 1860, several thousand are in museums. The silver sulfide, or tarnish, that is found on daguerreotypes can be cleaned using lasers.

For the most part, Miller used LIBS to study the composition of daguerreotype surfaces. He also used laser Raman and laser-ablation mass spectrometry, albeit to a lesser extent, for the same purpose. Cleaning is usually done at lower laser powers, without a visible spark, which could damage rather than clean the surface. The cleaning process can be called laser ablation, desorption or vaporization; it is a gentler process than LIBS, Miller said.

Miller calls the daguerreotype research "sandbox science" because it felt to him more like a hobby than a job. Michael Gresalfi, a co-worker at Oak Ridge and an amateur collector of daguerreotypes, introduced Miller to the idea of laser cleaning after attending an annual meeting of the Daguerreian Society, which unites people from around the country who are interested in the art form.

Miller's research has been published in peer-reviewed scientific journals such as the *Journal of Cultural Heritage*, the *Journal of Imaging Science and Technology* and *Applied Spectroscopy*. "It was extremely fascinating. [A daguerreotype] is a remarkable thing you're holding in your hand. It's living, in a sense," Miller said. "It's 160 years old, but look at the resolution compared to a modern photo. It looks great and has high resolution."

Why lasers?

Lasers have four main advantages over traditional abrasive and chemical techniques for art conservation, Miller said.

First, "a laser can be selective with regards to what is being removed," Miller said. "By choosing the wavelength to correspond to the absorption of the

undesirable layer, one can in principle limit the removal of any other layer with lower absorption. For instance, removing black soot from marble could be self-limiting in that the removal stops when the lighter surface of the stone emerges."

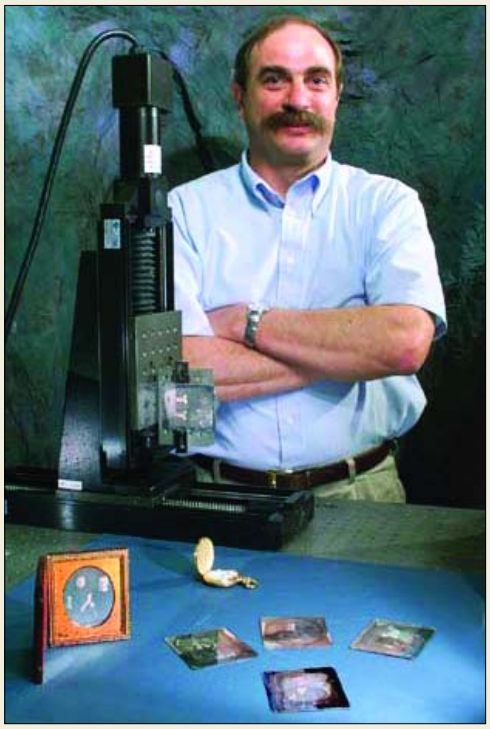
Also, real-time monitoring of laser cleaning is possible. "If one monitors the emission from the laser surface interaction zone, that emission will change when the laser breaks through the last layer of the undesirable contaminant. The emission is then characteristic of the underlying surface and the operator knows to stop the laser cleaning or at least slow down and be careful."

A third advantage is that spot cleaning by laser is possible, offering more precision than traditional techniques, such as immersion in a solvent, or treatment of a larger area than is desired. If a fiber optic wand is used, "the light can be directed into hard-to-reach parts of an item or into crevices," Miller said.

Finally, if the laser power, distance of the laser, laser pulse rate, movement of the sample, and monitoring of the cleaning is controlled by computer, "then the cleaning process can be exquisitely delicate," comparable to computer-controlled robotic surgery, Miller said.

"The interface of art and science is a fascinating area," Miller said. "The opportunity to work with art conservation professionals opened the door to an entirely different culture than that of the typically hard-science oriented community."

Miller jokes about the "interesting mix" at art conservation conferences, where the laser scientists drink beer at one table and the art conservators drink wine at another.



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— John Miller
U.S. Department of Energy

The art community's perspective

Carol Dignard is an objects conservator at the Canadian Conservation Institute, Ottawa, one of the largest art conservation labs in North America. She agrees with Miller that laser techniques are still experimental and that caution is necessary. "All museum or heritage objects hold valuable information within their shape and material composition, which speaks of the artist or craftsperson who made them, and of the people who used them or to whom these objects were valuable," Dignard said.

In cleaning art, a conservator is bound by a professional code of ethics to use techniques that "are not abrasive and do not change the original surface color, appearance, texture, and composition. For now, laser cleaning is still to some degree at a developmental phase. There remains much ongoing research," Dignard said.

In addition to concerns about the safety of the procedures, cost is a factor for some museums. Sarah Wagner, former senior photo conservator for the National Archives and now in private practice, says a $100,000 laser "would put quite a dent" in the equipment budgets of smaller museums. "It's not something people are opposed to in an anti-technology sense," but the costs of lasers would need to drop to be commonly used. "It's like wanting to buy a plasma television but waiting to spend $300, not $3,000," Wagner said.

Meg Abraham, a laser researcher at Aerospace Corp. in Los Angeles, also works on the staff of the Los Angeles County Museum of Art, the only U.S. museum with an in-house laser lab. Abraham is one of the few laser scientists in the country working for a museum. She has used Raman spectroscopy to study netsuke, intricately carved, ivory jewelry that is part of traditional Japanese dress.

Abraham notes that YAG lasers "are the real workhorse in the industry." With prices of YAG lasers coming down, they could be used for cleaning marble and stone. Abraham tested a generator-operated YAG laser to clean graffiti off boulders in Oregon at a national park. European art conservators use YAG lasers extensively to clean industrial pollution off marble statues and buildings, in part because they simply have more marble art, Abraham said. But excimer lasers, necessary for cleaning more delicate paintings, will not be cheaper in the near future, she said.

Still, Miller is optimistic about the future of laser-based art conservation. "I hope that more conservation labs … will acquire lasers and begin training staff to experiment and evaluate the usefulness of the laser tool compared to traditional techniques. Over time, I believe that it will prove to have important and unique capabilities."

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