The main objective of this project is to explore block copolymer self-assembly for generating functional materials with well-defined morphology on sub-20 nanometer length scale, which can be utilized in many important applications such as solar cells and nanolithography.

One of the specific targets is to fabricate interconnected and highly ordered metal oxide films by using a nano-porous polymer with gyroid morphology as the template. This unique structure is ideal for the solar cell application where a mesoscopic metal oxide scaffold functions as the electron collection and transport material. Two deposition methods, namely nanocasting and atomic layer deposition (ALD) will be applied to fabricate compact, inter-connected, and continuous metal oxide films. In this way, the structure integrity will be preserved after template removal during the annealing procedure.

Another objective of this project is to employ block copolymer (BC) self-assembly for nanolithography. We present a procedure that significantly simplifies the main stream BC lithography process, showing a broad substrate tolerance and allowing for efficient pattern transfer. The masks are directly applied on substrates with broadly varying surface energy, including polymers, silicon and graphene, thus bypassing the laborious and delicate substrate chemical pre-modification. To push the boundary even further for minimal lithography steps, a scalable ultra-fast block copolymer lithography procedure is developed. Using selective solvent spin-casting, the block copolymer self-organizes into monolayer packed sphere pattern, without any surface treatment of the substrate and annealing process. Arrays of nano-pillars and nanowells of various materials are fabricated in dry etch processes over wafer scale without defects. We also show an in situ Al2O3 hard mask formation process by ALD to obtain high aspect ratio nanostructured silicon.

This Ph.D. project has led to fruitful scientific contributions and technological developments, which have already allowed to initiate several collaborations with other research groups at DTU Nanotech and DTU Photonics. We believe this project opens up for a number of strategies aiming at the creation of high-performance functional materials on the length scale of sub-20 nanometers that cannot be manufactured in an easy fashion by conventional top-down lithography methods.