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Microprobes for high-speed roughness measurements

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Abstract
High-speed roughness measurement is demanded by on-site quality inspection. The microprobe with an integrated silicon tip is a candidate probe for high-speed roughness measurement because of the superior dynamic properties and satisfying measurement accuracy. The microprobe tip geometry stability is inspected in this paper since the tip geometry has a great influence on the measurement uncertainty. A comb tip characterizer TSPN developed by PTB is used to determine the 2d tip profile variation. The results indicate that the tip end breaks when it collides with the artifact vertical structures and the tip geometry changes accordingly. These silicon tips are not stable enough and microprobes with a more durable tip are required for high-speed roughness measurements.

Keywords: roughness measurement, piezoresistive, tip characterization

1. Introduction

Surface roughness affects the performance of a mechanical component and determines the component quality. On-site roughness inspection demands roughness measurement instruments with high throughput and sufficient precision.

The key of improving the throughput and the traverse speed of a tactile stylus instrument, is a probe with better dynamic properties and qualified signal accuracy.

Microprobe [1] is a promising candidate for high-speed roughness measurement. It consists of a 5 mm long silicon cantilever with a full bridge piezoresistive strain gauge on the back. The strain gauge can measure the cantilever bending of up to 200 µm with a nonlinearity below 0.3 % [2]. The 100 µm-high integrated silicon tip (see Fig. 1) allows the microprobe to access deep structures. The mass of the microprobe is about 0.1 mg, less than one-tenth of existing stylus probes. The superior dynamics enables the microprobe to measure steep structures with high fidelity and without tip flight at traverse speeds of up to 10 mm/s [3]. This traverse speed is much higher than the maximal traverse speed of the state-of-the-art stylus instruments.

Besides dynamic properties, the stability of the probe tip geometry should also be considered in high-speed probe evaluation. The measured profile is the dilation result of the probe tip and the artifact surface. A stable tip is important for a reliable measurement result.

To investigate the microprobe tip stability in the measurement, a tip characterizer with rectangular structures, named TSPN ("Tastspitzenprüfnormal" in German, which means probe tip test standard) is used in the following investigations to map the tip geometry.

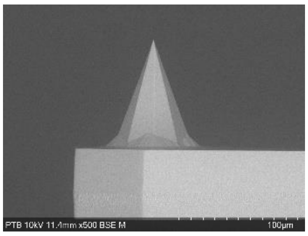

Figure 1. The integrated silicon tip of the microprobe is a 100 µm high octagonal cone with a tip radius of about 0.1 µm.

2. Microprobe tip geometry stability

2.1. Tip characterizer TSPN

Tip characterization using rectangular features is an effective method to determine the tip geometry [4], as shown in Fig. 2. The steep sidewalls with sharp edges characterize the tip outline directly.

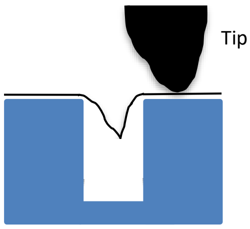

Figure 2. Characterizing the tip geometry using a rectangular structure

TSPN is a comb characterizer with multiple features developed by PTB (see Fig. 3). The microprobe is mounted on the head of a stylus instrument with 15° tilting angle to the artifact surface. During the measurement the microprobe tip traverses across the rectangular structures with the probing force of about 10 µN and the traverse speed of 25 µm/s. The tip geometry variation during the measurement can be characterized through analyzing the measured profile. As shown in Fig. 4, altogether seven rectangular structures are measured in the profile.

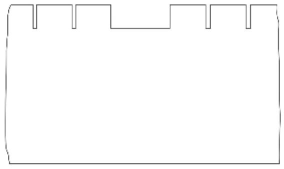

Figure 3. Design of the comb tip characterizer TSPN with rectangular structures

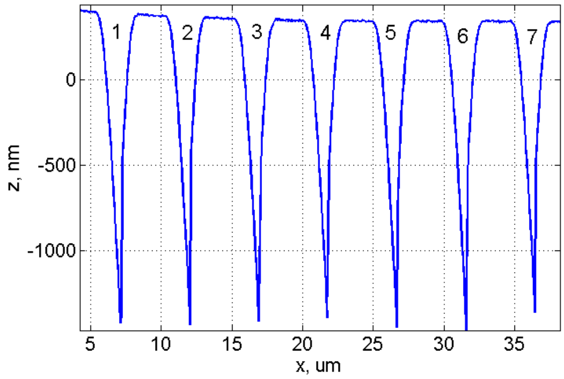

Figure 4. The measured profile of the tip characterizer TSPN using a microprobe

2.2. Tip geometry analysis

Seven tip profiles are acquired from the measured rectangular structures and compared in Fig. 5.

The right profiles of the tip keep stable but the left profiles change gradually. It can be inferred that the left side of the tip collides with the side walls of the artifact rectangular structures and the tip end breaks again and again at each measurement.

The end of the tip in profile 1 is about 0.4 µm deeper than the tip end in profile 2. It indicates that a 0.4 µm-high tip end is broken in the second measurement of the rectangular structure. Another 0.4 µm-high tip end is broken in the third measurement of the structure (Tip profile 3). The tip geometry keeps relatively stable in the measurements no. 5, 6 and 7. Altogether about a 1 µm-high tip end is broken after seven measurements of the rectangular structures.

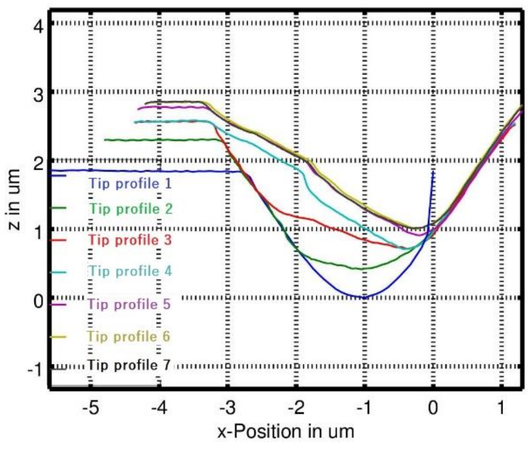

Figure 5. Successive silicon microprobe tip profiles acquired from TSPN tip characterizer measurements.

The measurement results imply that the silicon tip of the microprobe is not stable enough. Further measurements with more tip breakage prove the above results. For high-speed roughness measurement, a microprobe with a stabler tip is preferred.

3. Summary

As a probe for high-speed roughness measurements, not only superior dynamic properties and qualified signal accuracy, but also a stable tip geometry is required.

Microprobes with an integrated silicon tip are a candidate probe for high-speed roughness measurement. The tip geometry is investigated using a comb tip characterizer. The result indicates that the tip end broke at each characterization measurement and the tip geometry changed considerably during the measurement of this tip characterizer with steep sidewalls. Measurement conditions (lower probing force and lower scanning speed) need to be found so that the tip does not break with every measurement.

For high-speed roughness measurement a microprobe with a more durable tip is preferred.

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