Seminars Cycle: "*To Know us Better"*

"New Advances and Trends in the Science & Technology of Graphene and other 2D Materials"

Graphene is a perfect 2D crystal of covalently bonded carbon atoms and forms the basis of all graphitic structures. The material was well known as a concept structure (platform) to mathematicians and modelers for many years. However, its isolation and characterization by Geim and Novoselov in 2004 has given rise to a dramatic surge in research and potential applications for this material. Graphene is the best conductor of heat we know, the thinnest and the stiffest material ever made, it conducts electricity much better than silicon, is >200 times stronger than steel and has unique optical properties. These superior characteristics can be exploited in many areas of research; new possibilities are being recognized all the time as the science of graphene and other two-dimensional materials progresses. Needless to add that graphene science and technology relies on carbon one of the most abundant materials on Earth. It is therefore an inherently sustainable and economical technology that involves planar materials and, as such, is compatible with the established production technologies in information and communication industries.

In order to familiarize ourselves with the work we are doing in the Department and also at FORTH/ ICE-HT, we will start by visiting the modern methods for graphene production and we will try to answer the question what is "*graphene"* and what is a *"graphene-related-material"* or *GRM*. Then we will proceed to look at modern automated Chemical Vapour Deposition (CVD) methods for the synthesis of large graphene sheets which are leading shortly into roll-to-roll production systems that will pave the way for industrial adoption and expansion. Special emphasis will be given to the employment of molten metal catalysts in the CVD process that should facilitate the separation of the material from its substrate and will allow cooling from high temperatures free of thermal stresses and undesirable graphene-substrate interactions.

Another technology developed by the group is the use of Raman microscopy (remote and stationary) to assess the mechanical characteristics of graphene but also of other 2D materials. Loading such a thin material in air or embedded in host matrices is extremely challenging. Our recent work has shown how such material, like any other thin film, forms lateral wrinkles under tension in air due to Poisson's contraction. In contrast, for simply-supported or fully-embedded graphene such an out-of-plane phenomenon can be suppressed by switching to micro-ribbon designs rather than the (often used) irregular GRM flakes. In compression, the critical strain to buckling for fully embedded graphene was found to be ~0.6% and independent of the flake's dimensions. This is indeed an extraordinary result for such a thin 2D crystal and its significance for engineering applications will be commented upon.

Strain engineering or in other words the creation of specific structures and applications by the imposition of strain fields is also of one of our main activities to date. Furtermore, interface interactions that lead to tensile and/or compression stress transfer from a polymer matrix to a graphene flake is also of extreme interest for us particularly for composite applications. Stress/ strain transfer profiles can be extracted with our devised methodology in a composite system and a quantitative assessment of the interfacial shear strength can be made.

As an epilogue we will present briefly a recent activity of the group that concerns the protection of art objects and particularly paintings with the use of graphene. Indeed fading, yellowing and discolouration are the most common degradation effects on artworks triggered by the exposition to ultraviolet and visible light also in addition to oxidizing agents. We will show how a thin and transparent veil of graphene can provide adequate protection against discolouration based on its higher absorbance in the UV region of the spectrum. The development of this approach for the protection of both modern and old paintings will be discussed.