**In-Situ and Real-time Spectroscopic Ellipsometry for the investigation of graphene growth mechanisms with Chemical Vapor Deposition**

Graphene is one of the most promising high performance two-dimensional nanomaterials with unique properties that is expected to revolutionize the performance of several applications, ranging from Organic Electronics, to photonics, sensors, and energy. The deposition of high quality graphene over large area substrates (e.g. Copper – Cu and Nickel – Ni) is the subject of intense research efforts for the last years. In addition, the graphene growth process by Chemical Vapour Deposition (CVD) includes several process steps (e.g. heating, annealing, cooling) for the formation of the graphene layer. Therefore, the understanding of the effect of the different growth process steps on the formation mechanism of the graphene ultra-thin layers will significantly contribute to the optimization of the process and the fabrication of graphene layers with the desired quality and performance. Optical metrology has the potential to offer robust and detailed information on the above, and the flexibility to be combined with the graphene growth technology.In this work, we report on the in-situ and real-time optical monitoring of graphene growth onto Cu and Ni substrates by the use of Spectroscopic Ellipsometry (SE) in the visible to far ultraviolet spectral range. The in-situ and real-time SE measurements have revealed the optical, electronic and structural modifications of the metallic substrates during the annealing and cooling stages of the growth processes. Also, the timing of the graphene growth has been identified by the monitoring of the electronic transitions attributed to the sp2 bonded carbon during the growth. Finally, the thickness of the graphene layer structures has been determined. The investigation of the optical response of the graphene – substrate system has revealed information on the process mechanisms and kinetics. Finally, this work emphasizes the importance of in-situ optical monitoring for implementation to graphene processes from lab to industrial scale. The establishment of a robust, accurate and non-destructive method for the in-situ and real-time investigation of graphene quality will be a key step for the optimization of the whole graphene CVD growth process, parameters towards the fabrication of tailored and high quality graphene for transfer and implementation to its envisaged applications.