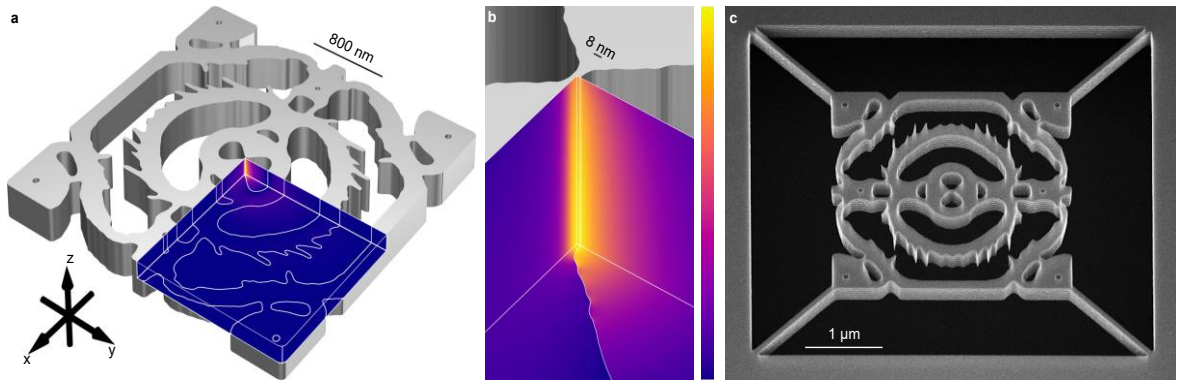
ANNUAL HIGHLIGHTS

With the launch of NanoPhoton in April 2020, we strive to explore a novel regime of extreme dielectric confinement (EDC) of light in optical cavities. The research is made possible by recent progress in the numerical modeling and design of optical cavities in combination with simultaneous and tremendous advances in semiconductor nanofabrication technology.

As an important scientific highlight of the opening year, we successfully designed and fabricated an optical cavity with a record-low mode volume of a few parts in ten thousand relative to the cubic wavelength of the light inside it (see figure below). Because of the incredibly delicate features of the structure – including a central part with a width of only 8 nm despite a membrane thickness more than 30 times larger – this achievement was made possible only by a close collaboration between design and fabrication in which the carefully measured fabrication tolerances were included in the modeling as hard optimization constraints. In fact, we consider this result to be the precursor of a new era in optical nanofabrication in which it does not make sense to talk about the design goals of a structure without specifying the fabrication constraints. Additional scientific highlights include the prediction of superior performance of EDC-based light-emitting diodes by use of so-called quiet pumping from low-noise electronic driving, and the proposal and successful demonstration of a new approach to direct epitaxial growth of III-V compound semiconductors on silicon. Both results lay the foundation for exciting applications of optical cavities with deep subwavelength confinement of light, which we will explore in the coming years.

We are pleased that NanoPhoton members secured additional funding through six complementary research grants, including a Grand Solutions project from Innovation Fund Denmark and a Young Investigator grant from the Villum foundation already in the first year of the centre. In late summer, all members met for the first NanoPhoton workshop, where we were able to exchange ideas and research visions throughout a two-day event. The workshop was a great success, and we expect it to become an annual retreat.



Design and fabricated topology-optimized silicon dielectric bowtie cavity. ***a****, Rendering of EDC cavity design generated by tolerance-constrained topology optimization. The electric field is projected on the faces defining the three symmetry planes of the design.* ***b****, Zoom-in of the solid silicon bowtie exhibiting a strong field confinement due to the bowtie bridge dimension of 8 nm.* ***c****, Scanning electron micrograph of a fabricated cavity.*