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Comparison testing between Renishaw OPTiMUM™ diamond styli and common ball materials on aluminium alloy AA6082

Aluminium alloy AA6082

AA6082 is a popular aluminium alloy used in many applications.

However, using conventional styli balls for measurement in co-ordinate measuring machine (CMM) and computer numerical control machine tool probes (CNC) can cause material transfer, also known as adhesive wear, which affects accuracy.

Renishaw has investigated this issue thoroughly, and the findings are detailed in this white paper.

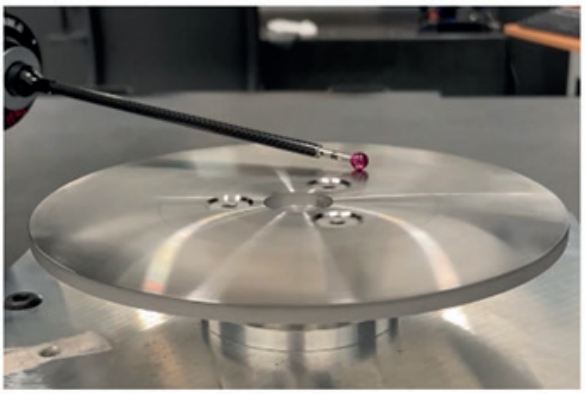


Figure 1 Application testing 1 in progress..

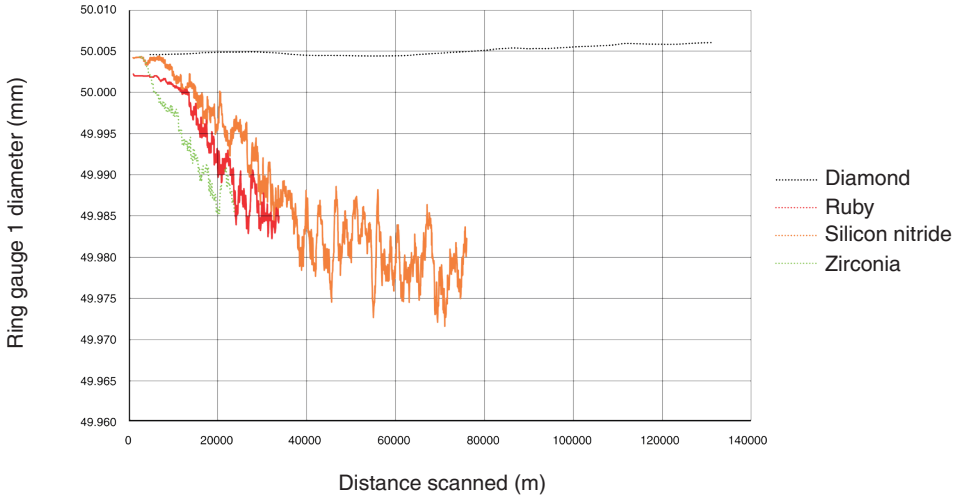
Application testing 1

Sweep scanning trials were conducted on an aluminium 6082 disc using a REVO 2 probe.

This was a continuous 15,000 m test using ruby, silicon nitride, zirconia and OPTiMUM diamond styli.
A ring gauge scan was conducted every 50 m to determine whether pick-up or wear was occurring.

With OPTiMUM diamond styli, exceptional scanning performance was achieved, with no change in metrology results and no pick-up.

A graph to show adhesive wear on styli balls when scanning aluminium workpieces



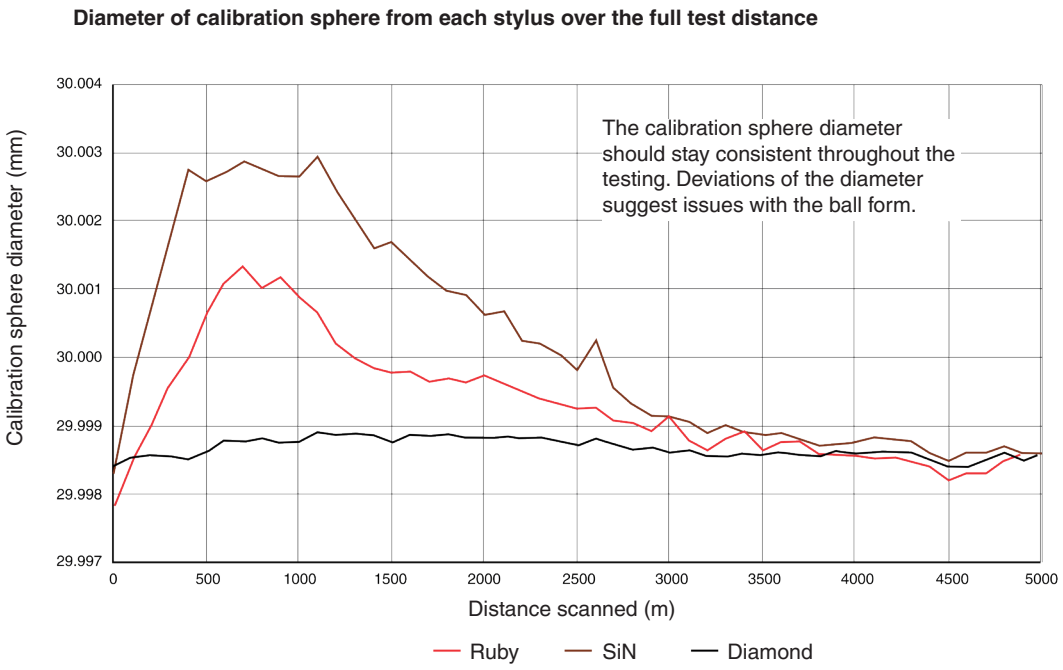
Application testing 2

Scanning trials were also conducted on an aluminium 6082 cylinder using a REVO 2 probe to a distance of 5,000 m.

A spiral scan inside the cylinder and a sweep scan on the face were performed using ruby, silicon nitride, and OPTiMUM diamond tip styli. Pick-up or wear was determined by monitoring CMM results and calibration sphere measurements.

Material transfer could be seen on the ruby and silicon nitride (SiN) balls at the end of the testing. It was also evident that this material transfer was affecting the metrology.

In contrast, using OPTiMUM diamond tip styli resulted in exceptional scanning performance, with no changes in metrology and no material pick-up.



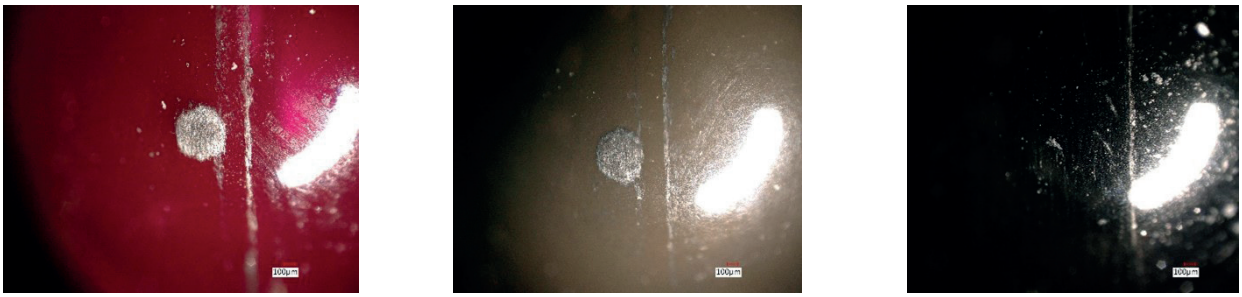


Figure 2 Microscope photos of the balls after the completed testing (1 – ruby ball, 2 – silicon nitride ball, 3 – OPTiMUM diamond coated).

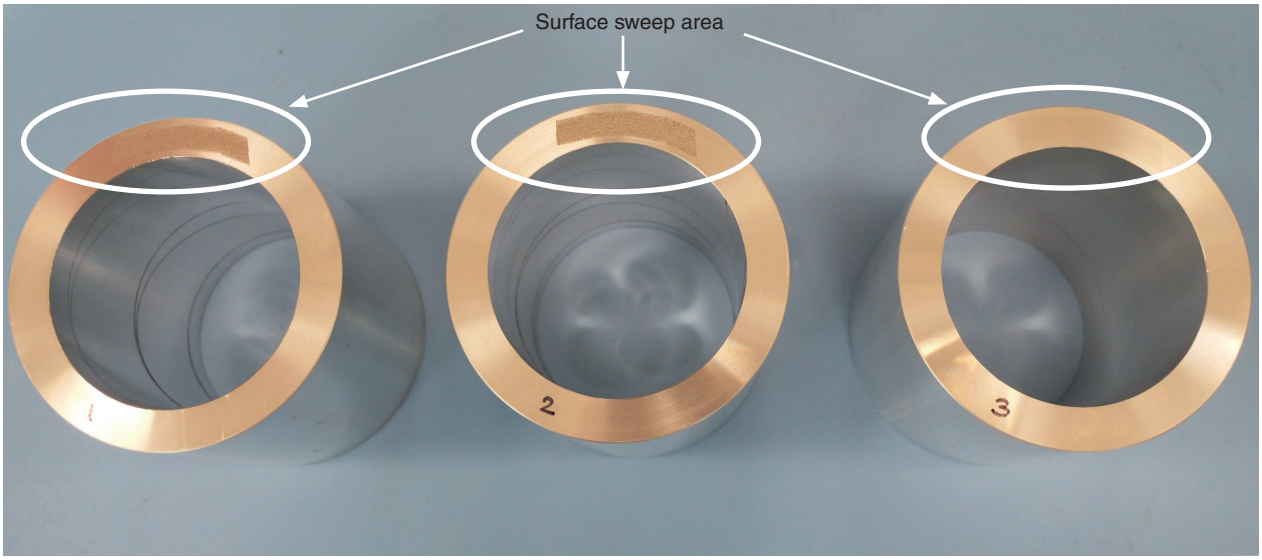
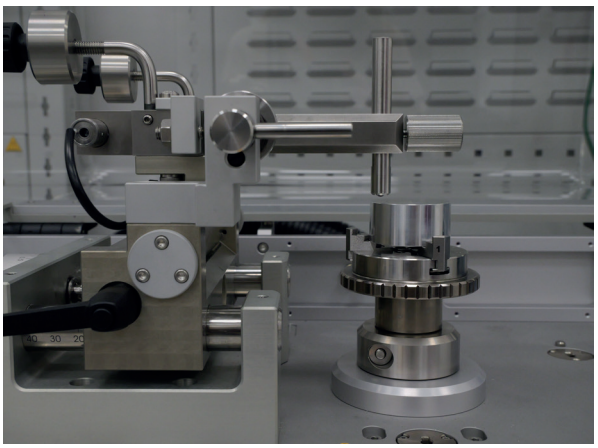


Figure 3 Resulting scanned cylinders, 1 – ruby ball testing, 2 – silicon nitride ball testing, 3 – OPTiMUM ball testing. Higher wear can be seen with ruby and silicon nitride balls (internal spiral scan path and front face surface sweep path can be seen).

Tribology testing



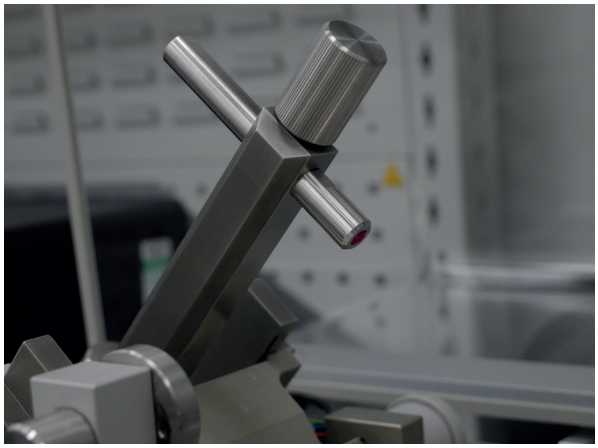


Figure 4 Pin-on-disc triometer, showing ruby ball and aluminium alloy sample.

Using an in-house pin-on-disc tribometer, we compared the effects of OPTiMUM diamond styli and ruby styli on AA6082. The tribometer, along with a 3D Optical Profiler, provided data on material transfer, wear, and friction over a scanning distance of 50 m.

Material transfer

Material	Material transfer (µm³)
Ruby	0.000167
OPTiMUM diamond	0

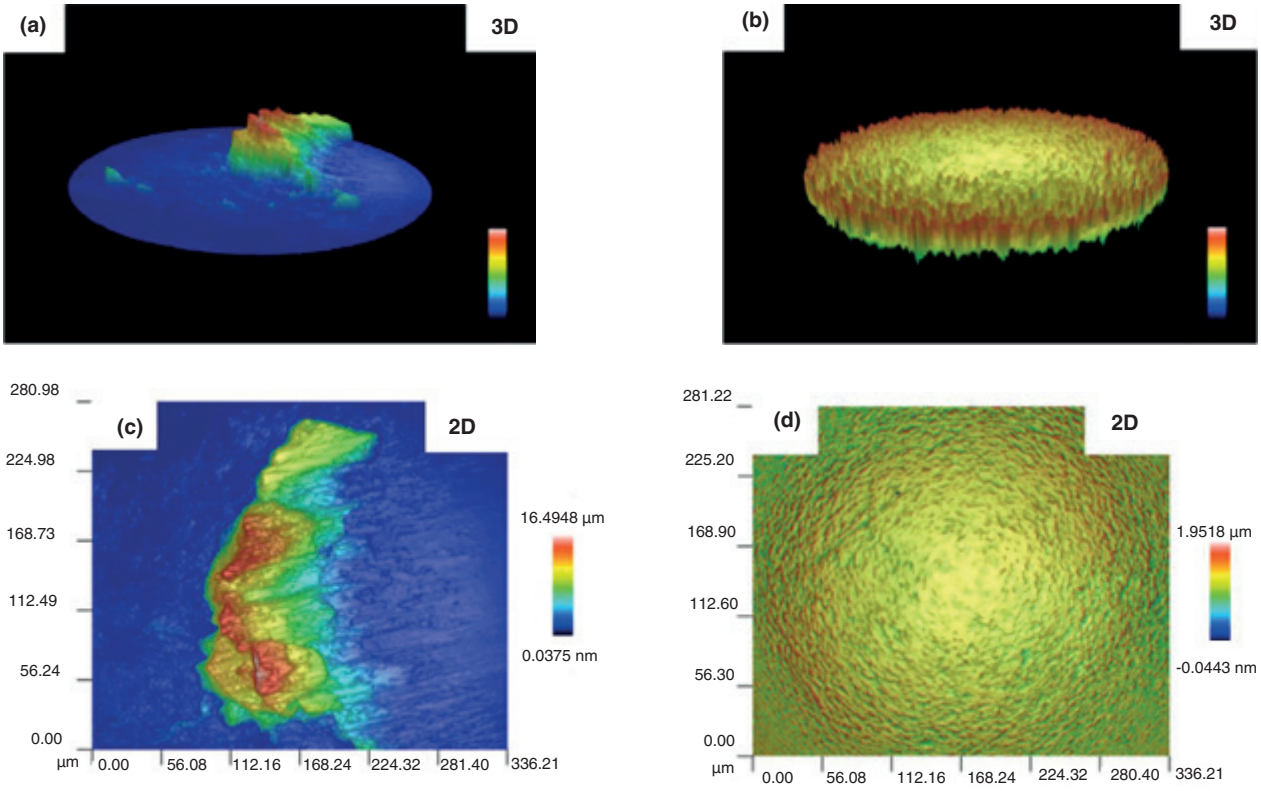
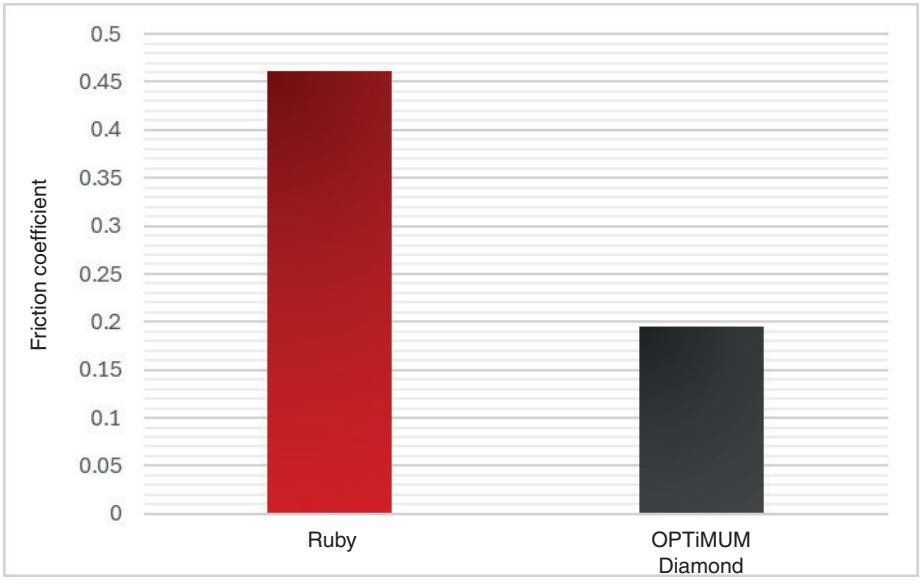


Figure 5 Representative white light interferometric images of ruby (a, c) and OPTiMUM diamond (b, d) balls utilised on AA6082 surface showing material transfer using the ruby stylus and none using the OPTiMUM diamond stylus.

NOTE: Different scales are used in the images.

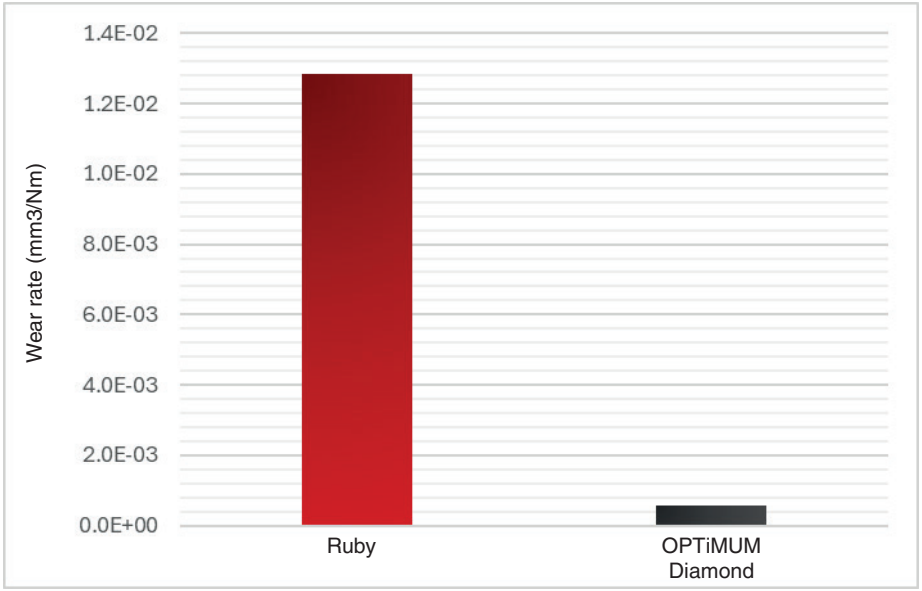
Friction coefficient

Material	Friction coefficient
Ruby	0.461
Diamond	0.196



Sample disc wear

Material	Wear rate (mm^3/Nm)
Ruby	0.0128
Diamond	0.000587



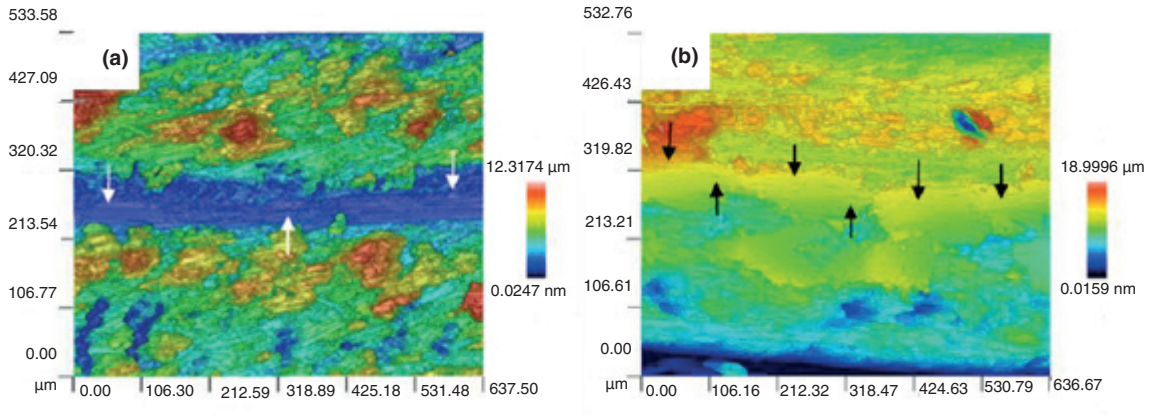


Figure 6 White light interferometric images of wear tracks on AA6082 due to (a) ruby and (b) diamond balls showing material removed (marked with white arrows) and asperities smoothed (marked with black arrows).

Conclusion

The material and application testing shows that using an OPTiMUM diamond stylus on AA6082 prevents material transfer, maintaining the ball's geometry and ensuring accurate measurements. OPTiMUM diamond styli were tested up to 15,000 meters with no material transfer, unlike ruby, silicon nitride, and zirconia balls, which showed measurable transfer.

Material transfer with a ruby ball occurred within just 50 meters. The tribology study found that the friction coefficient between OPTiMUM diamond and AA6082 is over 50% lower than that between ruby and AA6082. This is due to diamond's crystalline structure, which prevents new bond formation, leading to minimal material transfer and low wear rates.

Additionally, OPTiMUM diamond styli showed a significantly reduced wear rate in both the tribology study and application testing. These combined results demonstrate that OPTiMUM diamond styli are the superior choice for scanning aluminium alloy 6082.

UK +44 (0) 1453 524524 uk@renishaw.com USA +1 847 286 9953 usa@renishaw.com

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