Biologically inspired assembly of ordered and disordered optical materials

This session has been organised in collaboration with the NCCR Bio-inspired Materials.

Wednesday, 29.06.2022, Room E 140

Time	ID	Biologically inspired assembly of ordered and disordered optical materials I *Chair: Ullrich Steiner, Université de Fribourg*
14:30	801	**3D Printing of Photonic Colloidal Glasses into Objects with Isotropic Structural Color** *Ahmet Faik Demirörs, ETH Zürich* Additive manufacturing approaches were recently exploited for the fabrication of exquisite photonic objects, but the angle-dependence observed limits a broader application of structural color in synthetic systems. Here, we propose a manufacturing platform for the 3D printing of complex-shaped objects that display isotropic structural color generated from photonic colloidal glasses. We print structurally colored objects from aqueous colloidal inks containing monodisperse silica particles, carbon black, and a gel-forming copolymer. Using Rheology and Small-Angle-X-Ray-Scattering measurements we identify the processing conditions leading to printed objects with tunable structural colors. Multimaterial printing is eventually used to create complex-shaped objects with multiple structural colors using silica and carbon as abundant and sustainable building blocks.
15:00	802	**Light scattering of micron-sized self-assembled colloidal aggregates** *Pavel Yazhgur, Geoffroy Aubry, Luis Froufe, Nicolas Muller, Frank Scheffold, University of Fribourg* Strongly correlated heterogeneous dielectrics can exhibit structural coloring. Such materials are widely used by nature. Thus, it is desirable to derive a bioinspired design platform for bright ultrastable synthetic pigments. This can be achieved by using spherical aggregates of nanoparticles, known as photonic balls (PB). In our research, we experimentally study the light scattering of PBs and developed a theoretical framework to explain a structural color formation by them. We use photonic balls as a model system to elucidate fundamental aspects of phase delay and momentum transfer of light in optically soft heterogeneous dielectric materials. We use the developed knowledge to demonstrate the PB's potential for graphical printing applications.
15:15	803	**Structurally Colored Micron-Sized Particle Assemblies** *Nicolas Muller, Frank Scheffold, Pavel Yazghur, Geoffroy Aubry, Luis Froufe, University of Fribourg* In the context of Industry 4.0, the inkjet printing technology has the unrivaled advantage of being digital and extremely versatile by its nature. This technology offers a new universe of highly customizable products, adding multi material and while at the same time being fast, flexibly scalable and cost-effective. The recent breakthrough in the understanding of structurally colored materials found in nature provides new design platforms for colored materials and pigments in a variety of applications such as packaging, coatings, electronic paper and sensor applications. The aim of this project is to design inks that generate colors via interference by structural pigments and that can be printed with state-of-the-art inkjet technology.

15:30	**804**	**Varying Disorder in the Photonic Structures of Longhorn Beetles** *Viola Bauernfeind [1], Ullrich Steiner [1], Bodo D. Wilts [2]* *[1] Adolphe Merkle Institute, University of Fribourg* *[2] Department for Chemistry and Physics of Materials, University of Salzburg* Photonic nanostructures can vary in their degree of order and their optical appearance is often altered by pigmentary content. Longhorn beetles display vivid colours in the UV-VIS spectral range and rely on varying degrees of (dis)order combined with pigments to create complex colour patterns. The green-orange coloured subspecies Sternotomis amabilis ssp. sylvia was studied by combining optical characterization and ultrastructural analysis of the coloured scales that adorn the insects' bodies. Body-centred cubic and amorphous photonic crystals inside scales featuring micrometre-scale cortex ribs produce angle-independent blue-green and orange colour, respectively. Additionally, these photonic structures contain pigments, thus illustrating the complex interplay of structural and pigmentary colour in longhorn beetles.
15:45	**805**	**Interplay between order and disorder in structural colored materials** *Lukas Schertel, University of Fribourg* The interplay between disorder and order in structured materials has been increasingly recognized as an important parameter for the creation of a wide range of optical effects from iridescent bright colors created by ordered (crystalline) structures, angle-independent matt colors found in disordered (correlated) structures to extreme white appearances stemming from anisotropic (random) network systems. We combine analytical modeling and in silico synthesis of 3D structures for FDTD optical simulations to study the limitations of structural color in natural and synthetic materials. The predictive nature of such models allowed for strategies towards an improved optical response to be proposed in silico and subsequently applied in self-assembled polymeric systems.
16:00	**806**	**Order and disorder in inverse Opals** *Jansie Smart, Marco Lattuada, Kata Dorbic, Alessandro Parisotto* *Adolphe Merkle Institute, University of Fribourg* Inspired by nature, structural colours can be mimicked by self-assembling monodisperse colloids into crystals. The amount of order in the crystalline structure impacts the iridescence (ordered) and non-iridescence (slightly disordered) of the colours. This project is looking at introducing disorder into the system through non-spherical dimpled particle templates. The dimples introduce an inherent type of disorder into the system, the idea being that the disorder can be controlled by the dimple size. The dimpling process changes the particle's surface properties, thereby changing the stability and the self-assembly at the liquid interface. Particle synthesis and surface preparation has to be optimised to enable the formation of semi-ordered crystalline arrangements.
16:15		
16:30		***Coffee Break***
		BIOLOGICALLY INSPIRED ASSEMBLY OF ORDERED AND DISORDERED OPTICAL MATERIALS II *Chair: Ahmet Faik Demirörs, ETH Zürich*
17:00	~~**811**~~	~~**Inspiration from nature: Photonic hands, legs, and skin**~~ ~~*Diederik Wiersma, LENS – Florence, Italy*~~ ~~In this talk we will discuss photonic materials from various points of view, taking nature as source of inspiration. We will go into the relation between the physical structure of a material and its resulting optical properties and we will look at ways to influence the structure of a material using the light itself thereby creating a two way interaction: the structure determining the optical properties and the light influencing the structure. The application of photonic materials in micro robotics will also be looked into, in particular how one can realize a "photonic hand" that automatically grabs particles of certain colour and microscopic robots that can walk, using light as source of energy.~~ *cancelled*

17:30	**812**	**Transport properties of bioinspired diffusive photonic materials** *Geoffroy Aubry [1], Nathan Fuchs [1], Gabriele Botta [2], Mato Knez [2], Silvia Vignolini [3], Sergey Skipetrov [4], Frank Scheffold [1]* *[1] Université de Fribourg, [2] CIC nanoGUNE BRTA,* *[3] Department of Chemistry, University of Cambridge, Cambridge, UK,* *[4] Université Grenoble Alpes, CNRS, LPMMC, FR-38000 Grenoble* The scales of the Cyphochilus beetle exhibit one of the whitest whites observed for organic materials up to date. The intense and broadband reflectance is striking as the scales are composed of a very thin (7 - 8 μm) disordered network made of low refractive index chitin rods (n ~ 1.55). We will first present the speckle frequency correlation setup used to characterize these samples. We will then show how they can be used as bio-templates for the design of optimized high index diffuse reflectors. Our findings suggest that bio-inspired photonic material design can prove to become instrumental for the development of ultra-thin diffuse reflection coatings with thicknesses comparable to the wavelength of light.
17:45	**813**	**Dielectric foam networks as photonic crystal materials** *Abraham de Jesús Aguilar Uribe, Stefan Aeby, Pavel Yazghur, Frank Scheffold* *Université de Fribourg* Nanostructured dielectric materials with a photonic bandgap (PBG) are considered “semiconductors for light” and promise rich fundamental physics and multiple technological applications, such as low-loss waveguides, perfect reflectors, or optical elements for computers. In PBG materials, the propagation of electromagnetic waves is forbidden within a specific frequency range. Recently, dielectric 2D foam networks, potentially produced on a large scale using self-assembly, have been numerically predicted to have a large PBG. To check the potential of 3D foam-like dielectric networks, we report, for the first time, the 3D printing by 3D laser Nanolitography and experimental PBG study of foam-like photonic crystals.
18:00	**814**	**Disordered micro-pillars create enhanced absoprtion in Euprotaetia beetles** *Alessandro Parisotto, Adolphe Merkle Institute, University of Fribourg* The beetle *Euprotaetia.nox* possesses a black, velvet like allure. Through optical microscopy and spectroscopy, it is found that the cuticle of this insect demonstrates far greater optical absorption than common insect cuticle. Electron-microscope investigations reveal the presence of chitinous micro-pillar arrays adorning the insect elytron. To identify the presence of a structural absorption phenomenon, ultrastructural and optical studies are accompanied by FDTD simulations. Furthermore, various micro-pillar geometries and assemblies are compared by FDTD analysis to determine the optimal properties required for enhanced light absorption.
18:15	**815**	**Orienting single molecules with DNA origami constructs** *Aleksandra Adamczyk, Guillermo Acuna, Mauricio Pilo-Pais, University of Fribourg* One of the main advantages of DNA nanotechnology is that colloidal nanoparticles and fluorophores can be positioned with nanometric precision. In order to fully manipulate the interaction between these species it is necessary to not only control their relative position but also their relative orientation. In this work, we study the orientation of Cy5 fluorophores incorporated in an innovative way using two independent measurements carried out in a standard wide-field fluorescence microscope. Our results show that single fluorophores attached with two anchoring points can adopt different orientations on a DNA-origami, from perpendicular to aligned with the double-helix depending on the number of bases removed from the complimentary sequence.
18:30		***END; Transfer to Dinner***
19:30		***Conference Dinner***