Application Note
ARPES on nearly ideal graphene

In the chase of new materials suitable for nano-electronics etc. great interest is paid to graphene. Ideal graphene is a pure two dimensional sheet of carbon that has a two-dimensional isotropic liner dispersion of the π and π* bands near the Dirac point such that it defines a cone with an apex at the Dirac point of energy. M. Sprinkle et al. used angular resolved photoelectron spectroscopy (ARPES) in there study presented in PRL 103 (2009) 226803 for a first direct observation of a nearly ideal graphene band structure. The observations was made on graphene grown on the SiC(000-1) surface using Scienta R4000 and SES 100 analysers located at the Cassiopée beam line at SOLEIL and at the 12.0.1 beam line at the Advanced Light Source (ALS).

Multilayers of graphene grown on SiC(000-1) has been shown to consist of electronically decoupled non graphitic graphene sheets. The ARPES data from M. Sprinkle et al. presented in this Application note provides the first direct experimental evidence of this decoupling by the fact that the electronic band structure of the individual graphene layers in the sample are unperturbed Dirac cones as expected for isolated graphene sheets as seen in Figure 1. This figure displays two bright intersecting Dirac cones and a third faint cone, better seen in the momentum dispersion curve at the bottom of the figure.

ARPES at 30 eV kinetic energy is very surface sensitive and only the 3-4 top layers are seen in the spectra. Since the graphene film is much thicker than 4 layers no bands from the SiC substrate is seen. Thus, the three cones are originating from individual rotated layers, with the top layer being the brightest.

The spectra recorded for the SiC/graphene film system all show liner dispersion of the intersected Dirac cones from each layer. Therefore each layer/sheet of graphene film can be considered as being isolated from each other. The isolation stem from the stacking order of the sheets in the film and all that is required to preserve graphene's linear dispersion in a multilayer stack is to break the AB-stacking symmetry of graphite.

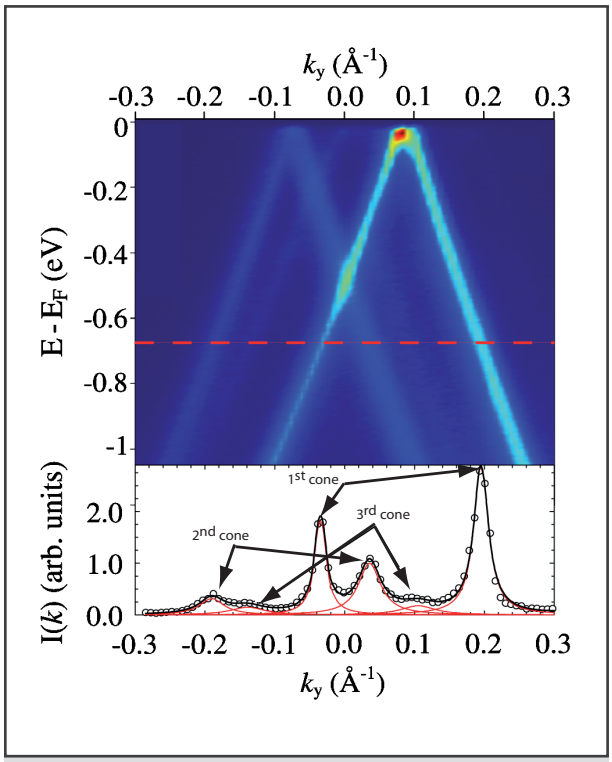

Figure 1: Top) ARPES spectrum of intersecting Dirac cones of graphene grown on SiC(000-1). Bottom) Momentum dispersion curve from top image, as indicated by the red dashed line.

This Application note was made in collaboration with Amina Taleb-Ibrahimi at the Synchrotron SOLEIL, L'Orme des Merisiers, Saint-Aubin, Gif sur Yvette, France.
For further questions regarding this work please contact: amina.taleb@synchrotron-soleil.fr.