Novel fluid materials for CMOS photonic WDM systems

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Summary

We propose a simple and low-cost WDM (Wavelength division multiplexing) system (Fig 1a) based on novel fluid materials using micro-ring multichannel filter design with *in-situ*, electrically and magnetically tunable, integrated 2D liquid crystal nanocomposite materials. We achieved a quality factor on the order of $10^{\#} - 10^{\%}$ and fine tuning within the entire C-band range.

Introduction

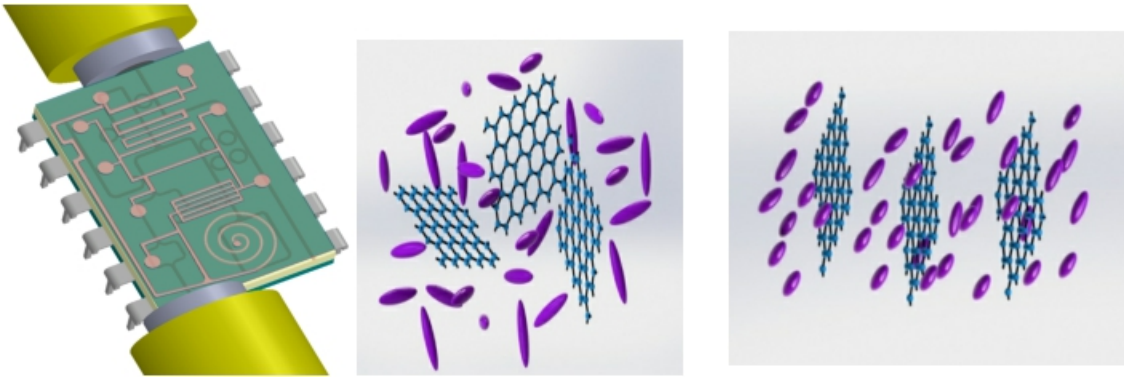
The ever-increasing demand for higher communication capacity and computational performance, with no increase in cost, is a grand challenge to current optical communications technology. Recently commercialised CMOS photonics promises dramatic miniaturisation, substantially lower cost, and significant power savings. However, this technology is still in its infancy and its further advance relies on the development of new photonic materials and structures capable of efficiently controlling the propagation of electromagnetic radiation and of modifying light matter interactions on chip at high-speed.

Among all the currently developed photonic materials, only graphene and graphene related materials have been shown to be truly outstanding for application in reconfigurable CMOS photonics, facilitating endless opportunities for truly reconfigurable operation in electronic-photonic devices, which will further increase functional processing capacity. [1]

Discussion

2D material nanocomposites have received a great level of attention recently owing to the extraordinary possibilities of their intrinsic properties including broadband nonlinearity, extremely large Kerr coefficients, and ultrafast recovery times, but- most importantly- due to their unique tuning capability simultaneously utilising electro-optic, magneto-optic and thermo-optic effects. [2]

In this paper we propose, for the first time, 2D material liquid crystal (Fig. 1(b,c)) [3] nanocomposites as a novel class of reconfigurable photonic metamaterials for application in CMOS photonics. We propose a new practicable technology concept for realisation of the first fully integrated WDM systems on chip. To achieve this objective, we combine two emerging technologies: silicon photonics and microfluidics. Application of methods from silicon photonics allows fabrication of actively tunable devices using electro-optical or thermo-optical effects, whilst silicon optofluidic technology offers wafer-scale integration of novel reconfigurable photonic materials as a back-end technological process.



(a) (b) (c)

Figure 1. (a) WDM based on Si optofluidic waveguide system. (b) 2D material liquid crystal nanocomposites and (c) assembled nanophotonic structure.

The proposed designs are based on coupled micro-resonator structures on silicon-on-isolator (SOI) platform with an integrated SiO_2 microfluidic cladding. By microfluidic infiltration of 2D material liquid crystal nanocomposite materials onto the coupled Fabry-Pérot and coupled micro-ring systems and selective application of the electric field in certain micro-cavties we demonstrate fine tuning of individual channels. We achieve reversible tuning of the individual resonance channels through the application of the electric field or magnetic field. Using the Transfer Matrix Method [4], [5] we show quality factors in the order of 10# − 10%. A bandwidth on the order of 3-4 nm is achieved and a resonance shift with respect to the resonance position of 0.21% is demonstrated.

Conclusions

For the first time, we propose novel fluid materials for CMOS photonic WDM systems based on different tuning technologies. We achieved high quality factors and fine tuning within the entire C-band range.

References

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