Nanostructured Thin Films for Spectroscopy and Imaging

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Nanostructured thin films requires a minimal amount of optics, which is an asset in the development and integration of miniature spectrometric or imaging systems. Plasmonic nanostructures were used as a polarization-tunable filter to provide color input to a black & white camera. In addition, a miniature photo-spectrometer based on dielectric nanostructures was fabricated, calibrated and successfully characterized with a green LED light.

In the last years, the need for miniature photo-spectrometers (< 250 cm^3) has significantly increased. The main drivers are: reduced time for results, in situ analysis, decreased costs and increased ease-of-use of systems for non experts [1]. A promising application of such miniature spectrometers was recently reported as non-destructive testing of fruit ripeness [2]. In this framework, nanostructured thin films have the advantage to require a minimal amount of optics, which is an asset in the development and integration of miniature spectrometric or imaging systems.

A plasmonic nanostructure has been fabricated with UV nanoimprint lithography and thin layer metallization. A plasmonic resonance can be observed in transmission in the visible range for the polarization across the grating lines, thus generating a given color at a broad range of viewing angles. If the plasmonic nanostructure is inserted between an input polarizer at 45° and an analyzing polarizer, such as shown in Figure 1(a), four different colors can be observed in transmission [3].

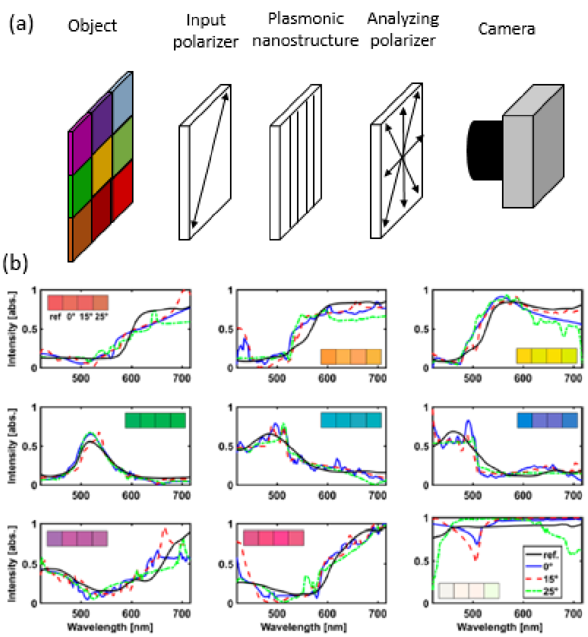

Figure 1: a) Plasmonic nanostructures used as tunable filters for imaging; b) Reconstruction of color spectra from colored patches (Macbeth ColorChecker) recorded with a conventional spectrometer (ref.) and the imaging system at tilt angles of 0, 15, and 25°.

This system has been used as a tunable filter for a camera, where the transmitted color is actuated by a rotation of the analyzing polarizer. In Figure 1b, the reflectance spectra from various colored patches (Macbeth ColorChecker) have been reconstructed using the tunable plasmonic filter in front of a black & white camera [4]. A reasonable agreement with the reference is observed, which shows that color information can be obtained on a camera without the loss in resolution inherent to the use of a matrix of standard absorbing filters. The reconstruction of the spectrum is relatively stable with a field of view of at least 25°.

Dielectric nanostructures can also be used as filters in photo-spectrometers. Figure 2 shows a miniature photo-spectrometer fabricated using a nanostructured film as optical filtering element.

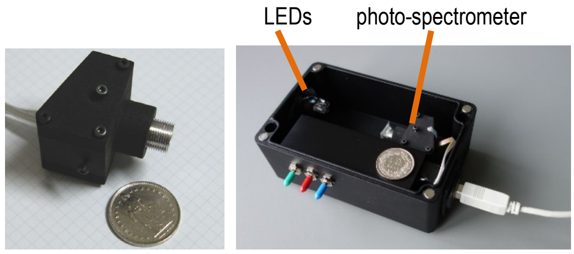

Figure 2: The fabricated miniature photo-spectrometer (left), a suitable housing including LEDs and USB connector (right).

The miniature photo-spectrometer was mounted in a housing together with RGB LEDs for illumination and a USB connection for data processing on a computer. The measured data are acquired with a miniature CMOS sensor of 4.3×5.7 mm². A measurement for the green LED light together with the exact reference spectrum is shown in Figure 3. A promising agreement between the measured and the green LED reference spectrum is found using compressing sensing.

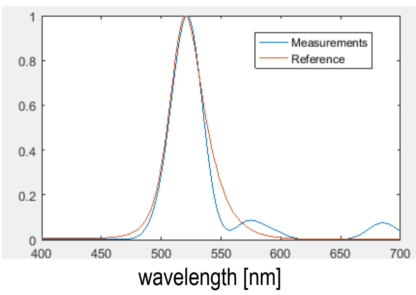

Figure 3: Miniature photo-spectrometer measurement of a green LED, exact spectrum (reference, in red) and measured spectrum (in blue).

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[3] L. Dümpelmann, B. Gallinet, L. Novotny, ACS Photonics 4, 236−241 (2017).

[4] L. Dümpelmann, A. Luu-Dinh, B. Gallinet, L. Novotny, ACS Photonics 3, 190−196 (2016).