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Application Note

Measurement Soluions for Industry

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Introduction

The use of Optical Metrology for industrial applications and R&D has increased dramatically over recent years and there are varying techniques in use today.

The Focus Variation principle was first commercially developed by Alicona (now Bruker Alicona) in 2001 and is now accepted in many industries as the defacto method of verification of components within those industries.

As the technology has evolved and been developed over these years the applications that are now possible has increased. This now includes very smooth surfaces, and internal bores making the technology useful and necessary in many areas. This application note covers one of those areas.

With all measurements being fully traceable to international standards, known levels of uncertainty and highly repeatable the technique has become a “go to” technique for many users.

APPLICATION:

The use of Bruker Alicona Focus Variation for the measurement of Ballistic Toolmarks

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The measurement of ballistic toolmarks on both fired bullets and spent cartridge cases has relied on the use of 2D comparative microscopy since 1912 [1]. This method is still preferred in a court of law due to the lack of validation of modern acquisition techniques, as highlighted by the US National Academy of Sciences report on 'Strengthening Forensic Science in the United States' [2].

The use of 2D microscopy in toolmark measurement has the following disadvantages:

- **Subjectivity**
  The comparison of two possible matching toolmarks relies on the opinion of the expert examiner. Using these methods, the examiner must believe 'beyond reasonable doubt' that the toolmarks were created by the same firearm.

- **Qualitative**
  2D imaging and consequent digital greyscale microscopy are able to infer height details of a surface from the varying levels of light intensity across a surface, however this can be skewed due to shadowing effects.

- **Dependence on ambient light**
  The measurement of micro scale roughness related to ballistic toolmarks can be affected by ambient light. The difference between lighting on different measurement occasions could mean that some surface information is not recorded sufficiently.

- **Repeatability**
  To satisfy the Daubert standard, measurements should be repeatable. Due to issues with subjectivity, qualitative data and lighting, repeatability cannot be guaranteed [3].

Consequently true areal capture of topography information is considered a more reliable technique for ballistic data capture.

Areal measurement techniques such as interferometry and confocal microscopy have been employed for the acquisition of ballistic toolmarks. However, these measurement techniques have inherent issues for such complex surface measurement such as the firing pin impression on spent cartridge cases. The steep angles of the firing pin impression along with variations in material reflection can result in data loss.

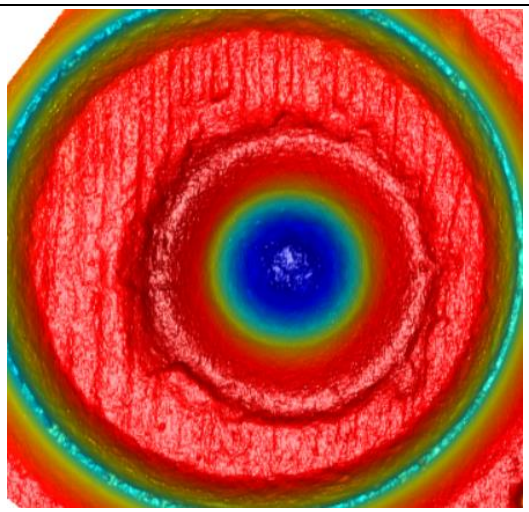
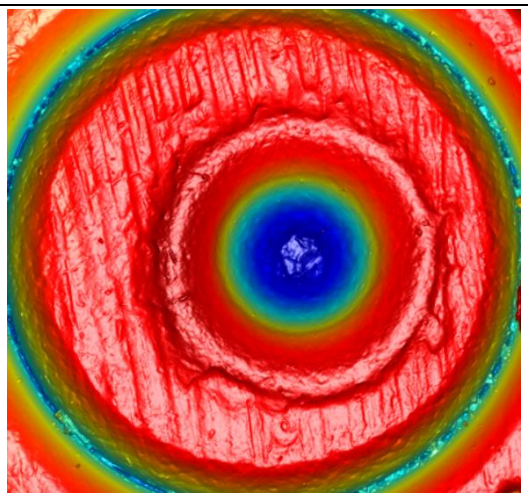
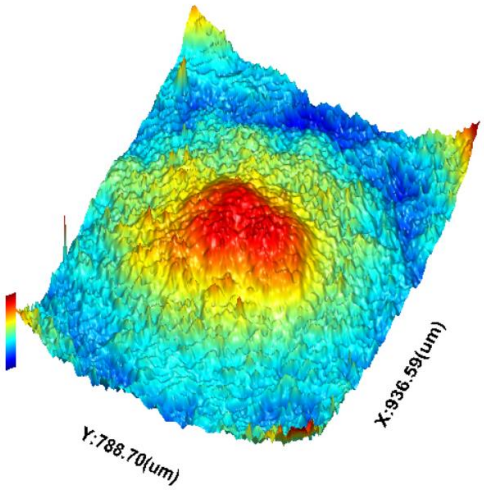
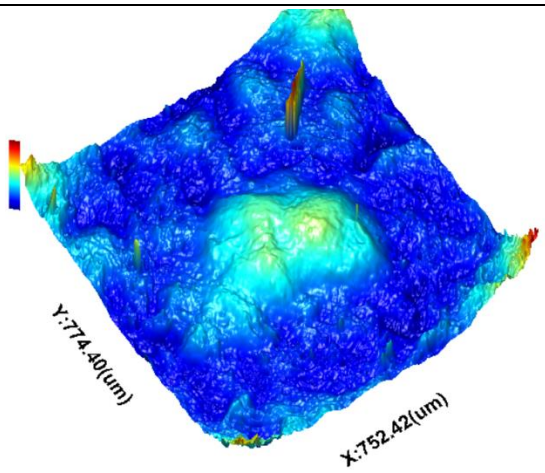
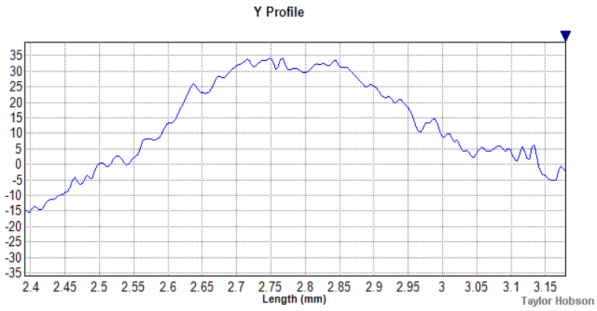
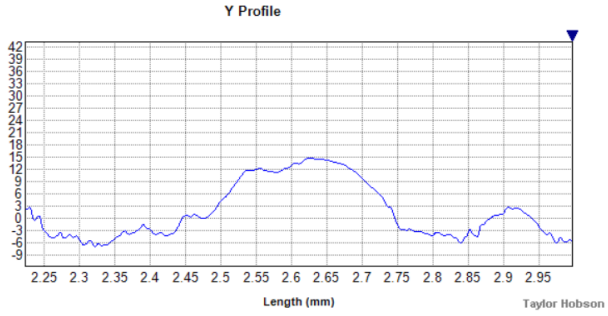
The Bruker Alicona InfiniteFocus G5 is able to acquire the full topography of the cartridge cases through a combination of modular light settings and a small depth of focus. Consequently, the system is able to acquire data from steep flank regions retaining the materials deformation information caused by the firing pin contact. Combined with the ability to acquire high resolution data through a range on lenses, the Alicona G5 could prove to be the measurement method of choice in ballistic toolmark comparison recording high resolution images necessary for accurate correlation and comparison analysis.

A comparison is also shown between data from the previous generation G4 InfiniteFocus and the current G5 showing substantial advancement in the system and technology.

Figure1: Head of a cartridge case acquired using the Alicona G5

Compared to measurements acquired using the previous G4 generation system, G5 acquired images show a reduction in noise within the region of interest, and therefore it is expected that validation tests of areal correlation using G5 acquired datasets will result in a more robust methodology that can be applied within a court of law, with evidence of both repeatability of objectivity.

The table below shows this in detail with profiles exctracted.

InfiniteFocus G4	**InfiniteFocus G5**
Primer Cap	Firing Pin Impression
	
	
2D Firing Pin Impression	2D Firing Pin Impression
	

Conclusion

From the data provided it is clear that the Focus Variation technique used by Alicona in the G5 and µCMM system is capable of providing clear comparative data suitable for use for forensic examination.

[1] Warlow, T. (2012). Firearms, the Law, and Forensic Ballistics. CRC.

[2] Committee on Identifying the Needs of the Forensic Sciences Community . (2009). Strengthening Forensic Science in the United States : A Path Forward. Washington: National Academies Press.

[3] Page, M., Taylor, J., & Blenkin, M. (2011). Forensic Identification Science Evidence since Daubert: Part II--Judicial Reasoning in Decisions to Exclude Forensic Identification Evidence on Grounds of Reliability. Journal of Forensic Sciences, 913-917.