Turning metal black more than just a novelty

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(PhysOrg.com) -- University of Rochester optics professor Chunlei Guo made headlines in the past couple of years when he changed the color of everyday metals by scouring their surfaces with precise, high-intensity laser bursts.

Suddenly it was possible to make sheets of golden tungsten, or black aluminum.

A recent discovery in Guo's lab has shown that, beyond the aesthetic opportunities in his find lie some very powerful potential uses, like diagnosing some diseases with unprecedented ease and precision.

Along with his research assistant, Anatoliy Vorobyev, Guo has discovered that the altered metals can detect electromagnetic radiation with frequencies in the terahertz range (also known as T-rays), which have been challenging, if not impossible, to detect prior to his discovery.

"When we turned metals black, we knew that they became highly absorptive in the visible wavelength range because the altered metals appear pitch black to the eye. Here, we experimentally demonstrated that the enhanced absorption extends well into the far infrared and terahertz frequencies," Guo said.

With wavelengths shorter than microwaves, but longer than infrared rays, T-rays occupy a place in the electromagnetic spectrum that is capable of exciting rotational and vibrational states of organic compounds, like pathogens. This quality could allow doctors and biomedical researchers to get previously impossible glimpses of diseases on the molecular level.

In addition, unlike X-rays, T-rays are non-ionizing, which means that people who are exposed to them don't risk the possible tissue damage that can result from X-rays.

University of California, Berkeley, bioengineering Professor Thomas Budinger says terahertz radiation is like much-higher-frequency radar, except that it theoretically can allow its users to see intricate details of tissue architecture, on the scale of one-thousandth of a millimeter and smaller, instead of large objects like airplanes and boats.

"Terahertz electromagnetic radiation has the capability to interrogate tissues at the cellular level. If applied within microns of the subject of interest, this form of imaging has the theoretical capability to detect properties of molecular assemblages that could be attributes of disease states," Budinger said.

What made terahertz radiation so difficult to detect in the past was that typical materials do not readily absorb that frequency. However, after undergoing Guo's femtosecond structuring technique, metals become over 30 times more absorptive.

The key to creating the black metal in terahertz is a beam of ultra-brief, ultra-intense laser pulses called femtosecond laser pulses. The laser burst lasts less than a quadrillionth of a second. To get a grasp of that kind of speed, consider that a femtosecond is to a second what a second is to about 32 million years. During its brief burst, Guo's laser unleashes as much power as the entire grid of North America onto a spot the size of a needle point. That intense blast forces the surface of the metal to undergo some dramatic changes and makes them extremely efficient in absorbing terahertz radiation.

Source: University of Rochester (news : web)

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