Self-assembled flat chiral light sources

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Circularly polarized light has many applications, including circular dichroism spectroscopy, three-dimensional displays, bio-sensing and even quantum computation. Circular polarization is usually created with optical filters, or with chiral organic emitters. However, there has been recently great interest in developing materials that could generate or control the flow of electromagnetic waves (e.g. light) in unprecedented ways. The structural elements of these so-called metamaterials that dictate their properties are small building blocks or unit cells in large 1D, 2D or 3D periodic arrays. Furthermore, it is well-known that the emission of molecular fluorescent molecules are modified when such emitters are placed close to metallic nanoparticles that display localized surface plasmon resonances. The aim of this thesis is to create flat chiral light sources in which the polarized emission of molecular dyes is modified by a designed chiral plasmonic environment.

The chiral thin films will be prepared using Grazing Incidence Spraying (GIS), a technique we have recently developped, which allows allows depositing 1D nano-objects such as nanowires and nanorods into oriented thin films that display highly anisotropic optical and electronic properties.[1-6] This approach can be combined to the well-established Layer-by-Layer (LbL) approach[7] to assemble multilayer thin films that can comprise several nanomaterials deposited in a well-defined architecture. We have recently shown that chiral plasmonic assemblies that display very high chiroptical properties in the visible range can be obtained.

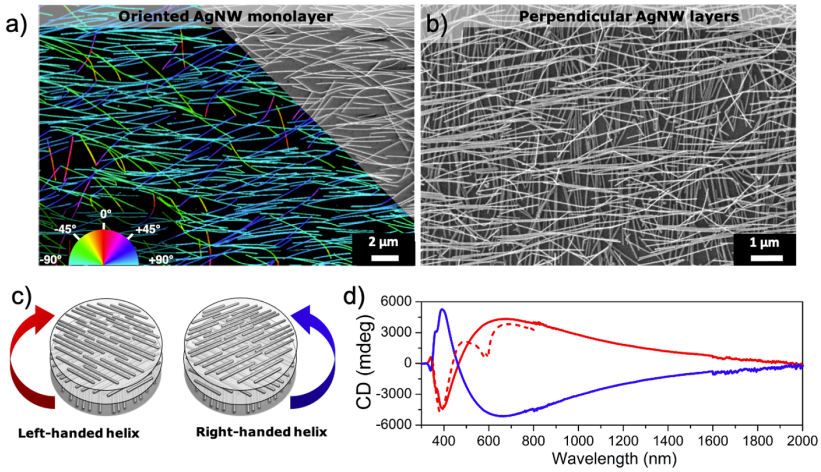

Fig. 1: a) SEM image of an oriented silver nanowire monolayer in which the nanowires are color-coded according to their orientation b) SEM image of 2 perpendicular layers, c) scheme of chiral tri-layer samples, in which the director is rotated 60° between each layer, and d) CD spectra, showing CD peaks of very high intensity for AgNWs (full) and AgNWs + an achiral dye (dashed).

The PhD thesis will focus on the optical properties of chiral hybrid assemblies of metallic nanowires/nanorods and molecular fluorescent emitters. We will make use of the high versatility of GIS combined to LbL to investigate the tight relationship between the thin film design and the resulting optical properties. Polarized UV-Vis-NIR spectroscopy, polarized fluorescence and circular dichroism will be used to investigate the effect of the thin film structure on the resulting macroscopic properties. More advanced spectroscopic and polarimetric studies (ellipsometry and Mueller Matrix Polarimetry) will be performed on selected samples. The properties will be modeled by transfer matrices and FDTD simulations.

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