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Nanostructured self-assembled diamond-like morphologies in biological and polymeric materials

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The diamond morphology, known as the "champion photonic crystal", is a particularly interesting morphology displaying a robust full photonic bandgap. In this thesis, 3D characterisation methods are used to identify and analyse self-assembled diamond-like structures at the nanoscale. After introducing basic concepts related to photonic crystals, polymer self-assembly and structure characterisation, the workflows for 3D data acquisition and subsequent reconstruction and analysis processes are outlined.

Self-assembled nanostructured bicontinuous structures are investigated using 3D slice-and-view imaging, structural and optical characterisation, and FDTD simulations. A comprehensive analysis of the biophotonic networks found in the scales of the weevil *Pachyrhynchus congestus mirabilis* is presented, showing that the red colouration originates from a near-perfect diamond structure, while the blue colouration originates from its amorphous counterpart. Despite the absence of long-range order and low refractive index contrast, a pseudo-band gap is formed, which is responsible for the observed colouration.

In two subsequent chapters, ptychographic X-ray computed tomography and FIB-SEM slice-and-view techniques are used to identify the elusive diamond morphology in a purely polymeric self-assembled film. The study shows that the PI-*b*-PS-*b*-PGMA terpolymer triblock forms an alternating diamond structure, which is replicated in a functional gold single diamond. Furthermore, the study quantifies the process-induced symmetry-breaking affine distortions, which improves the understanding of the structure formation process.

Finally, the last part explores the generation of photonic structures by quasi-ordered colloidal assembly. The study examines the packing of spheres on the scale of the longhorn beetle *Anoplophora graafi*, using the aforementioned tools to uncover a local neighbourhood approaching the connectivity expected for the diamond. Molecular dynamics simulations are used to investigate the criteria necessary to create a pseudo-band gap, and the potential of using patchy particles functionalised with DNA to construct such a system is discussed.

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