APPLICATION NOTE

# Graphene Analysis by *Nomadic*™ Raman Microscope



Raman spectroscopy is an *in situ*, non-invasive, and sensitive technology to probe and analyze chemical compositions and structures with high specificity, in a near real-time manner. As a non-contacting optical method, it essentially does not require sample preparation. It has proven to be one of the most effective tools for characterization of semiconductor materials such as Si, SiGe, InGaAs, GaAs, GaN and graphene because they exhibit precise, distinct Raman bands directed associated with their structural properties. Coupled with an optical microscope, the Raman imaging technique has been successfully implemented quantitatively determine microstructure composition on thin-films, strain in the multilayer device, and to identify defects across the surface.

BaySpec's ***Nomadic***™ large-format Raman microscope is an ideal tool for automatic wafer inspection, characterization and Raman chemical imaging on large samples (e.g. wafer) with a spatial resolution up to 1 µm. Particularly, the microscope stage can accommodate large samples with a size up to 12 inches. Differences in chemical composition and structure on a sample can be vividly revealed automatically – features that are often completely invisible in optical imaging. With regional mapping features, it can automatically analyze many pre-defined regions on a large sample with a click of a button.

Graphene is defined as a two-dimensional single-layer of carbon atoms arranged in a hexagonal pattern. Due to its exceptional electronic and phonon properties, it has become a very popular topic in this decade. Raman spectroscopy can indeed identify and characterize all the members of the carbon family (e.g., graphite, graphene, diamond, nanotube and fullerene), directly giving detailed structural information.

For example, in Raman spectra of graphene, the most obvious difference is the G' (or 2D) band around 2680 $cm^{-1}$, which is more intense than the G band (around 1580 $cm^{-1}$) in graphene compared to graphite. The relative intensity, shape and shift of these bands are directly related to the underlying structure of these materials[1]. For instance, the G' band in a single layer grapheme is much sharper and intense than the G band. The ratio of these 2 bands can quantitatively define the quality of the graphene sample (e.g., number of layers). Moreover, the ***Nomadic***™ can easily generate the chemical maps of the graphene to inspect the coating.

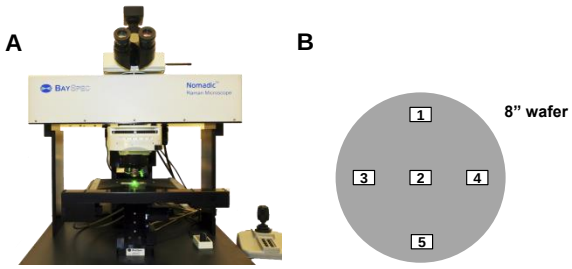


**Figure 1**. (**A**) **Nomadic**™-532 large-format Raman microscope. (**B**) Regional mapping function can automatically scan multiple pre-defined sites on a large sample (e.g., 5 sites on an 8" wafer).

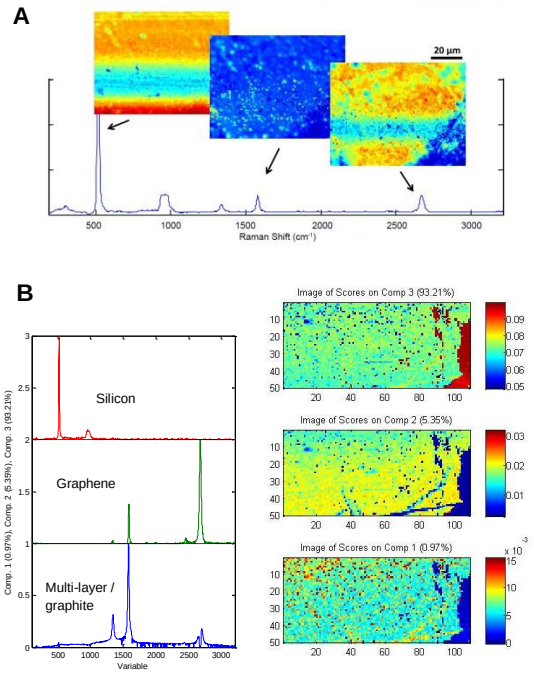


**Figure 2**. (**A**) Direct Raman chemical imaging of a graphene sample on silicon substrate. Raman images are reconstructed by silicon's 520 $cm^{-1}$ peak, graphene's G band, and G' band. (**B**) Further chemometric analysis (Multivariate Curve Resolution, MCR) are performed using Solo+MIA (optional package included in Nomadic's Spec20/20 software suite). Components (silicon, graphene and graphite) distribution can be quantitatively revealed.

With fast imaging and confocal optics, ***Nomadic***™ is a powerful tool for quantitative characterization of graphene, or similar materials/coatings, in a real-time manner.

Reference: [1] A.C. Ferrari, *Solid State Communications* **143** (2007) 47–57

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