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3D Surface Measurement in the Medical Field

3D surface measurement is used in a range of industries, such as medical implants and devices, automotive and aerospace, sensors, and semiconductor. It meets the requirements of research labs as well as production floors. In each of these industries, the precision and repeatability of the measurements is of utmost importance, but perhaps in no industry is this as obvious as in the medical field.

Medical applications for precise 3D surface measurement include stents and their coatings, medical implants such as hip joints, contact lenses, and medical instruments such as scalpels. Manufacturers of medical implants and devices have been relying on 3D surface measurement to control the quality of such products for years.

TECHNOLOGY EXPLAINED

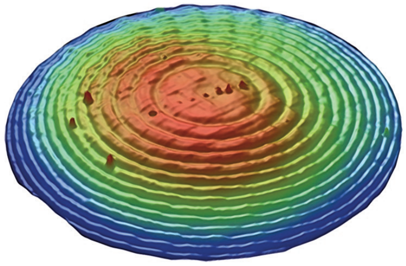
Let's take a closer look at how surface measurement based on white light interferometric technology works. 3D optical microscopes provide a large amount of information in a short amount of time. The process begins when incident light from a high-brightness LED source is split into two beam paths. One is focused on the sample while the other is reflected from a mirror. The two beams are then recombined and focused onto a CCD camera. The recombined signals yield a 3D contour map of the sample surface. The map is highly accurate and created quickly—the measurement technique can acquire the 3D full array of a 480x640-pixel CCD in seconds.

White light interferometry microscopes can be used to measure surface profiles at any magnification. These microscopes can scan up to 100 microns per second vertically, imaging the entire field of view in a fraction of a second. The technique also enables the part to be measured more accurately and completely. As compared to 2D measurements, 3D surface measurement results in a better understanding of a part's surface texture and shape, as well as functionality.

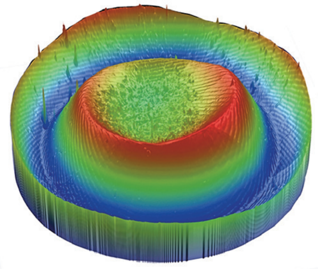
STENTS

More than ten million stents are produced worldwide each year, and they continue to be used successfully to treat atherosclerosis by opening a cavity to improve blood flow. The quality of a device implanted in the human body is obviously critical, and stents available today have features that enable more successful outcomes. Drug eluting stents, the most commonly used today, are coated with anti-coagulant drugs in order to improve reactions within the body. The coatings allow for better dissemination of the drugs and allow blood to flow through the stents. Stents must be measured for surface roughness and coating thickness. If the stent is malformed, it could impede blood flow, thus compromising its role within the body and increasing risk within the patient. Coating thickness is no less important. The even application of drugs to the stent means that the exact dosage will be released at the correct times. Even a one micron difference could have critical consequences.

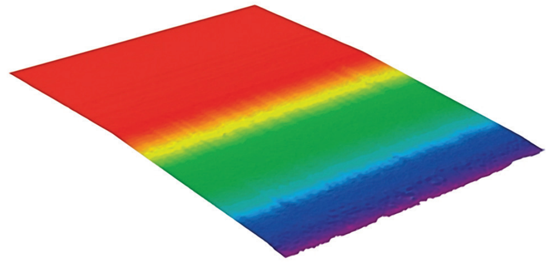
Thus it is important for manufacturers to be able to measure both the stent surface and their coatings. 3D optical microscopes can measure both simultaneously. The instrument displays critical parameter data for both top and bottom surfaces of a coating or multiple coatings, as well as providing data on the underlying substrate. After



Stitched measurement of a bifocal contact lens showing form.



3D form measurement of intraocular lens.



Topography map of a medical cutting blade angle and edge.

measurements are taken, software identifies deviations from the ideal shape. Defective stents are identified, and the dimensions, depths and volumes of each pit are tracked in a database. The wonderful end result of these measurements is safer and more effective stent-based treatments for the general population.

MEDICAL IMPLANTS

As the baby boomer generation ages, hip replacements have become the most common orthopedic surgery and large volumes of the components for this surgery are manufactured each year. Failure to create a quality product could obviously have huge implications both for the person hosting the hip implant and for the company itself.

The 3D optical profiling technique allows for the collection of data from hard to access areas, including inside small diameter hip cups. 3D optical microscopy can be used from design to manufacturing to studying the wearing and aging of the product. Analyzing material wear is an important consideration, as improper contact between the implant and the body can lead to wear and debris, which in turn can lead to inflammation. This can cause a host of additional problems, from an annoying squeaking sound to osteolysis (bone destruction) and pseudotumors.

Material wear often takes place when materials are placed in constant contact with others, which happens by necessity with hip cups. The surface analysis technique was used to test wear in the following study. A one-inch sphere made up of PolyEtherEtherKetone (PEEK) was used to simulate a hip joint. The surface was mapped using a 3D microscope, with measurements being taken consisting of several fields of view measured at 5x magnification and combined to produce a view of the surface. After analyzing this sphere, a wear mark was created to simulate wear and volume removal. Once a volume of material was removed, the surface was re-mapped. By subtracting the original surface from the second, worn one, the material mass and volume loss can be determined. As with stents, it is the average patient that benefits from the improvements in quality made possible by good surface measurements.

CONTACT LENSES

With the changing demographics of today's contact lens wearer—older and with more complex visual conditions—the industry needs to measure increasingly complicated lenses. Interocular lenses and bifocal lenses are just two examples. 3D optical profiling creates a full 3D surface and shape map for these complicated lenses. The microscope scans vertically with respect to the surface so each point of the test surface is checked. The 3D microscopes provide a more complete picture of the lens surface than is possible with 2D techniques, providing noncontact surface finish and form measurements as well as surface defects detection. For manufacturers, this helps them develop new types of lenses, lenses that last longer, and most importantly, lenses that perform better and are more comfortable for the consumer.

MEDICAL INSTRUMENTS

Yet another example can be found in the measurement of medical instruments. 3D optical profiling can provide inspection for medical scalpels as well as basic consumer razors, assessing a host of factors such as how well a blade will perform in a given situation. For razors, blade comfort and cutting quality depend on surface finish characteristics and cutting angles. Both can be measured through 3D optical profiling, which gathers surface finish data on average roughness (Ra) and peak-to-valley height as well as the curvature of the scalpel cutting surface. Noncontact inspection can be done without interfering with sterilization.

Emerging point-of-care medical testing devices based on microfluidic structures also require precision measurement of the 3D channel structures and the surface roughness of the micro channels in these devices to guarantee the quality and performance of such products.

CONCLUSION

3D optical surface profiling is a powerful tool for guaranteeing the quality and performance of precision medical devices. With precision optics and sophisticated control and analysis software, surface measurement data can be collected and analyzed quickly, and the data can be saved and stored for additional analysis. Today's powerful 3D optical profilers can be automated for fast, reproducible testing in production. These measurements greatly affect safety, performance, and comfort for countless patients. And many new medical applications for high-end 3D optical microscopes are being explored and put to use every year. To learn more, visit www.bruker.com/nano.