Materials: Precise placement of graphene sheets

By using a self-release layer, graphene sheets can positioned and placed accurately at the desired location

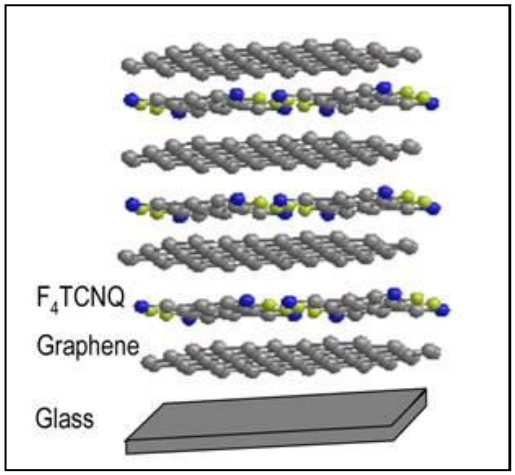

Figure 1: First artificial graphite intercalation compound made by layer-by-layer stacking of graphene. [Image source: Asst Prof Chua Lay Lay]

A graphene sheet comprises of one monolayer of carbon atoms bonded into a honeycomb structure. This material has attracted a lot of attention in recent years because of its unique electronic, optical and mechanical properties. Although it was first available as tiny slivers stripped from small single crystals of the mineral graphite or of artificially-produced highly-oriented pyrolytic graphite, recent advances in chemical vapor deposition (CVD) have made large sheets of graphenes grown on copper foils available almost at industrial scale. However in order to be most useful, these graphene monolayers need to be transferred out of their growth substrate onto the applications substrate. This is where a substantial stumbling block has existed for many years up till now. The problem is that these graphene sheets are fragile (because they are made of many mosaics joined together with defects) and are further susceptible to contamination. Previous methods to transfer the graphene suffer from sheet cracking, sheet contamination and the inability to place the sheet accurately at the desired site.

Now the team of ONDL scientists from the Departments of Chemistry and Physics, NUS has overcome these challenges by inserting a special layer, called the self-release layer, between an elastomeric (i.e., rubber) stamp and the graphene sheet. This layer provides a low work of adhesion on the stamp that facilities the delamination of the graphene and its subsequent accurate placement on the destination substrate. “It is a remarkably simple idea that works, very much akin to the use of an anti-stick coating that you can then subsequently removed under very mild conditions,” says Asst Prof Lay-Lay Chua, the Principal Investigator who led the team.

Using the new method, these scientists demonstrated that ultra-thin polymer capacitors and low-operation-voltage field-effect transistors can be fabricated by transferring the graphene sheet to give the capacitor electrode or gate electrode on a thin stack of organic polymer materials. This opens new applications of graphenes as ultrathin electrodes in devices which were previously not possible. Furthermore, unlike traditional evaporated metal films, which damage the underlying organic film due to metal atom penetration that cause early dielectric breakdown, the transferred graphene sheets do not compromise the integrity of the underlying layers. This leads to superior dielectric breakdown strengths even in very thin films of the insulator.

This project is a collaboration with Dr Geok-Kieng Lim, principal scientist at DSO National Laboratories and adjunct professor at Department of Physics, NUS; and with the group of Prof Peter Ho, from Department of Physics, NUS.

Publication:

Song J., Kam, F.Y., Png, R.Q., Seah, S.L., Zhuo, J.M. Lim, G.K., Ho, P.K.H, Chua, L.L. "A general method for transferring graphene onto soft surfaces", ***Nature Nanotechnology*** 8, 356-362 (2013)