# Towards Optical Modulators based on Graphene Surface Plasmons

**T Wood*, M Kemiche, J Lhuillier, P Demongodin, S Callard, B Vilquin, P Rojo-Romeo, C Monat**
*University of Lyon, Institut des Nanotechnologies de Lyon, Ecole Centrale de Lyon / INSA de Lyon*
**tomwood321@hotmail.com*

Graphene is a two-dimensional material displaying unique optoelectronic properties; namely a high in-plane conductivity and a dielectric constant that can be strongly tuned through relatively small modifications to its charge carrier concentration. This places graphene at the interface between optical and electrical devices, and numerous applications have been demonstrated in the literature [1,2] including fast photodetectors, high-transparency electrodes, and polarisers. The ERC GRAPHICS project at Ecole Centrale de Lyon seeks to develop graphene for on-chip optical information processing systems [3]. Among the components being developed, including mode-locked lasers and wavelength converters, this presentation will focus on low power consumption electro-optic modulators.

Over the past five years, graphene's surface plasmon polariton (SPP) – a surface mode corresponding to a strong coupling between photons and charge waves on the graphene lattice – has been the subject of intense interest [4,5]. Such modes appear only at photon energies for which graphene is optically transparent, requiring doping levels that scale with the square of the energy in question. The high wavevectors associated with SPPs translate to confinement of light in sub-wavelength components, whilst presenting challenges for meeting the phase matching conditions necessary to couple to them. In this work, two issues will be addressed in order to unlock graphene's SPPs at optical communications wavelengths: how to electrically dope graphene sufficiently and in a modulatable fashion for data encoding, and how to efficiently couple light from free-space or standard waveguides into SPP modes. Simulations of optimised coupler structures will be presented, along with an overview of device realisation.

This work has been financed by the European Research Council under the project GRAPHICS.

[1] "Graphene integrated photodetectors and opto-electronic devices— a review", X Wang, X Gan, Chin. Phys. B, Vol. 26, No. 3, 034203, 2017.
[2] "Graphene Photonics, Plasmonics, and Broadband Optoelectronic Devices", Q Bao, K P Loh, ACS Nano, Vol.6, No.5, 3677-3694, 2012.
[3] "Le graphène : à nos crayons pour redessiner le paysage de l'optoélectronique", T Wood, M Kemiche, J Lhuillier, S Callard, C Monat, Photoniques 87, p31, 2017.
[4] "Infrared Nanophotonics Based on Graphene Plasmonics", Q Guo et al, ACS Photonics, ASAP article: doi: 10.1021/acsphotonics.7b00547, 2017.
[5] "Graphene Plasmonics: Challenges and Opportunities", F J Garcia de Abajo, ACS Photonics 1, 135-152, 2014.