

Nanophotonics technology enables a new kind of optical spectrometer

January 29 2013



Dr. Junpeng Guo, UAHuntsville Associate Professor of Electrical Engineering and Optics, and doctoral student Haisheng Leong view the spectra from a new nanoscale photonic device called a super nano-grating. Credit: Aaron Sexton / UAHuntsville

(Phys.org)—By bringing nanophotonics technology to traditional optical spectroscopy, a new kind of optical spectrometer with functions of sensing and spectral measurement has been recently demonstrated by a research team at The University of Alabama in Huntsville.

Dr. Junpeng Guo, Associate Professor of Electrical Engineering and Optics at UAHuntsville, recently created a new nanoscale photonic device called a super nano-grating, with the assistance of his doctoral student, Haisheng Leong. With a fabricated super nano-grating, Dr. Guo's group demonstrated a new kind of optical sensing apparatus called

spectrometer sensors.

Traditional optical spectrometers measure the spectra of light.

Traditional [optical sensors](#) use light to detect the presence of chemicals.

A spectrometer sensor is an optical spectrometer and also a [chemical sensor](#) because it measures the optical resonance spectrum that is controlled by chemicals bonded on the nanostructure surface. A spectrometer sensor with a super nanoslit metal grating was first published in [Optics Letters](#) (vol. 36, 2011) and a spectrometer sensor with a super nanohole metal grating was published recently in [Optics Express](#) (vol. 20, 2012).

Nano-gratings are periodic nanostructures with the feature size in the [nanometer scale](#). One nanometer is one millionth of a millimeter, about 1/50,000th of the diameter of a human hair. Because the feature size of nanostructures is less than the [wavelength of light](#), we are not able to see nanostructures with our eyes. However, light can sense nanostructures by strong absorptions at specific wavelengths. This phenomenon is called optical resonance of nanostructures, a fundamental phenomenon in optics.

Optical resonances of nanostructures typically are measured by using optical spectrometers. By creating a super-grating pattern of nanostructures, the UAHuntsville team made super diffraction gratings with nano-grating structures. With the super nano-grating, the resonance of the nanostructure can be measured with a photodetector array. That way, the use of an optical spectrometer is not needed.

The [nanostructures](#), such as nanoholes or nanoslits, are made by using a tightly focused electron beam, a technique called electron-beam lithography. Nanostructure patterns were first drawn with a computer and then sent to the electron-beam lithography machine to control the movement of the tightly focused electron beam to write nanoholes or any

other nanostructure patterns in a thin layer of special polymer called e-beam resist.

The e-beam written [polymer layer](#) is then developed so the nanostructure patterns are imprinted to the thin polymer layer. The patterned polymer layer works like a mask and an argon ion etching process is used to transfer the pattern from the polymer layer to the thin metal film underneath it. This device was made by Haisheng Leong, a graduate research assistant at UAHuntsville.

The super nano-grating is a super-period nanohole array drilled in a thin gold film on a transparent glass substrate. The thickness of the gold film is 60 nanometers and the size of the nanoholes is about 100 nanometers. The periodic nanoholes in the thin metal film support collective free electron oscillations, referred to as surface plasmons, in the nanostructured metal.

The super nano-gratings have rich physics that needs to be investigated, Dr. Guo said. A paper he wrote and recently published in *Applied Physics Letters* (vol. 101, 2012) is trying to explain the resonance mode splitting phenomenon observed in the super-nanohole grating. The resonance mode splitting can be utilized to make better sensitivity chemical sensors.

The spectrometer sensors can detect toxins or contaminants in very small quantities. UAHuntsville recently has filed a patent to license the new technology.

"Spectrometer sensors are best suited in applications requiring small size and weight," Dr. Guo said. Such small size and lightweight sensors may be useful for NASA space exploration applications like measuring the chemical makeup on the surface of Mars, he said.

Provided by University of Alabama in Huntsville

Citation: Nanophotonics technology enables a new kind of optical spectrometer (2013, January 29) retrieved 22 June 2024 from <https://phys.org/news/2013-01-nanophotonics-technology-enables-kind-optical.html>

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