The Road Ahead for Electromagnetic Metamaterials

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Over the last twenty years photonics has played a key role in creating the world as we know it, with enormous global social and economic impact. It is no longer possible to imagine modern society without fibre core telecommunication networks and broadband internet, high quality displays and compact semiconductor lasers found in any data storage device or quality printer, precision laser-assisted manufacturing and lasers in medicine.

The next stage of photonic technological revolution will be the development of active, controllable and nonlinear metamaterials surpassing natural media as platforms for optical data processing and quantum information applications. Metamaterials are artificial media structured on a scale smaller than the wavelength of external stimuli. Conventional materials derive an origin for their electromagnetic characteristics in the properties of atoms and molecules - metamaterials enable us to design our own electromagnetic 'atoms' and when combined with active and nonlinear functionalities give access to new ground breaking functionalities.

We overview our recent results on achieving new functionalities in nanostructured photonic metamaterials containing nonlinear and active media such as switchable chalcogenide glass, carbon nanotubes, graphene, semiconductor quantum dots and report on the exciting properties of superconducting quantum metamaterails and metamaterails that can be reconfigured on the nanoscale at will to tune and adjust their characteristics.