Stylus tip characterizer

Principle

At PTB, a stylus tip characterizer has been developed for the calibration of the radius and of the 2D shape of diamond stylus tips of conventional profilometers and of special silicon stylus tips [1]. This calibration standard (Fig. 8) made of silicon contains 28 × 10 rectangular grooves having a width w from 0.3 µm to 3.0 µm in 0.1 µm increments.

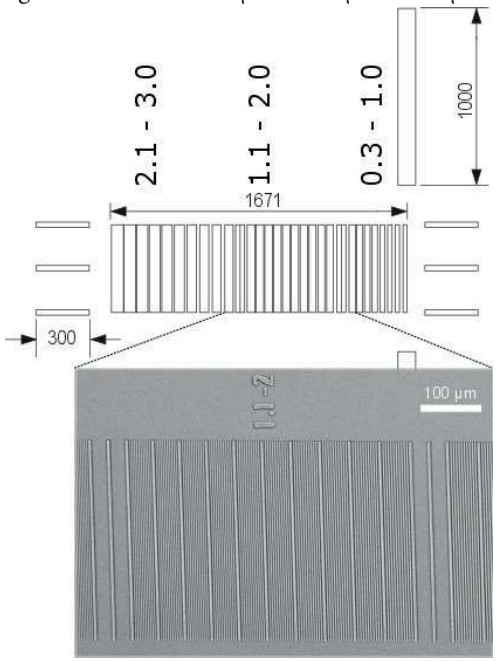

Figure 8: Sketch of PTB's stylus tip characterizer (all measurements in µm)

With the tip to be characterized, a profile is scanned perpendicular to the grooves on the stylus tip test standard (Fig. 9). Depending on the radius of the tip r_{tip} and its opening cone angle, the depth of penetration of the tip is different depending on how wide the different grooves are. From the measured penetration depth h, it is possible to calculate the radius of the tip r_{tip} if the width of the grooves w is known and when assuming that the edge radii R are minimal ($R < 50$ nm):

$$r_{tip} = h/2 - R + (R + w/2)^2/(2 \cdot h) \qquad (1)$$

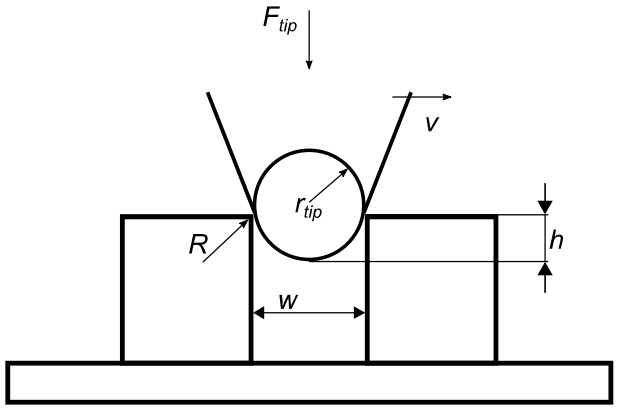

Figure 9: Principle of the radius measurement of a stylus tip using rectangular grooves of known width

2D tip-shape - Profilometer

Figure 10 shows the measurement result (dots) of a spherical stylus tip of 2 µm in radius on the stylus tip characterizer [2]. In addition, in Figure 10, the penetration depths h measured were plotted over the widths for a tip with a radius of 2 µm (black dashed line) and 1.5 µm (continuous red line), respectively. The points determined with a real tip agree best with the red line representing the 1.5 µm tip.

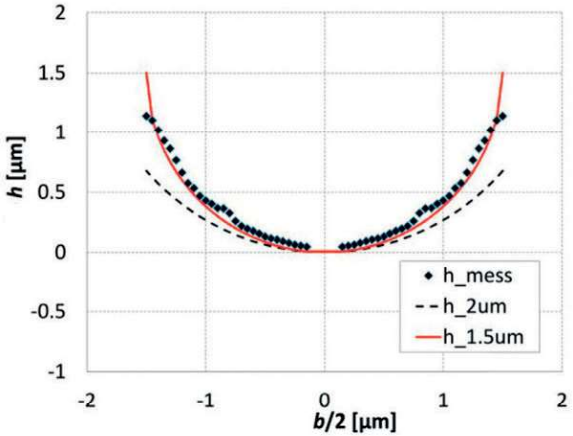

Figure 10: Penetration depth h of a spherical stylus tip with a nominal radius r_{tip} = 2 µm measured using PTB's stylus tip characterizer.

Stylus tip characterizer

2D tip-shape - Silicon microprobe tip

The topographic measurement of grooves with discretely increasing width allows the determination of the tip radius, the tip width at various heights and the determination of the cone angle. Figure 11 shows the profile measurement of a silicon microprobe tip which has already been used [3] via PTB's stylus tip characterizer. The tip is no longer spherical and looks flat. This is typical of worn silicon stylus tips. The width and the cone angle of the tip can be determined.

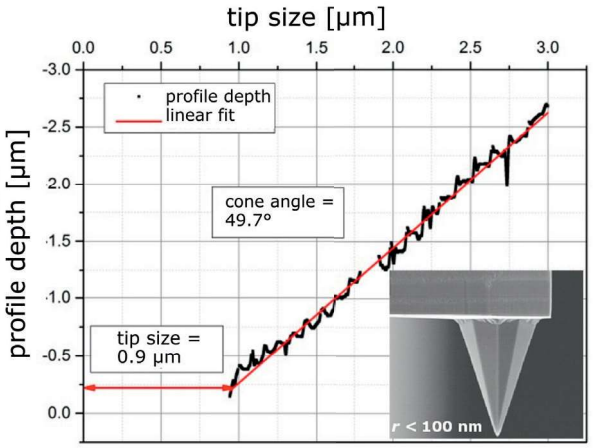

Figure 11: Penetration depth h of a silicon stylus tip into the rectangular grooves of PTB's new microprobe tip characterizer (groove width = tip width).

Literature

[1] Brand, U., Doering, L., Gao, S., Ahbe, T., Buetefisch, S., Li, Z., Felgner, A., Meeß, R., Hiller, K., Peiner, E., Frank, T., Halle, A., 2016. Sensors and calibration standards for precise hardness and topography measurements in micro- and nanotechnology - IEEE Xplore Document, in: Micro-Nano-Integration; 6. GMM-Workshop; Proceedings pp. 68–72.

[2] Brand, U., Gao, S., Doering, L., Li, Z., Xu, M., Buetefisch, S., Peiner, E., Fruehauf, J., Hiller, K., 2015. Smart sensors and calibration standards for high precision metrology, in: Sánchez-Rojas, J.L., Brama, R. (Eds.), p. 95170V. doi:10.1117/12.2179455

[3] Peiner, E., Balke, M., Doering, L., Brand, U., 2008. Tactile probes for dimensional metrology with microcomponents at nanometre resolution. Meas. Sci. Technol. 19, 064001 (8pp).