Thesis subject

Laboratory: Institut Fresnel

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Spatially structured thin-film optical filters for hyperspectral imaging

Multispectral imaging and more generally hyperspectral imaging is a key technology for space studies as it allows at the same time imaging a scene and spectrally analyzing it. However, as of today, there is no mature technology to provide compact, high performance and dense hyperspectral components. In this Ph.D. thesis, we will investigate several concurrent approaches in order to produce spatially structured components. All these development will be carried out within the thin-film research team of institut Fresnel and will use plasma assisted reactive magnetron sputtering (PARMS). (Bühler HELIOS 800).

The first approach will consist of tuning the actual HELIOS machine to provide variable filters with similar overall performances but spatially varying spectral properties. By inserting a gradient mask in between the sputtered targets and the substrates to be coated, it is possible to generate a gradient of thickness, and therefore a change of spectral properties along one direction. We have previously demonstrated that this technology is compatible for both visible and SWIR regions. However, we have faced several limitations: low deposition rate, cosmetics issues, limited spectral ranges and gradient slopes. Within this Ph.D. thesis we aim at fixing these limits in order to provide a mature technology that can be implemented for future missions.

A second approach will consist of producing multilayer optical metasurfaces. The study of the effect of producing nano-holes in inorganic layers, considering size and distribution, on those layers effective refractive index will be investigated both numerically and experimentally. We will then realize complex optical functions by inserting those layers into multilayer stacks, creating optical metasurfaces with spatially dependent spectral properties through the control of the hole distribution. These nanoholes will be produced using either direct laser writing system using the femtosecond laser based system available at institute Fresnel or ion beam etching through already established collaboration.

In addition to these technological development, we plan to develop proper metrology for the local measurement of the spectral properties of such filters. We aim a measuring the spectral performances with down to 20 micron, if possible 10 micron spatial resolution and 1 nm spectral resolution. This step will be critical in order to analyze the experimental results and that way improve the developed technology.