



# Surface measurements with picometer resolution



*BW-S50 graphene layer height measurement  
(image courtesy of Dr. Peter Blake, Graphene Industries Ltd)*

## BW-S and BW-D series White light interferometric microscope systems

Building on Nikon's Industry leading Double Beam Interferometry objectives, Nikon Metrology has launched a series of White Light Interferometry (WLI) Systems, which will set a new the standard in 2D and 3D surface profiling.

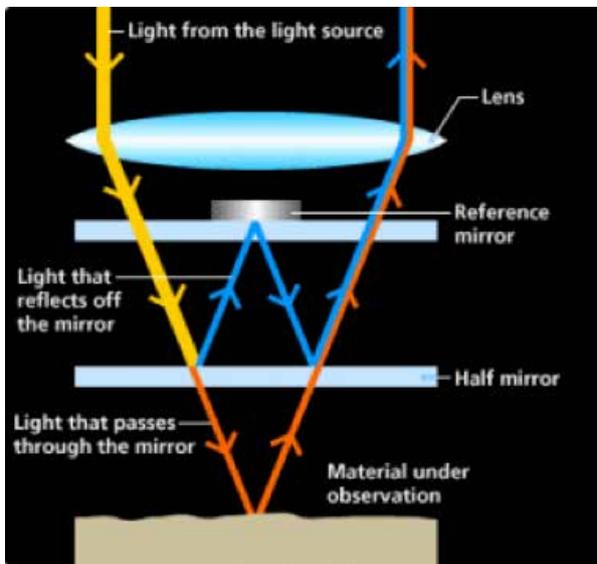
Nikon's new Focus Variation with White Light Interferometry (FWLI) moves the technique into new ground. With effective height resolution of 15 pm (picometer), more precise and accurate 3D surface height measurements are now achievable.

Integrating Nikon's existing industrial research grade microscope range with the latest WLI technology, Nikon is able to combine a WLI system, with standard optical techniques such as Brightfield, Darkfield, polarized light, DIC and Epi-fluorescence, making the BW series, truly versatile imaging systems.

The BW series offers a variety of options including: a choice of high speed and high resolution cameras; a range of Nikon DI Objectives; piezo objectives and nosepieces; and manual or motorized scanning stages, all of which add up to numerous systems suitable for all customer's needs and budgets.

Applications for the BW series include surface and roughness analysis of: glass; ceramic; silicon wafer; ball bearings; image sensors; thin films; graphene; molds; rubber; metals; plastics.

These next paragraphs explain the background on the proprietary algorithms that enable to accurately measure surface profiles.



Light from the light source is split at the half mirror. The light path length of the reflected light is always the same, but that of the light that passes through varies depending on the asperity of the surface of the material under observation.

## Surface profile measurement is indispensable in materials R&D

The items around us are made with various combinations of materials. The field of science that researches and develops such materials is known as Materials Science. New materials used in such areas as advanced medical care, alternative energy, aeronautics and aerospace are being produced every day.

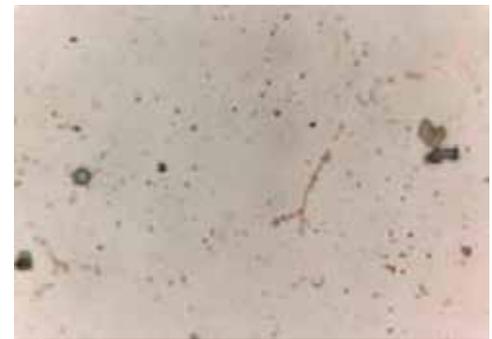
One of the important processes during R&D in Materials Science is the measurement of surface profiles. The surface of a material may have some minute asperity or scratches that are invisible to the eye. Since slight roughness such as this can affect the product, it is necessary to accurately measure the surface profile.

Research laboratories at universities and materials manufacturers require ever higher levels of precision in surface measurements. In the case of silicon carbide (SiC), essential to next-generation power semiconductors, researchers need to visualize surface profiles on the order of less than 1 nanometer. The Nikon white light interferometric microscope system has been designed to meet these highly exacting needs.

### Structure of two-beam interferometry

Light from the light source is split at the half mirror. The light path length of the reflected light is always the same, but that of the light that passes through varies depending on the asperity of the surface of the material under observation.

The white light interferometric microscope system uses a method known as two-beam interferometry to measure surface profiles. As the term "two-beam interference" suggests, two beams of light interfere with each other.



Brightfield image  
Identifying minute asperity on a surface is difficult.



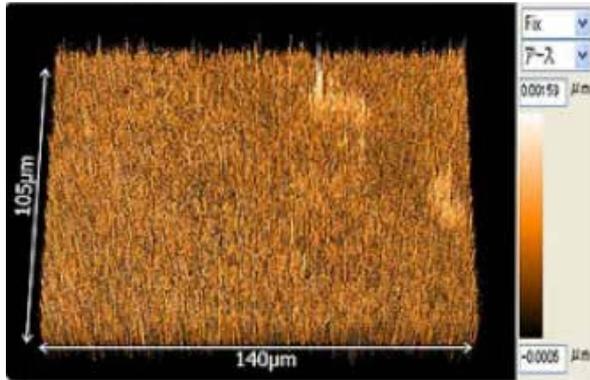
Two-beam interference image  
Observation is possible when interference fringes are added to the minute asperity of the surface. When white light is used as the light source, patterns of strong contrast can be seen where there are no differences in light paths (center). When the differences are greater, the patterns become weaker (toward the edges) and look fuzzy.

The light from the light source splits in two when it hits a special mirror known as a half mirror. One part reflects off the mirror and the other passes through it. The reflected light then travels to another mirror called the reference mirror, while the light that passes through travels to the material under observation on the stage. Both beams of light bounce off the respective objects. The beams interfere with each other when they form an image in the camera, where they produce striped patterns known as interference fringes.

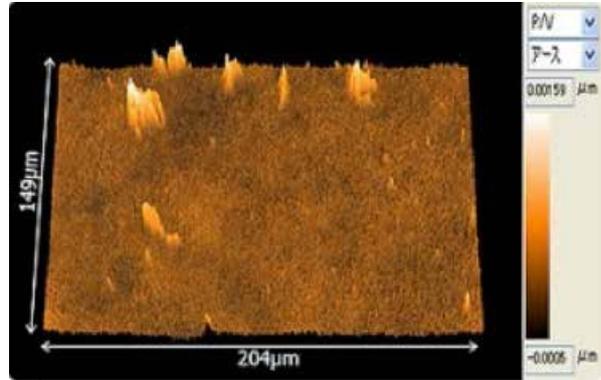
What is important here is the difference between the paths of the two light beams. Since the reference mirror has an extremely smooth surface, the light that bounces off it always passes along a fixed, uniform path. However, light that bounces off the material under observation passes along paths that may be longer or shorter depending on the asperity of the surface.

When white light, which has a wide wavelength interval, is used as the light source, the brightness contrast of the interference fringe that results is strongest in areas where there is no difference in the light paths, and it becomes weaker as differences in the light paths become greater. These characteristics are used when two-beam interference measures height, and as the objective lens is adjusted vertically and

## Measuring a polished SiC wafer (50x)



Ordinary white light interferometric microscope system  
The surface profile of the material under observation cannot be accurately measured due to high levels of measurement noise.



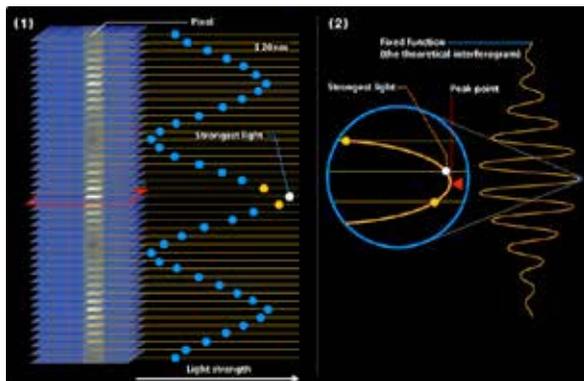
Nikon's white light interferometric microscope system  
Even heights of less than 1 nanometer can be quantified, and surface profiles can be reproduced in a pseudo-color image.

the distance to the material under observation is changed, changes in the interference fringes are photographed by the camera. The captured images are analyzed by a computer to determine the position of the objective lens when there was no longer any difference between the light paths and the interference fringes were brightest. By identifying each image individually, it is possible to calculate the height of asperity on the surface of the material under observation.

### Using proprietary algorithms to achieving accurate measurements of surface profiles

Extremely smooth surface profiles of less than 1 nanometer in height cannot be measured accurately with ordinary white light interferometric microscope systems. However, proprietary algorithms that Nikon has developed have now made this possible. When taking height measurements at each pixel, the first step is to capture more than 500 scanned images while vertically moving the objective lens in

20-nanometer increments. The image with the strongest light is then selected, which means first confirming that the position of the "peak point," where the difference between light paths is zero, is no more than 20 nanometers from the selected image to the next or previous image. Next, to accurately identify the position of the peak point, the status where the degree of coincidence of the observed value (point group) and the fixed function (the theoretical interferogram) is at its highest point is analyzed in the extremely minute unit of picometers\*. Height is calculated from the peak point that was obtained. These analyses are performed on all pixels, and in a period of just a few seconds, it is possible to measure surface profiles with very high accuracy. The Nikon white light interferometric microscope system that utilizes proprietary technological capabilities to respond to exacting requirements continues to contribute to the R&D of new materials that will create a prosperous future.



(1) The objective lens is moved in 20-nanometer increments and more than 500 scanned images are captured. The image with the strongest light for each pixel is then selected from this number.  
(2) The peak point is found by analyzing the status of the highest coincidence degree of the measured value from the image and the fixed function. The height can then be calculated.