FURTHER READING

Page 142,
'A Plasmonic Device
for Spectral Analysis',
S.Y. Cho, C. Pelzman,
N. Chanover, and
D. Voelz.

Efficient spectral analysis using a microfluidic-based plasmonic device

changing channels

Researchers from New Mexico State University have put forward an experimental demonstration of a fluidic-based plasmonic device for use in spectral analysis which utilises the modification of surface plasmon resonance in periodically coupled metallic nanostructures. This work achieves precise control of the center wavelength of the surface plasmon resonance by changing the local environment of the nanostructures via microfluidic channels, offering an efficient way to acquire large spectral samples.

First light

To implement spectral analysis devices, two main components are required: dispersive optical elements, and photodetectors. The dispersive elements spatially separate frequency components of light and photodetectors convert spatially separated light into electrical signals for further data analysis.

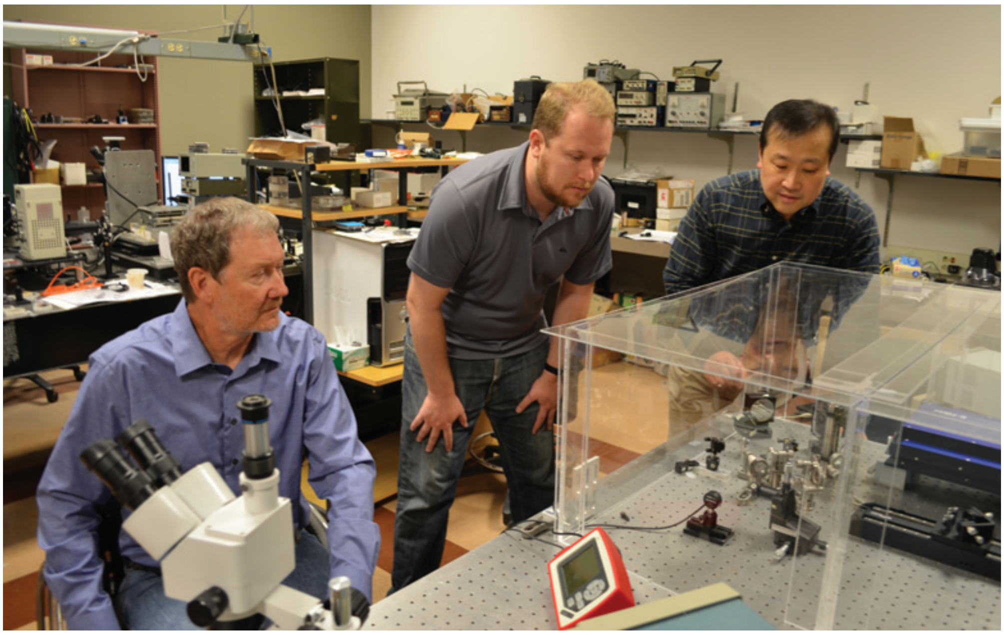
One of the attractive features of spectral analysis devices is their capability to measure unique optical signatures of specific chemical elements. This detection capability is highly specific and quantitative in nature, which makes the spectral analysis devices useful for a variety of applications.

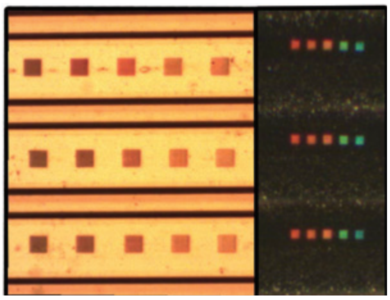
Carve out

In the teams Letter, they report the experimental demonstration of a fluidic-based plasmonic spectral analysis device. The demonstrated device consists of nanometer-scale metallic structures and polymer-based microfluidic channels. The metallic structures allow optical transmission within a pre-determined spectral band and reject other spectral components of light, acting as optical bandpass filters. The microfluidic channels were used to precisely control the center wavelength of each bandpass filter by changing the effective refractive index of the metallic nanostructures.

Co-author Sang-Yeon Cho discusses the proposed system: "Compared to other dispersive-optical-element-based spectral analysis devices, this work used a combination of plasmonic spectral filtering and fluidic-based refractive-index control to measure spectral information. This approach does not rely on angular dispersion of light but utilises resonance-assisted enhanced optical transmission through nanostructures. Therefore, the entire spectral analysis system can be miniaturised into a chip-scale device."

This fluidic-based plasmonic spectral analysis device uses a novel approach to precisely control the location of the center wavelength. The microfluidic channels implemented on top of the plasmonic filters can alter the microscopic optical environment of the metallic nanostructures by delivering refractive-index calibrated fluids. In theory, this approach can provide an infinite number of transmission bands (sampling points) for spectral analysis, which was not possible in previous systems.





Top: Prof. David Voelz (left), Mr. Charles Pelzman (middle), Prof. Sang-Yeon Cho (right). Mr. Charles Pelzman is a PhD candidate in Electrical and Computer Engineering at New Mexico State University, Las Cruces, NM, USA.
Bottom: Left: Metallic nanostructures integrated with SU8-microfluidic channels. Right: Dark-field transmission photomicrograph showing optical transmission at different wavelengths through the nanostructures.

Improved resolution

A major fabrication challenge was the integration of polymer-based microfluidic channels and metallic nanostructures due to their incompatibility. During nanostructure patterning in a dual-beam lithography system, microfluidic channels accumulated electrons and ions on the surface, leading to significant reduction in imaging and patterning resolutions in the lithography system. This technical issue was resolved by depositing an optically thin conductive layer on the surface of the sample to provide a path for discharging electrons and ions around the polymer structures.

This work is the first experimental demonstration of a fluidic-based spectral analysis device and this approach can greatly enhance spectral resolution by providing a very large number of sampling points for analysis. For short term uses, the demonstrated spectral analysis system can be used as a chip-scale optical spectrometer in the visible and near-infrared regions. For long-term developments, by making a 2D array of the demonstrated device, it can be used as a hyperspectral imaging device.

Further analysis

Currently, the team is trying to reduce the spectral width of the optical transmission bands by creating a symmetric environment for the surface plasmon waves in the fabricated nanostructure. Professor Cho notes on the progress: "Chip-scale spectral analysis devices are enabling technology in many applications because of their compact size, lightweight, and low power consumption."

Over the next decade, this new technology can be integrated with personal mobile devices for various sensing applications. For instance, a smart phone equipped with a chip-scale spectrometer will be able to analyse air quality or detect hidden explosives from unknown packages by simply taking photos. To fully implement this mobile sensing technology, one of the remaining hurdles is the further reduction of the transmission bandwidth.

doi: 10.1049/el.2019.0023