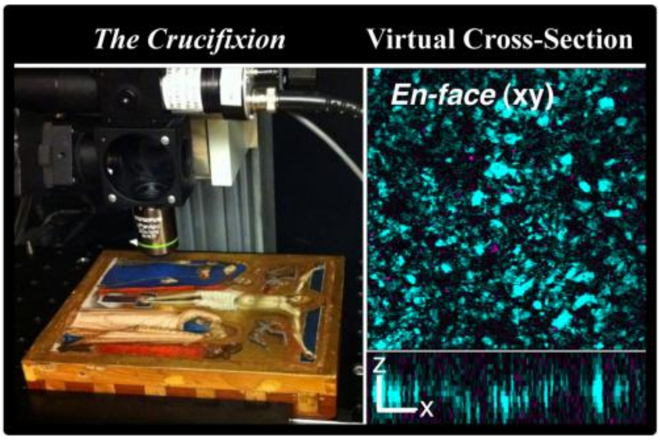
Skin cancer detector applied to paintings reveals 3D layering techniques of original artists

22 January 2014, by Bob Yirka



At left is a femtosecond pump-probe microscope positioned over a section of The Crucifixion by Puccio Capanna. At top right is a false-color face-on view of the section, showing blue lapis lazuli fragments. At bottom right is a 60-µm-thick cross-section of the painting, revealing the thickness of the pigment. Credit: *PNAS*, doi: 10.1073/pnas.1317230111

(Phys.org) —A team made up of university chemists, art conservationists and research scientists with the National Gallery of Art in Washington D.C., has discovered a new way to reveal three dimensional details of paintings. In their paper published in *Proceedings of the National Academy of Sciences* describing their research, the team describes how they applied a laser technique normally used to detect skin cancer, to paintings and how it allowed for viewing its 3D nature without causing harm.

Art conservationists attempt to keep old paintings from fading, decaying or decomposing by using a variety of techniques. But in order to know which techniques to use, they need to know the physical makeup of the painting. In many case, that means destroying a very small part of the painting in order to learn of its 3D makeup. In this new effort, the researchers applied a laser technique developed for analyzing skin to artistic paintings, allowing for discovering the same information without causing harm to the painting.

The technique is called pump-probe microscopy and makes use of a laser technique based on firing very short beam blasts. The blast excites the atoms that make up the paints used to create a painting. A second blast is used to measure how the atoms revert back to their unexcited states. Because the atoms that make up different types of paint relax at different rates, the technique allows for building a 3D image of a section of a painting, showing all the different pigments used.

To test their idea, the researchers first created paintings of their own using two techniques. The first involved creating a third color paint by mixing two other colors together. The second involved creating the illusion of a third color by laying a very thin coat of one color over the top of another. Pump-probe microscopy revealed exactly what had been done, confirming that it was able to create actual 3D representations of the paintings. Satisfied, the researchers tried the technique on a painting from the Renaissance period—the result was an accurate 3D rendering of a small patch of the painting.

Sadly, the lasers used in the exercise are too bulky and complicated for general use by art conservationists, but because the technique proved so valuable, it's possible lasers might be developed specifically for such a purpose, allowing paintings all over the world to be analyzed, and hopefully saved for viewing by future generations.

More information: Femtosecond pump-probe microscopy generates virtual cross-sections in

historic artwork, Tana Elizabeth Villafana, *PNAS*,
DOI: 10.1073/pnas.1317230111

Abstract
The layering structure of a painting contains a wealth of information about the artist's choice of materials and working methods, but currently, no 3D noninvasive method exists to replace the taking of small paint samples in the study of the stratigraphy. Here, we adapt femtosecond pump-probe imaging, previously shown in tissue, to the case of the color palette in paintings, where chromophores have much greater variety. We show that combining the contrasts of multispectral and multidelay pump-probe spectroscopy permits nondestructive 3D imaging of paintings with molecular and structural contrast, even for pigments with linear absorption spectra that are broad and relatively featureless. We show virtual cross-sectioning capabilities in mockup paintings, with pigment separation and nondestructive imaging on an intact 14th century painting (The Crucifixion by Puccio Capanna). Our approach makes it possible to extract microscopic information for a broad range of applications to cultural heritage.