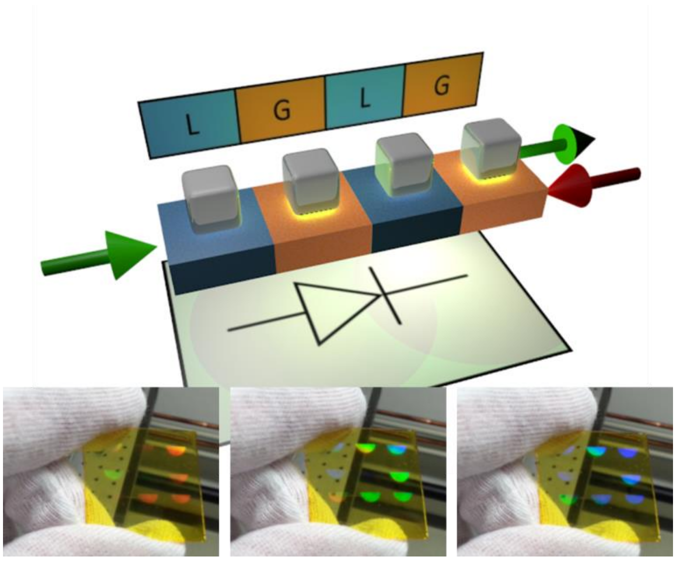
Optical metamaterial revolutionizes light propagation, October 12th 2016

The cloaking device, used by the Klingons in the fictional series Star Trek, makes a spacecraft invisible yet simultaneously allows the crew to see out. These cloaking devices may one day become reality using tailored control of light with colloidal nanoparticles.

Over the past few decades, scientists have made some progress toward building cloaking devices, however, with the best present-day cloaks, the concealed crew could never see through the device, because the cloaking schemes hide objects by redirecting the flow of light. With recent achievements in optics and material science, the following two challenges could be named: first, breaking the “reciprocity” of light and then, building up to the macrocopic scale at realistic costs.

Recently, a concept by the research group of Dr. Tobias A.F. König from the Leibniz-Institut für Polymerforschung Dresden e. V. has been introduced to manipulate light in a synthetic medium as new class of optical metamaterial to make such cloaking device feasible. As shown in the schematic, this synthetic matter consists of an alternating arrangement of amplifying and lossy nanostructures. From this alternating spatial arrangement, intriguing and unexpected optical phenomena such the unidirectional flow of light can be obtained. Until now, this symmetry breaking has only been shown demonstrated with elaborate setups that cannot be scaled up to hide huge objects at manageable costs. With our new colloidal self-assembly mechanism, it is now possible to fabricate large-scale assemblies of amplifying and lossy nanostructures in the excellent research environment in Dresden (Technische Universität Dresden and cluster of excellence: center for advancing electronics Dresden, cfaed). To break the reciprocity of light for macroscopic objects, directed self-assembly (with their high structural control and flexibility) is an ideal candidate. The key step toward this novel macroscopic “optical diode” is a fundamental understanding of the energy transfer between a gain and a loss material. This project from Dr. König and co-workers will open an entirely new field in materials science by specifically combining the optical properties of emitting semiconductor nanocrystals (gain) and plasmonic nanoparticles (loss) with a self-assembly mechanism. Another promising application for such “optical diode” is in future developments in nanophotonic circuits, where current optical shielding is only possible with large magnetic fields and long optical paths.



Schematic of the anticipated “optical diode” in analogy to the flow of an electrical current in a diode and a first approach to this device from the König group.

Recently, the international team of Dr. König was able to fabricate a template matrix for the directed self-assembly process. With this example Dr. König explains his motivation: “This is the first step to seeing the optical metamaterial effect with your bare eyes, which no one has seen before.”