Digital camera based on graphene-CMOS integrated imaging array

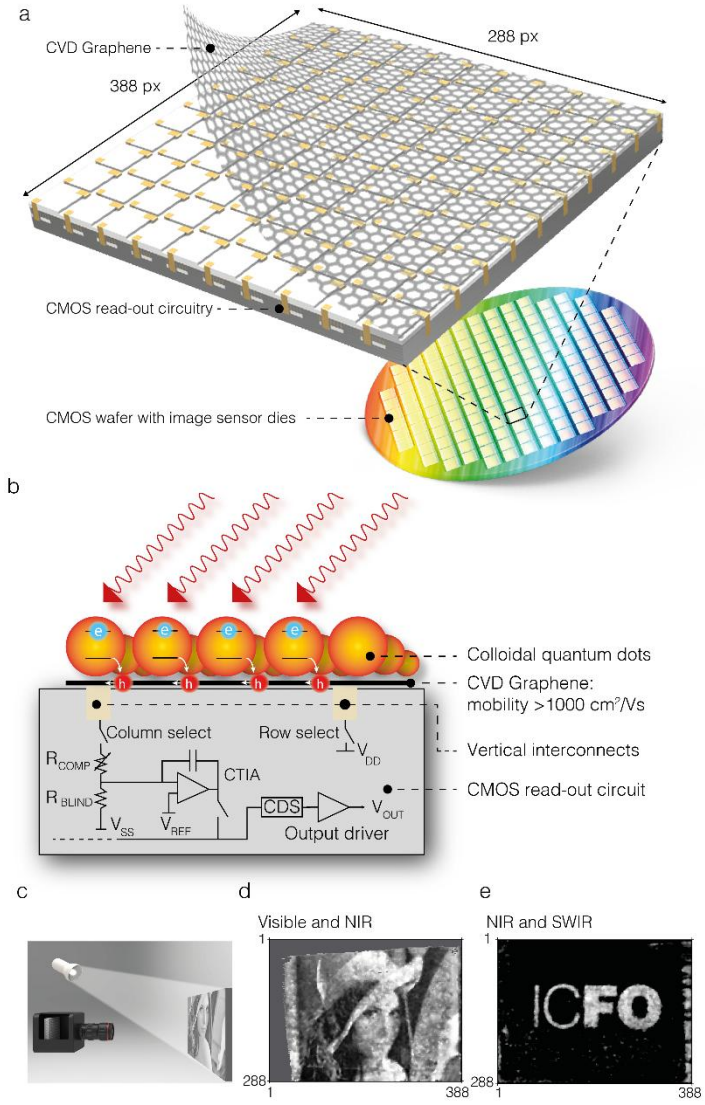
Stijn Goossens[1]
Gabriele Navickaite[1], Carles Monasterio[1], Shuchi Gupta[1], Juan José Piqueras[1], Raúl Pérez[1], Gregory Burwell[1], Ivan Nikitskiy[1], Tania Lasanta[1], Teresa Galán[1], Eric Puma[1], Alba Centeno[2], Amaia Pesquera[2], Amaia Zurutuza[2], Gerasimos Konstantatos[1], Frank Koppens[1]
[1] *The institute of photonic sciences, The Barcelona institute of science and technology, Av. Carl Friedrich Gauss 3, Castelldefels (Barcelona), Spain*
[2] Graphenea SA, Tolosa Hiribidea 76, Donostia - San Sebastian, Spain
stijn.goossens@icfo.eu

Integrated circuits based on CMOS (complementary metal-oxide semiconductors) are at the heart of the technological revolution of the past 40 years, as these have enabled compact and low cost micro-electronic circuits and imaging systems. However, the diversification of this platform into applications other than microcircuits and visible light cameras has been impeded by the difficulty to combine other semiconductors than silicon with CMOS. We show for the first time the monolithic integration of a CMOS integrated circuit with graphene, operating as a high mobility phototransistor [1]. We demonstrate a high-resolution image sensor and operate it as a digital camera. We integrated graphene and the image sensor read-out circuit with a pixel yield of 99.8%. Subsequently the graphene was coated with a layer of colloidal quantum dots to sensitize it to UV, visible and infrared light (300 – 2000 nm) [2, 3]. This demonstration of a graphene-CMOS image sensor is a major leap towards 3d integrated circuits based on 2d materials and Si-CMOS that can perform even more complex tasks than Si-CMOS alone. The natural layer-by-layer stackability of these 2d materials opens a wealth of possibilities for enhancing the functionality of future micro-electronics, sensor arrays, low-power integrated photonics and CMOS imaging systems.
Furthermore, we will show a prototype wellness monitor based on graphene colloidal quantum dot hybrid detectors. We leveraged graphene's flexible and transparent properties to create a wearable device that is conformal to the human body so that it can extract vital signs such as heart rate, breathing rate and oxygen saturation more reliably than conventional devices.

References

[1] Goossens et al., arxiv.org:1701.03242 [cond-mat.mes-hall]
[2] G. Konstantatos, et al., Nature Nanotechnol., 7 (June 2012)
[3] Nikitskiy et al., Nat. Commun., 7 (June 2016)

Figures



Back-end-of-line (BEOL) CMOS integration of CVD graphene colloidal quantum hybrid photodetector with 388 x 288 pixel image sensor read-out circuit. a) 3d impression of the CVD graphene transfer process on a single CMOS die. **b)** Side view explaining the graphene photoconductor and the underlying read-out circuit. **c)** Digital camera setup representation **d)** Visible light photograph of standard image reference 'Lena' **e)** Near infrared and short wave infrared light photograph of a logo cut out of a metal sheet