Nanophotonic devices without metal: from static to active

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Nanotechnology has prevailed our modern lives, for which the most prominent example is silicon chips. Since its invention in 1940s, the dimension of transistors has shrunk all the way from centimetres to nanometres, now is in the regime of quantum confinement effects. On the contrary, the number of integrated transistors on a single chip has increased to billions while the size of a computing chips changed from the size of a room to the size of an ant and the latter is more powerful than former. All these can be attributed partly to the sophisticated nanofabrication techniques developed.

Recently, these techniques are finding their new venue of applications in the fields of photonics and optics and it was hoped, in the near future, photonic devices and electronic devices can be integrated seamlessly. However, currently, the relevant dimension in photonics, which is tens or hundreds of nanometers, is several orders of magnitude larger than electronics. Plasmonics has been regarded as a promising candidate to bridge the size mismatch of photonic phenomena and electronic phenomena but the phenomenon comes with the expenses of high dissipation. Furthermore, its compatibility with the current semiconductor processing techniques is not that great. Alternatively, non-metallic materials such as high refractive index dielectrics offer great promises to this regard. Firstly, it resonates strongly with the incident light with Mie resonances. Secondly, it is highly compatible with the semiconductor manufacturing as silicon is one of the best high index dielectrics.

In this work, we will start with a short introduction of dielectric metasurfaces and Mie resonances in dielectric nanoantennas. Then we will discuss an intriguing phenomenon named as Huygens' condition and finally we will talk about the promises it shows for active modulating light modulation.