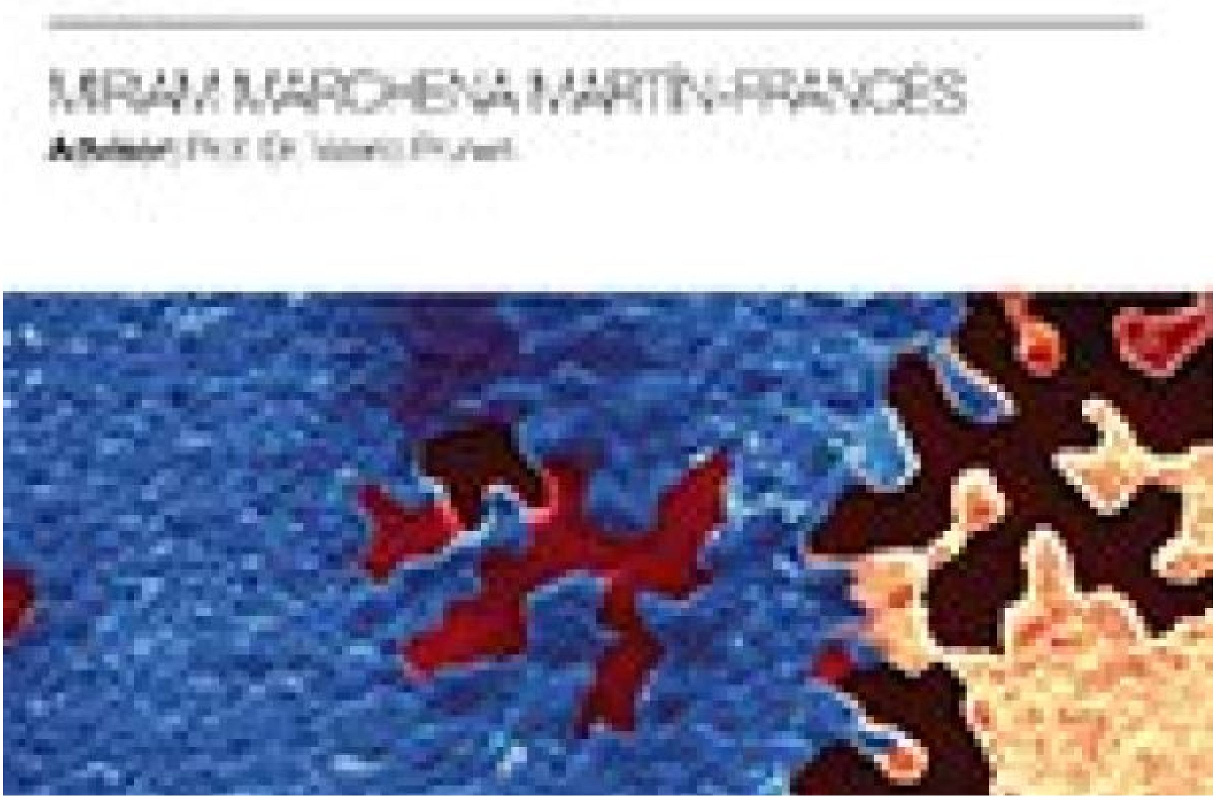

PhD Thesis Defense MIRIAM MARCHENA 'Scalable Techniques for Graphene on Glass'

MIRIAM MARCHENA

June 14, 2018

Thursday, June 14, 11:00. ICFO Auditorium

MIRIAM MARCHENA

Optoelectronics

ICFO-The Institute of Photonic Sciences

The combination of unique properties - high electrical mobility, thermal conductivity, transparency and mechanical flexibility - make graphene promising for a wide variety of applications, including transparent electrodes, flexible displays, touch-screens and wearables. One of the main reasons that prevent its widespread use is the difficulty to maintain all of the previously mentioned properties when grown using industrial grade techniques. The most widely used technique for growing graphene on a large scale is Chemical Vapor Deposition (CVD), where graphene is, typically, first deposited on a Cu catalyst foil and then transferred to a target substrate using additional sacrificial materials (polymers). The transfer is time-consuming and can worsen the graphene properties and its quality. For instance, residues from transfer materials can alter the doping level. This thesis has investigated the direct growth, dry transfer and doping control of graphene on glass substrates, suggesting new methods and designs to improve the use of such substrates in devices, with a particular focus on optical applications where preserving the transparency is often required.

The thesis demonstrates direct growth of graphene on the desired target substrate using two techniques without any transfer step. In the first technique, graphene was grown on large patterned areas by using catalytic ultra-thin metal films (UTMFs) made of Ni, with thicknesses ranging from 5 to 50 nanometers. The dewetting of Ni UTMF when exposed to high growth temperatures allows graphene to deposit on the glass surface while the metal film is breaking and is retracted. In the second technique, graphene was grown on large areas covered by Cu nanoparticles, which can be arranged into different patterns and with surface densities. Tuning the Cu density by dip-coating and evaporation techniques and the possibility of etching the Cu afterwards allow the growth of flat graphene networks, but also of graphene assembled into three-dimensional shapes with high effective surface area, which opens up more potential applications.

CVD of graphene on Cu foil is a powerful growth technique, but its transfer is still a challenge. This thesis has demonstrated a successful dry transfer technique for graphene on glass substrates using interfacial polyimide layers, which is faster,
easier and more scalable while preserving the electrical transport and optical properties.
The doping of graphene through the substrate surface or the additional top layers is not always easy to control. If not properly carried out, it can degrade the graphene properties, even when the previous growth and transfer steps have been successfully performed. This thesis has investigated a doping control post-processing technique, called "thermal poling" of glass, to induce the charge at the surface of the glass substrate and thus modify the electronic carrier density of graphene. The charge in the glass originates from the displacement of ions that become mobile at temperatures above 100ºC and when subjecte to an electrical voltage of up to few kV. The corresponding stable and "frozen-in" electri field is responsible for the doping of graphene.

The results of this thesis widen the range of graphene applications where largescale growth, practical transfer and doping control are required. At the same time, the thesis also opens new research avenues, especially to improve further the graphene quality when incorporated in devices.

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Thesis Advisor: Prof Dr Valerio Pruneri