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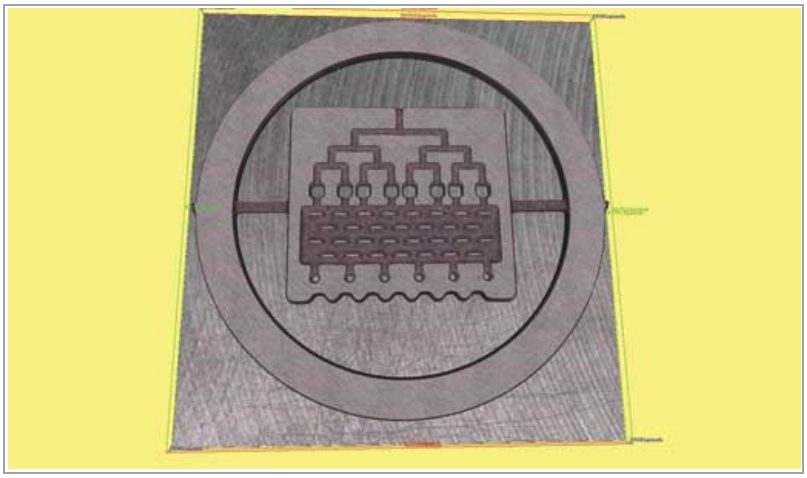
Micro measurement for micro-machining

New advances in optical 3D metrology provide 6-7% improvements in process performances in micro machining applications. By Brian Kyte and Mark Raleigh



The measurement of micro-machined components has produced significant challenges for measurement and inspection. The components to be measured generally have steep slopes, complex geometries, multiple forms, and varying reflective properties; (for example, see Figure 1, below). In addition, they generally have stringent surface finish requirements.

Products of this nature at this size can be impossible to measure with tactile systems, such as touch probe micro CMM's and stylus type surface finish systems. This is particularly true on items with steep slopes, narrow grooves, form and small edge radius measurements in the 5-10 µm range.

With a typical micro CMM probe size of 125 µm, some mechanical interference restrictions immediately become obvious on the measurement of these complex shapes. The first is that the smallest bore size that can be measured is about 250 µm and that any radii less than 125 µm cannot be measured at all. The micro CMM systems are very good for the measurement of external forms over small and larger areas, but are not optimised for complex micromachined components.
Optical techniques that have been typically used in this area, such as White Light Interferometry, confocal microscopy and Atomic Force Microscopy are very good for measuring smooth surfaces, but have restrictions in terms of complex geometry measurement, large Z heights, high slope angles and high aspect ratio measurements.

Consequently, industry requires new and effective measurement systems, providing traceable, repeatable and high-resolution results. Focus-Variation, from Alicona, a new optical technology, meets these demanding requirements. Measurements from a vertical resolution of up to 10 nm on complex topographies and across large measurement fields up to 100 mm x 100 mm, with full colour information, are possible. The readily obtainable data makes this technology ideally suited for use with micro-machined components which would prove almost impossible to measure with conventional techniques.

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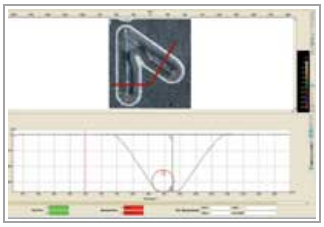
A typical example of where there would be mechanical interference with a micro CMM measuring the width is figure 2, shown here: when measured, the width at the bottom of the groove is 72 µm, the depth is 180 µm and the radius in the groove base is 14.41 µm and at the bottom the inclusive angle is 700 - but the radius unmeasurable.



Case Study - EDM Department

The EDM Department Inc. in Bartlett Il USA specialises in micro-machining. They use EDM and laser-based technology to produce very high precision components for R&D and production. It is able to produce features at sub 10 micron size. As demand increases for smaller and smaller micro components, it needed to move from a physical to a visual measurement technology for conformation of results.
After some 2 years of searching and trialling of different technologies they chose the FocusVariation technology used by Alicona in their InfiniteFocus instrument.

Mark Raleigh, CEO of The EDM Department Inc.explained, “Due to the increasing trend of miniaturisation and increased functionality, our customers are faced with the challenge of manufacturing products with very complex features and topography. It is the role of our company to not only meet these requirements, but also provide the means to confirm control. Additionally today, the solution must address surface metrology, as well as manufacturability.

Since we have acquired the InfiniteFocus, our abilities have dramatically changed. Now, we can provide solutions, as well as components. Reverse engineering has grown into an integral service, as well as a shared resource, for all levels of manufacturing. This sponsors process improvements. Small, independent steps forward; offering our customers what the next generation of product development will demand.

With refined statistical programmes, we have appreciated 6-7% improvements in process performances. Surface finishes have improved over 7% under identical resource requirements. All of this is because we can now see and measure what we produce.

The way InfiniteFocus visualises manufactured components in 3D is a true selling argument for us. Recently, six out of seven new customers came from the presentation of visualisation and measurement results. It simply proves our manufacturing quality.

“We have also seen some considerable advantages in areas that we had not considered when deciding to buy the system. The data produced includes a 3D point cloud of up to 100 Mio., even over large areas. This has enabled us to compare CAD data with the manufactured component, looking for variation that is easily quantified using the software available. The latest version of the software also has form- fitting functionality for cones, cylinders and spheres, improving versatility and capability even further.

The areal-based measurement tools have also enabled us to look at surface characteristics that directly affect the components performance; this is a new area to us that we are now exploiting to our advantage.

The measurement of surface texture plays a crucial part in checking and controlling the properties of technical surfaces. Also, the measurement of surface texture can be used to characterise and optimise surfaces with respect to their functional behaviour.

Traditionally, surface texture measurements have been performed by tactile devices with the use of profile roughness parameters. Optical measurement techniques, such as focus variation, have become increasingly popular in this area, as they have several important advantages over contact stylus instruments. As an example, they do not damage the surface and are able to measure whole areas, with complex geometries, at one time and not only surface profiles. This enables them to measure larger areas in shorter periods of time and to characterise surfaces by areal surface texture parameters. “

Mark concluded, “This area will become increasingly important in the Micro Engineering

sector as technology and demands increase. The focus variation technology described here will allow these functional characteristics to be measured, allowing micro engineering to play a larger part in mainstream activities."

Co-operation

As a result of having this technology available the EDM Department has worked closely with Makino the global manufacturer of high speed machining centres and EDM machines. At the recent IMTS show in Chicago, Makino displayed an InfiniteFocus 3D measurement system, supplied by the EDM department for the duration of the show.

This enabled Makino to show how advanced quality assurance in the field of high precision and micro technology using their high performance IQ300 vertical machining centre can be performed.

As this also applies to components with small radii and angles, the technology can be used to show how effective the machining process of the Makino high performance machining centres was. The was used for the measurement of high resolution, 3D inspection of high tolerance, micro machined features for plastic mold cavities, cores and tooling components.

John Bradford, Makino's Micromachining R&D manager said "Alicona's Infinite Focus metrology solution provides an ideal complement to Makino's micro machining technologies. This tool enables the user to analyze 3 dimensional machined surfaces to a very high degree of resolution, so that a clear understanding of processing trends can be established, and then intelligent process manipulations can be applied as needed. Furthermore, final 3D surface inspections can be quickly made, and compared to the original CAD data. Final dimensional deviations out of prescribed tolerance can be simply identified and corrected as needed. It is obvious that this powerful metrology technology will allow clients to improve their product quality, but most importantly, it will allow them to more intimately understand and adjust their in-process machining techniques to improve throughput efficiencies."l

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