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.

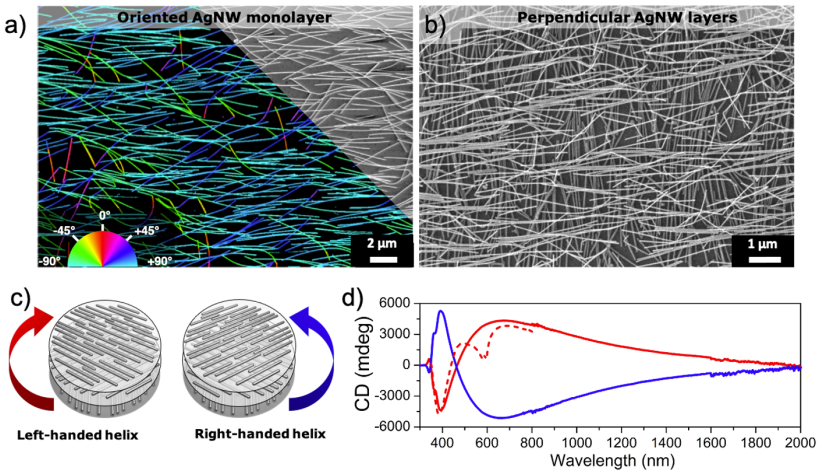

Fig. 1: a) SEM image of an oriented silver nanowire monolayer in which the nanowires are color-coded according to their orientation b) SEM image of 2 perpendicular layers, c) scheme of chiral tri-layer samples, in which the director is rotated 60° between each layer, and d) CD spectra, showing CD peaks 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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5. H. Hu; S. Wang; X. Feng; M. Pauly; G. Decher; Y. Long *Chem. Soc. Rev.* **2020**, *49*, 509-553.
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Information about the host institute

The Institut Charles Sadron (ICS) is an institute of the CNRS affiliated with the Université de Strasbourg (Unistra). It is a multi-disciplinary research laboratory devoted to basic research in the fields of Macromolecules and Soft Matter with applications in Materials Science. It is the largest research facility in this field in France (about 53 senior scientists, 38 engineers, technicians and administrative staff and 100 temporary researchers, e.g. visiting scientists, post-docs, PhD students...). It provides all infrastructures required for the complementary research of chemists, physico-chemists and physicists. ICS has major central facilities for polymer research and material science including home-made instrumentation for the synthesis and preparation of materials, their physico-chemical and structural characterization as well as the determination of their physical properties. They span a wide range of analytical, microscopic, spectroscopic, rheological and mechanical techniques as well as computer facilities. The scientific productivity of ICS is about 120 articles, 3-5 patents and about 80 invited presentations per year.
ICS is one of the founding members of the interdisciplinary thematic institute (ITI) HiFunMat, a unique project devoted to materials science (research and education) involving a dense network of academic and industrial partners.
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The PECMAT group at ICS has a leading expertise on the investigation of multi-composite materials possessing nanoscale organization, which includes:
- the preparation of nanoscale building blocks
- the organization of these building blocks into (multi)functional (multi)composites
- the multiscale analysis of the structure and the dynamics of such systems
- the optimization of the materials properties

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Candidate profile

This multidisciplinary thesis work, at the frontier between chemistry, nanoscience, materials science and optics will involve nanochemistry, structural characterization and physicochemical characterization. The thesis is intended for a master student with a strong background in chemistry, physical chemistry, material science or nanoscience.
Application should include a motivation statement, curriculum vitae, courses taken at the bachelor and master level and grades. As the recruitment procedure is highly selective, the applicant must have excellent grades and ranking. Applications will only be considered if all documents are provided.
Candidates should send their application to Matthias Pauly and Olivier Félix using E-mail addresses provided on the first page.