Wavelength-scale patterning of colloidal quantum-dot assemblies: a building-block approach to integrated photonics.

Ferry Prins

ETH Zurich, Optical Materials Engineering Laboratory, Leonhardstrasse 21, Zurich, Switzerland
fprins@ethz.ch

Colloidal quantum-dots (cQDs), or semiconductor nanocrystals, are highly versatile building blocks that combine size-tunable optical properties with low-cost wet-chemical methods. High quantum yields (>90%) and spectrally narrow emission throughout the visible and near-infrared range have placed cQDs among the highest color-quality emitters available.[1,2] As such, they are ideal candidates for the bottom-up construction of photonic devices, where the combined tunability of the nanoscale building-block and the wavelength-scale photonic structure introduces new levels of control over optical effects.

Here, we present a methodology to produce such patterned colloidal assemblies using template stripping.[2] Mechanical cleaving (i.e. "stripping") of a cQD film from a patterned hard silicon template allows for high-fidelity transfer of almost arbitrary shapes, yielding high resolution (<100 nm) and wafer-scale photonic structuring of cQD films. Using this technique, we are able to construct fully functioning photonic components composed purely out of cQDs. Examples include low-loss waveguides, high quality-factor ring-resonators, and distributed feedback lasers with heavily reduced thresholds. Moreover, we will demonstrate how synthetic control over the cQD building block can enhance the performance of these photonic devices, for example through wavelength tuning and core-shell based Stokes-shift engineering.

References

[1] Y. Shirasaki, G. Supran, M. G. Bawendi, V. Bulovic, *Nature Photonics* 7, (2013) 13–23
[2] A. Nurmikko, Nature Nanotechnology, 10 (2015) 1001-1004
[3] F. Prins et al., arXiv, (2016) 1610.03026

Figures

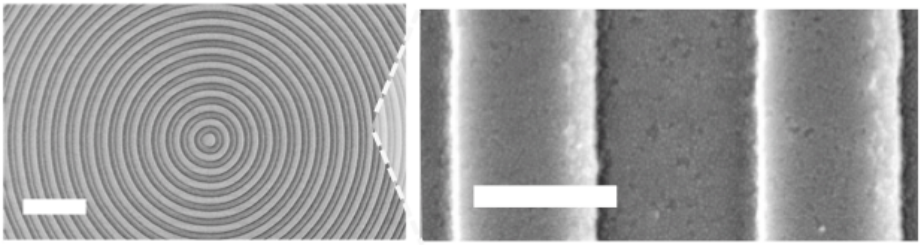

Figure 1: Structural detail of a distributed feedback laser composed purely out of colloidal quantum dots (~10 nm in size). Scale bars are 2 µm and 200 nm.