# Controlled Functionalization Of Graphene Based Solution Gated Field-Effect Transistors

**J. Binder [1], R. Stępniewski [1], W. Strupiński [2] and A. Wysmołek [1]**

[1] *Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*
[2] *Institute of Electronic Materials Technology, Wólczyńska 133, 01-919 Warsaw, Poland*

Owing to its strictly two-dimensional character graphene is an intuitive candidate for sensing applications. Indeed it has been shown that graphene is very sensitive to its environment, a characteristic that is essential for application. On the other hand this sensitivity can cause undesired side-effects and can require the encapsulation of graphene to obtain a stable device operation. In order to make graphene sensitive to a given species it is therefore important to functionalize the surface.

Here, we report on the controlled functionalization of epitaxial graphene by electrochemical means. In order to obtain a well-controlled process it is indispensable to have the possibility to follow the functionalization *in-situ*. To this end we make use of a novel setup that allows to measure Raman spectroscopy while the actual functionalization is taking place [1].

Figure 1 shows the Raman response of an epitaxial graphene field-effect transistor (on a 4H-SiC(0001) substrate) in an aqueous NaCl solution to a gate voltage sweep. After a certain threshold voltage, new peaks appear in the spectrum that can be ascribed to CH vibrations (Fig. 1 (b)). The observation of CH peaks indicates the chemisorption of hydrogen on graphene. We show that this hydrogenation process can be reversed by a sweep in opposite direction [1]. The results hence show that we obtained an electrical switch to the functionalization of graphene, controlled by *in-situ* Raman spectroscopy. The chemisorbed hydrogen can be used as an anchor to graphene for more complex functionalization schemes, which opens up new possibilities for applications in life sciences.

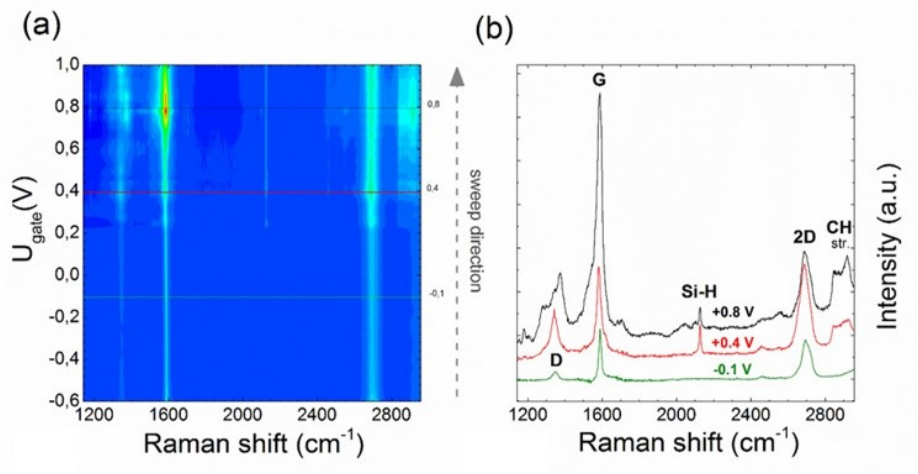


Fig. 1: (a) Raman false color map as a function of applied voltage. (b) Raman spectra for three different voltages.

[1] J. Binder et al. *Nanotechnology*, 27, 045704 (2016).

Acknowledgements:
This work was supported by the National Science Centre, Poland grant 2014/13/N/ST3/03772 and the European Union Seventh Framework Program under grant agreement n° 604391 Graphene Flagship.