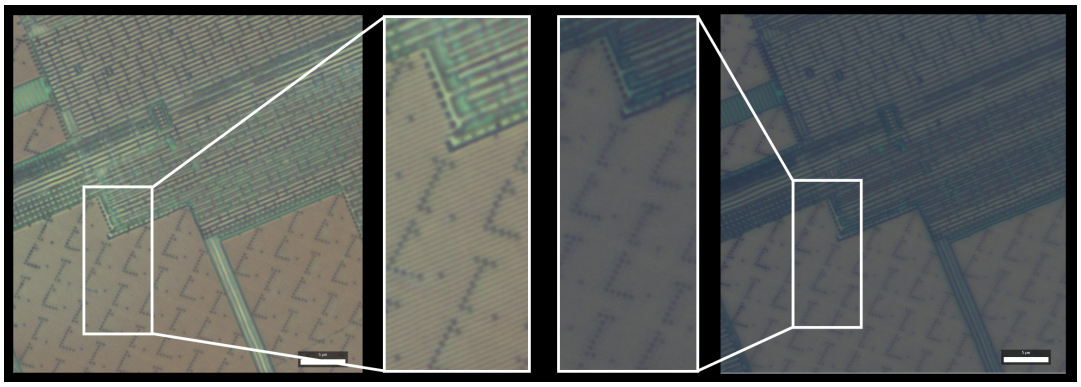
MICROSCOPY

Nikon Metrology Europe partners with UK special optics manufacturer to propel super high-resolution microscopy into the mainstream.



Comparison between inspection of a semiconductor wafer with a SMAL AIR lens on a Nanoro-M microscope (left) and with a conventional dry lens (right). 100nm lines are visible when magnified on the SMAL image but invisible in the same area on the other image. Similar functionality will soon be available on a standard Nikon Metrology microscope.

Established in 2014 as a tech start-up in Manchester, UK, LIG Nanowise (www.lig-nanowise.com) invented and brought to market in early 2019 a far-field, white light microscope with a resolution lower than 100 nanometres (nm), two to three times better than is normally achievable even with a perfect optical microscope set-up. Clever exploitation of the properties of a so-called glass microsphere was behind the invention, which contravenes a fundamental law of physics called the diffraction limit (see editor's note below).

The result of this breakthrough was the launch of the Nanoro-M microscope, a specialised microscope unit designed to enhance the imagery taken by the SMAL, (Super resolution Microsphere Amplifying Lens) which was invented and patented by LIG Nanowise. Based on Nikon's objectives, the initial version required the sample under observation to be immersed in water or oil. However, with advancements in technology, at the end of 2020 SMAL was joined by the complementary SMAL AIR, as a non-contact, immersion-free lens that operates in either air or vacuum.

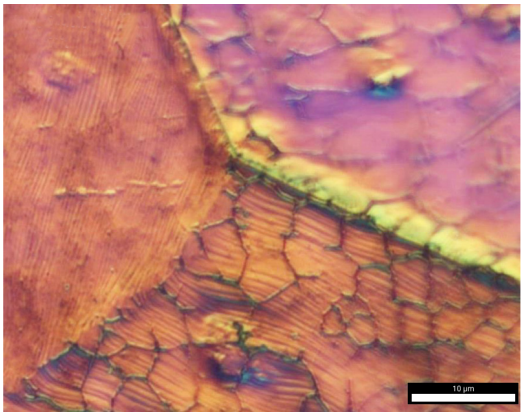
Both the wet and dry versions of the SMAL lens offer super resolution, brightfield microscopy in full colour with considerably increased magnification capabilities beyond standard optics. Alone, the SMAL optics offer up to 240x magnification and around 80nm spatial resolution. When in combination with the Nanoro-M microscope that houses a custom-built, directional light source, they can enhance the visual result and access rapid stitch scanning (provided that the specimens are sufficiently flat). With suitable high contrast samples, features as small as 50nm are discernible which is an astonishing result when using white light. Notably, inspection using a SMAL lens is entirely non-destructive, leaving the sample completely unaffected, whereas impingement of accelerated electrons in a scanning or transmission electron microscope, for example, can damage the material under investigation.

EVERYDAY LENS WITH SIMILAR PROPERTIES

With the aim of democratising super-resolution imaging, LIG Nanowise and Nikon Metrology Europe (www.nikonmetrology.com) have agreed to extend their cooperation by introducing these two new lenses on the Nikon LV range of microscopes. In addition to the SMAL lens products, LIG has been working closely with Nikon to bring the Nanoro-M's enhanced SMAL imagery to the LV microscopes with a modular upgrade that will be jointly marketed by both companies under the trade name LV-MOD. They will be supplied either for retrofitting to existing Nikon LV optical microscopes in the field, or as a complete microscope system. With an air and an immersion objective, both of which are a combination of LIG and Nikon optical technology, and an enhanced SMAL imaging mode module upgrade to LV microscopes, it is sure to be a winning combination.

The official launch of the LV-MOD is expected before mid-2021, after all necessary quality checks and product certification will have been completed. Tests have shown that the performance of SMAL on an LV100 microscope with LV-MOD upgrade closely rivals that of the SMAL on a Nanoro-M. The 240x maximum magnification and 80nm resolution remain the same and the contrast is enhanced

Nikon Metrology Europe partners with UK special optics manufacturer to propel super high-resolution microscopy into the mainstream.



Differential interference contrast imaging, using an LIG Nanowise Nanoro-M microscope, of grain boundaries in graphene deposited on three crystalline phases of copper. Tests are showing that the SMAL / Nikon LV-MOD composite lens delivers equivalent results.

to similar levels, but stitching capability is slightly reduced. However, that is greatly outweighed by having virtually identical capability on an everyday piece of laboratory equipment. Particularly promising application areas where excellent results are already being achieved are in semiconductor imaging, material science (e.g. graphene) and mineralogy imaging (e.g., platinum group elements).

DIFFERENT APPLICATIONS

Both categories of SMAL and their respective composite LV-MOD have their own strengths. The air lenses offer the major benefit of not contacting by fluid, marking or damaging the specimen, making it ideal for investigating sub-diffraction-limit features in the semiconductor and microelectronics industries as well as other sectors where contamination of the sample with oil or water must be avoided.

However, the dry lenses do have a shorter working distance of up to 200nm, compared with 5 - 10 microns for the wet versions, requiring samples to be polished to a flatter finish. Another advantage of the water/oil lens is that some samples such as biological or (electro) chemical specimens do require immersion, enabling even better enhancement of the colour information from the white light source over the air/vacuum lens.

COMMENTS FROM THE COMPANIES

Dr Daniel Lonsdale, Chief Technical Officer and acting CEO of LIG Nanowise commented, "The relationship between LIG Nanowise and Nikon Metrology is amazing and has been critical in developing the new product line-up. Nikon have assisted us every step of the way, loaning us equipment and being on-hand to offer expert advice to help our R&D.

"The Nikon LV microscope range is well known in the industry for its modularity and large range of options for tackling a multiplicity of different inspection applications. Add to this extremely competitive product range, sub-100nm resolution and beyond state-of-the-art magnification alongside traditional objectives on the same nosepiece turret, offering the customer a truly interesting value proposition.

"The microsphere technology and solutions LIG provide remain unique and offer fascinating new insights to the microscopy world. The availability of these new sub-diffraction composite lens products, through both Nikon Metrology Europe and LIG Nanowise, heralds a major extension to the flexibility of optical microscopy, and I am extremely excited about the future."

Dr Sebastien Vilain, Senior Optical Engineer at LIG-Nanowise added, "At the outset, our team chose Nikon Metrology for the development of these products due to the high quality images with outstanding clarity that their lenses deliver, coupled with a very robust design and build quality."

Tadashi Nakayama, Corporate Vice President of Nikon Corporation in Tokyo concluded, "We are very enthusiastic about this development in optics, especially as there is already a lot of interest internationally. The big advantage of the microsphere lens is that it provides nanometric resolution that edges towards the capability of an electron microscope, but results in a full colour rather than a monochrome image.

"Perhaps the most pronounced advantage of the new white light technology is that it is possible to incorporate it directly into a production line for automated quality assurance. It therefore fits neatly with our vision of Quality 4.0, the aim of which is to provide feedback to control and optimise a manufacturing process as close to real-time as possible to reduce defects to zero."

"The availability of these new sub-diffraction composite lens products, through both Nikon Metrology Europe and LIG Nanowise, heralds a major extension to the flexibility of optical microscopy, and I am extremely excited about the future."

Dr. Daniel Lonsdale, CTO and acting CEO of LIG Nanowise Ltd

EDITOR'S NOTE

In essence, the diffraction limit says that normally it is impossible to resolve features smaller than approximately half the electromagnetic wavelength being used to illuminate and observe an object, in this case light in the visible spectrum, irrespective of the quality of the lenses and the way the optics are arranged. The exact physical mechanism by which microsphere imaging breaks this physical law and allows resolution of objects far beyond the conventional optical resolution limit is a source of debate.

There are three possible models. One is super-resonance theory, involving a description based around evanescent (standing) waves amplified and converted into travelling electromagnetic waves, allowing access to the super-resolution information held in the near field. Another is based on super-resolution photonic nanojets that can reach feature sizes much smaller than traditional optical limits allow. The third is the enhanced constructive light model, or whispering gallery mode theory, which provides another route to describing how small features can be detected, transmitted and observed. The current consensus points towards a complex theory in which all three phenomena contribute.

Sales.Europe.NM@nikon.com
www.nikonmetrology.com
+32 16 74 01 00