Taking the guesswork out of forensic analysis of fingermarks

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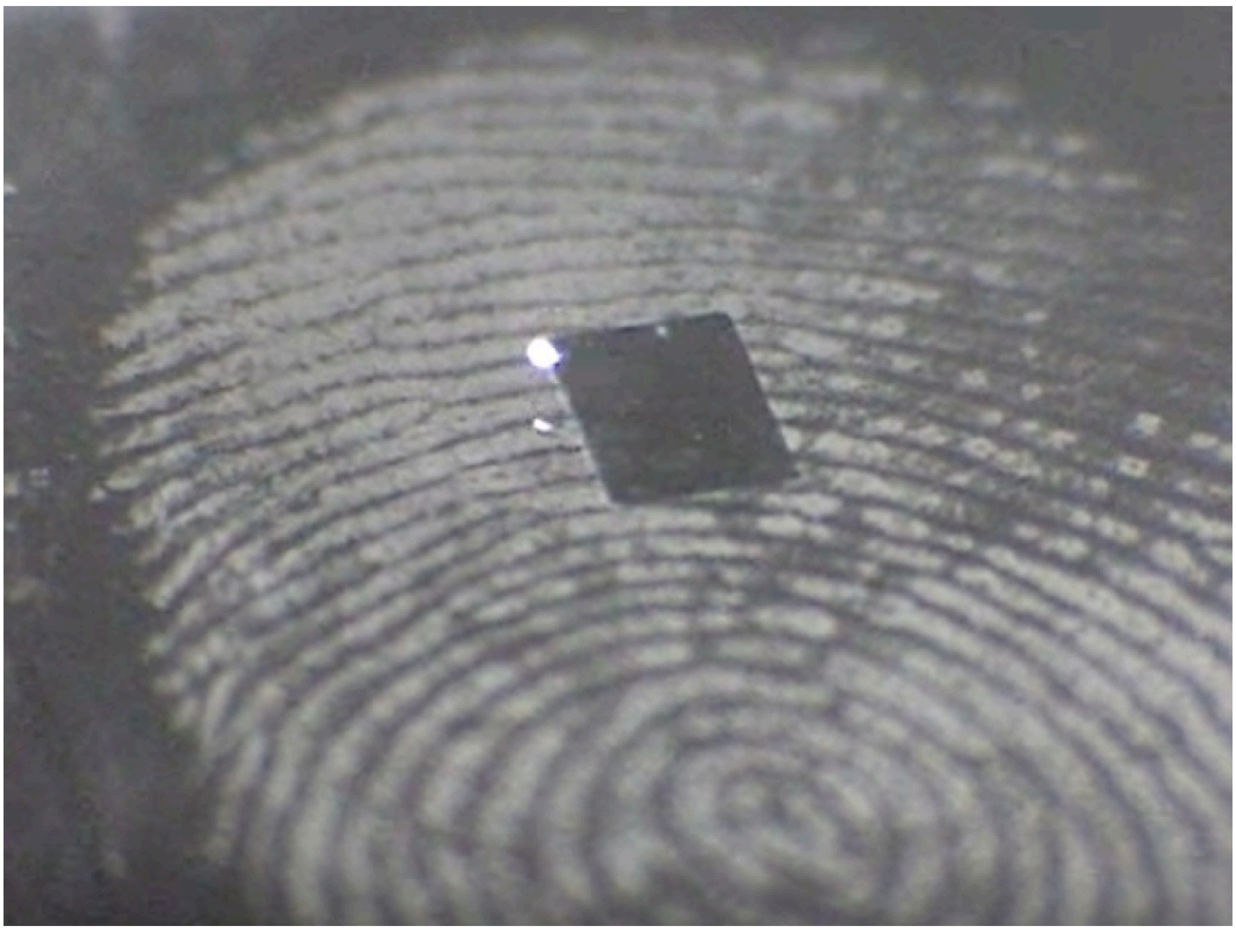

Scientists use infrared lasers to lift fingerprints from crime scenes. Credit: LSU

Researchers in the Louisiana State University Department of Chemistry including postdoctoral researcher Fabrizio Donnarumma, former undergraduate researcher and current LSU alumus Eden E. Camp, graduate student Fan Cao and Roy Paul Daniels Professor of Chemistry Kermit K. Murray have developed an infrared laser ablation and vacuum capture system for fingermark sampling that takes the mystery out of the process of identifying the chemical compositions of fingermarks at a crime scene. They've described the approach and instrumentation in a new paper published in the *Journal of The American Society of Mass Spectrometry*.

The idea started when undergraduate chemistry student Eden Camp, who had interned at the Louisiana State Police Crime Lab during the summer of 2015, approached Murray and Donnarumma with the idea of using their laser lab's equipment to detect substances from fingermarks.

"I've always had a great interest in forensic science and I wanted my undergraduate research to reflect that," Camp said. During her internship at the LSP Crime Lab, Camp started brainstorming ways that forensic experts could detect chemical substances from fingermarks. "The most challenging part was trying to determine a method of collection that lost the least amount of sample and wouldn't destroy the surface it was on."

Fortunately, the Murray lab has extensive experience using lasers to ablate or remove tiny layers from various tissues for bioanalysis.

"We realized that if our techniques work for biomolecules as fragile as DNA and RNA, it should work with almost anything," Donnarumma said. "We can capture almost anything that is on a surface. In this case, it just happened to be fingermarks."

Together, the researchers came up with the idea to use the lasers in their lab to ablate fingermark materials from a surface, suck them into a filter and then analyze them using spectrometry techniques. The technique could be used to capture and analyze a variety of molecules contained in fingermark, including lipids, proteins, genetic material or even trace amounts of explosives.

Running with the idea, Murray's Lab received a grant from the LSU LIFT2 program to pursue research related to laser ablation and analysis of fingermarks and the creation of a portable laser capture system for forensic applications. Based on the project, the team is also developing a patent and collaborating with multiple companies and law enforcement offices to develop better techniques for analyzing the chemical signatures of fingermarks at crime scenes.

While the approach can be used for traditional fingermark analysis, its real power is in being able to capture, filter and analyze biomolecules and trace substances left behind by fingermarks, such as DNA or explosives like TNT.

The approach works by focusing a laser, using mirrors and optical fibers, onto a surface containing a fingermark. Within a surface area the width of 300 microns, the laser heats up the moisture or any water present on the surface, causing chemical bonds in the water to stretch and vibrate. With enough energy focused in a small area, the water basically "explodes," becoming a gas and lifting biomolecules such as DNA with it off of a surface. This process is called laser ablation. The laser system that Murray's lab uses is extremely selective - it causes vibrations in water oxygen-hydrogen bonds more than in any other bonds in other molecules.

While the process sounds violent, it's actually much less so than other mechanisms used to remove biomolecules from surfaces. Laser ablation can capture very delicate materials such has DNA while preserving their integrity for analysis.

After the laser ablates or lifts the fingermark, a small vacuum pump system pulls the water and all associated molecules with it into a thimble-sized filter that captures everything left behind by someone's finger. Researchers can then flush the contents of the filter into an analysis device such as a mass spectrometer or a gas chromatography-mass spectrometer. These devices determine the mass of any compounds or molecules in the sample, allowing researchers to identify exactly what they are.

"Let's say I was preparing a bomb, and I wasn't using gloves. If I touched the bomb and then touched a surface, my fingermarks might leave behind trace amounts of an explosive," Donnarumma said. Using this technique, forensic teams could lift those compounds off of a surface, for example with a portable laser system or, better yet, a portable laser system transported by a robot, and send the samples into a lab for analysis and identification. In the future, this approach could help forensic bomb squads find and deactivate bombs without needing to send squad members into dangerous areas, while potentially at the same time capturing and identifying any genetic material also present at the site.

The research team in Kermit Murray's lab is also working on creating optical fiber attachments for their laser system that would allow for a portable laser fingermark-capturing system to sample various surfaces in the field. Dependent on funding, Donnarumma plans to continue developing this portable system in the future.

"A laser beam is a straight line," Donnarumma said. "It can be difficult to focus a traditional laser system at a precise point, especially on an uneven surface. But if you run that laser through a flexible optical fiber, similar to how a fiber optic cable works, you can sample a wider variety of surfaces more easily."

Using infrared laser ablation coupled to vacuum capture, Donnarumma and colleagues in Murray's lab demonstrated successful ablation and capture of materials from fingermarks on glass, plastic, aluminum and cardboard surfaces. Their results were published in the *Journal of The American Society of Mass Spectrometry* on May 22, 2017.

Fingermarks and associated materials on porous cardboard surfaces in particular can be next to impossible to capture using traditional forensic methods, such as placing sticky tape on the surface to pull the fingermark. But Murray's lab's laser system can penetrate porous surfaces like cardboard easily.

The research group created fingermarks on glass, plastic, aluminum and cardboard to test their infrared laser ablation system. They laced these fingermarks with substances as diverse as caffeine, Neosporin antiseptic cream, condom lubricants and TNT. In each case, they were able to identify these substances after fingermark capture using mass spectrometry.

"We have been using infrared lasers for many years to ablate biomolecules from tissue samples for mass spectrometry, so we know that they are very efficient," Murray said. "Thanks to Eden's initiative, we now have a promising new application."

More information: Fabrizio Donnarumma et al, Infrared Laser Ablation with Vacuum Capture for Fingermark Sampling, *Journal of The American Society for Mass Spectrometry* (2017). DOI: 10.1007/s13361-017-1703-2

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