FIB surface finishing of micro-EDM metrology artefacts

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Abstract

In contact based surface measurement, stylus dimension conformity is a critical area to inspect to ensure measurement accuracy. The most common method uses a sharp edge that the stylus ball is dragged over. The work present a novel combination of electro discharge machining and focused ion beam milling to manufacture a high precision saw tooth profile. The use of FIB polishing is able to produce an edge radius of approximately 0.25 μm. Measurement taken using a Form TalySurf indicates the viability of the structure and the texture.

1. Introduction

Stylus based surface metrology is widely used for the characterisation of surfaces to determine both form and texture in many engineering applications. Critical to the performance of measurements made using a stylus is having a good understanding of the stylus tip geometry. This is typically a precision engineering conispherical diamond with a tip radius that may be as small as 2 μm. One method that may be used to establish the exact shape of the stylus tip, is to use the stylus to measure a well-defined sharp (edge radius << the tip radius) edge geometry. The resulting profile measurement may then be used to solve for the geometry of the stylus tip. A number of reference artefacts have been proposed for this and are commercially available. The razor blade technique [1] is the simplest method for conducting geometry characterization of a diamond stylus tip specimen. The tip radius of a standard razor blade is around 0.35 – 0.45 μm [2]. However the edge is not well defined with a rough profile to the edge.

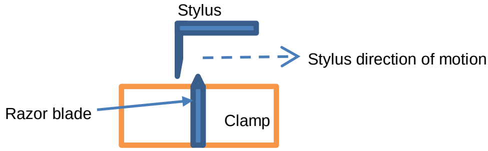

Figure 1: Schematic of the razor blade technique

A more expensive solution is a standard form for stylus tip analysis which is produced by Halle made of stainless steel but is limited to 1 µm radius [3]. In this work development and application of a two stage machining process has been undertaken to allow the production of ultra-sharp edges in hard materials is presented.

2. Artefact Manufacturing

Focused ion beam (FIB) machining has the capacity to focus and produce a milling area with a resolution as low as 5 nm using the Carl Zeiss NVision 40. The ion beam ability to focus and having a very small spot size ranging between 5-10 nm has created the potential of doing sub-micromachining processes with high precision accuracy and good surface finish quality doing micro/nanoscale structures and rapid prototyping of highly precise specimen and profiles. This paper intends to investigate a manufacturing concept of such a feature with better or equivalent sharpness by creating saw tooth profile on a stainless steel block similar to the design of the Halle artefact.

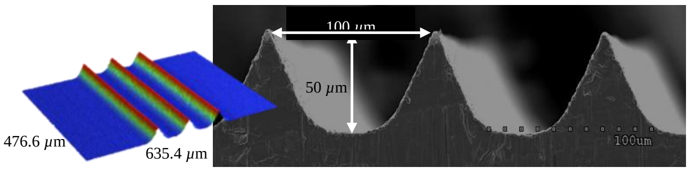

Figure 2: EDM stainless steel stylus control artefact

3. Experimental Methodology

The block is manufactured from two types of material: stainless steel and diamond. These materials were chosen for performance comparison. Initially using an electrical discharge machining (EDM), three semi-finished triangular profiles of 60^o angle with internal radius of less than 20 µm are produced before polishing into a final sharp edge using the focused ion beam (FIB). Ion beam would pass along the intended surface (as shown by arrow direction in Figure 3) on both sides of the tooth to do milling with a higher current of 6.5 nA (for roughing) initially before going on deeper with a 3 nA current (for polishing) under the Mill for Depth mode.

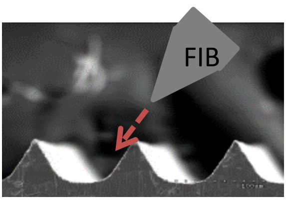

Figure 3: Direction of ion beam for FIB milling

The FIB machined tooth undergoes comparison analysis of surface quality and profile's dimension, form and roughness definition using the Scanning Electron Micorope (SEM) and Form Talysurf PGI.

4. Results & Discussion

SEM images of the tooth show a clear sharp edge formed from the initial rough EDM saw tooth profile. Figure 4 indicates that the initial diamond saw tooth tip radius of approximately 1.75 μm (left image) from EDM was reduced to around 0.25 μm (right image) after FIB polishing. The Talysurf inductive stylus was used to evaluate stylus

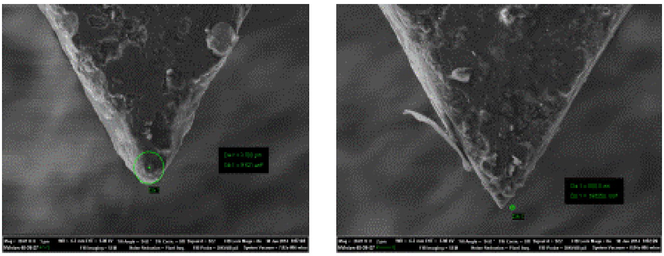

Figure 4: SEM images of EDM diamond tooth (left) and FIB polished diamond tooth (right)

tip quality by generating a profile of the saw tooth shown in Figure 5 with the aim to show consistency in the shape of the measured profile under repeated measurements. From the observation and images, it is apparent that the FIB saw tooth generates significantly improved form consistency and surface texture.

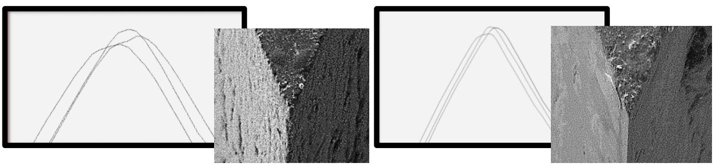

Figure 5: Three profiles traces and SEM tooth edge image of the diamond tooth before (left) and after (right) FIB machined

5. Conclusion

The combined process of EDM and FIB shows a promising result in producing an ultra-sharp edge on the chosen hard material, i.e. stainless steel and boron doped diamond. The result obtained an edge radius of 0.25 μm and structurally standing the Form Talysurf stylus preliminary test, thus opening a possibility for a contact stylus instrument control standard application to be manufactured in this way.

Reference

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