



Figure S1. The calculation flow chart of 2D power spectral density.

The following describes the calculation process of the two-dimensional power spectral density of the grinding surface. Firstly, input the surface topography data. Secondly, set the signal length and sampling interval. The sampling length of the topographic data in this paper is 3mm and the interval is 2.931 μ m. Then define a two-dimensional Hanning window with energy normalization, and use the fft2 function in MATLAB software to perform a two-dimensional Fourier transform on the data. Finally, PSD calculation is performed on the data, and the power spectral density is displayed graphically.

Table S1. The relative errors of roughness parameters under different δ_{\min} — Surface 1

	Measured surface 1	$\delta_{\min} = 10^{-3}$ m	$\delta_{\min} = 10^{-4}$ m	$\delta_{\min} = 10^{-5}$ m	$\delta_{\min} = 10^{-6}$ m	$\delta_{\min} = 10^{-7}$ m	$\delta_{\min} = 10^{-8}$ m	$\delta_{\min} = 10^{-9}$ m	$\delta_{\min} = 10^{-10}$ m
S_a (μ m)	0.112	0.0492	0.0955	0.1114	0.1160	0.1180	0.1187	0.1189	0.1190
The relative errors (%)		-56.07	-14.73	-0.54	3.57	5.36	5.98	6.16	6.25
S_q (μ m)	0.132	0.0569	0.1016	0.1170	0.1214	0.1234	0.1240	0.1242	0.1243
The relative errors (%)		-56.89	-23.03	-11.36	-8.03	-6.52	-6.06	-5.91	-5.83
S_{sk}	-0.142	0.0066	-0.1221	-0.1419	-0.1520	-0.1311	-0.136	-0.1357	-0.1355
The relative errors (%)		-104.65	-14.01	-0.07	7.04	-7.68	-4.23	-4.44	-4.58
S_{ku}	2.796	2.4704	2.7369	2.8254	2.7961	2.8123	2.814	2.8144	2.8137
The relative errors (%)		-16.65	-7.11	-3.95	-5.00	-4.42	-4.36	-4.34	-4.37

Table S2. The relative errors of roughness parameters under different δ_{\min} — Surface 2

	Measured surface 2	δ_{\min} = 10^{-3} m	δ_{\min} = 10^{-4} m	δ_{\min} = 10^{-5} m	δ_{\min} = 10^{-6} m	δ_{\min} = 10^{-7} m	δ_{\min} = 10^{-8} m	δ_{\min} = 10^{-9} m	δ_{\min} = 10^{-10} m
Sa (μm)	0.266	0.114	0.2152	0.247	0.2555	0.259	0.2601	0.2604	0.2605
The relative errors (%)		-57.14	-19.10	-7.14	-3.95	-2.63	-2.22	-2.11	-2.07
Sq (μm)	0.288	0.132	0.2293	0.2601	0.2682	0.2715	0.2726	0.2729	0.273
The relative errors (%)		-54.17	-20.38	-9.69	-6.87	-5.73	-5.35	-5.24	-5.21
Ssk	-0.129	0.0067	-0.1155	-0.1354	-0.144	-0.1285	-0.132	-0.1317	-0.1316
The relative errors (%)		-105.19	-10.47	4.96	11.63	-0.39	2.33	2.09	2.02
Sku	2.936	2.4633	2.7157	2.8118	2.7892	2.8021	2.803	2.8035	2.8031
The relative errors (%)		-16.10	-7.50	-4.23	-5.00	-4.56	-4.53	-4.51	-4.53

Table S3. The relative errors of roughness parameters under different δ_{\min} — Surface 3

	Measured surface 3	δ_{\min} = 10^{-3} m	δ_{\min} = 10^{-4} m	δ_{\min} = 10^{-5} m	δ_{\min} = 10^{-6} m	δ_{\min} = 10^{-7} m	δ_{\min} = 10^{-8} m	δ_{\min} = 10^{-9} m	δ_{\min} = 10^{-10} m
Sa (μm)	0.403	0.1826	0.3394	0.3864	0.3984	0.4032	0.4046	0.405	0.4051
The relative errors (%)		-54.69	-15.78	-4.12	-1.14	0.05	0.40	0.50	0.52
Sq (μm)	0.441	0.2115	0.3621	0.4074	0.4188	0.4233	0.4247	0.425	0.4252
The relative errors (%)		-52.04	-17.89	-7.62	-5.03	-4.01	-3.70	-3.63	-3.58
Ssk	-0.137	0.0068	-0.1118	-0.1315	-0.1393	-0.1262	-0.1291	-0.1289	-0.1288
The relative errors (%)		-104.96	-18.39	-4.01	1.68	-7.88	-5.77	-5.91	-5.99
Sku	2.903	2.4592	2.704	2.8022	2.7828	2.7941	2.7948	2.7952	2.7949
The relative errors (%)		-15.29	-6.85	-3.47	-4.14	-3.75	-3.73	-3.71	-3.72

Table S4. The relative errors of roughness parameters under different δ_{\min} — Surface 4

	Measured surface 4	δ_{\min} = 10^{-3} m	δ_{\min} = 10^{-4} m	δ_{\min} = 10^{-5} m	δ_{\min} = 10^{-6} m	δ_{\min} = 10^{-7} m	δ_{\min} = 10^{-8} m	δ_{\min} = 10^{-9} m	δ_{\min} = 10^{-10} m
Sa (μm)	0.672	0.3068	0.5678	0.6448	0.6642	0.6718	0.674	0.6746	0.6748
The relative errors (%)		-54.35	-15.51	-4.05	-1.16	-0.03	0.30	0.39	0.42
Sq (μm)	0.733	0.0069	0.6058	0.6801	0.6984	0.7057	0.7078	0.7083	0.7086
The relative errors (%)		-99.06	-17.35	-7.22	-4.72	-3.72	-3.44	-3.37	-3.33
Ssk	-0.135	0.0069	-0.1107	-0.1303	-0.1379	-0.1254	-0.1281	-0.1279	-0.1279
The relative		-105.11	-18.00	-3.48	2.15	-7.11	-5.11	-5.26	-5.26

errors (%)									
<i>Sku</i>	2.912	2.4579	2.7005	2.799	2.7805	2.7913	2.7921	2.7924	2.7921
The relative errors (%)		-15.59	-7.26	-3.88	-4.52	-4.14	-4.12	-4.11	-4.12

Table S5. The relative errors of roughness parameters under different modeling methods – Surface 1

	Measured surface 1	Ubiquitiformal surface	The relative errors (%)	Fractal surface	The relative errors (%)
<i>Sa</i> (μm)	0.112	0.118	-5.36	0.138	-23.21
<i>Sq</i> (μm)	0.132	0.124	6.06	0.141	-6.82
<i>Ssk</i>	-0.142	-0.136	4.23	-0.024	83.10
<i>Sku</i>	2.796	2.814	-0.64	2.748	1.72

Table S6. The relative errors of roughness parameters under different modeling methods – Surface 2

	Measured surface 2	Ubiquitiformal surface	The relative errors (%)	Fractal surface	The relative errors (%)
<i>Sa</i> (μm)	0.266	0.26	2.26	0.298	-12.03
<i>Sq</i> (μm)	0.288	0.273	5.21	0.305	-5.90
<i>Ssk</i>	-0.129	-0.132	-2.33	-0.024	81.40
<i>Sku</i>	2.936	2.803	4.53	2.723	7.25

Table S7. The relative errors of roughness parameters under different modeling methods – Surface 3

	Measured surface 3	Ubiquitiformal surface	The relative errors (%)	Fractal surface	The relative errors (%)
<i>Sa</i> (μm)	0.403	0.405	-0.50	0.46	-14.14
<i>Sq</i> (μm)	0.441	0.425	3.63	0.472	-7.03
<i>Ssk</i>	-0.137	-0.129	5.84	-0.024	82.48
<i>Sku</i>	2.903	2.795	3.72	2.709	6.68

Table S8. The relative errors of roughness parameters under different modeling methods – Surface 4

	Measured surface 4	Ubiquitiformal surface	The relative errors (%)	Fractal surface	The relative errors (%)
<i>Sa</i> (μm)	0.672	0.674	-0.30	0.765	-13.84
<i>Sq</i> (μm)	0.733	0.708	3.41	0.784	-6.96
<i>Ssk</i>	-0.135	-0.128	5.19	-0.024	82.22
<i>Sku</i>	2.912	2.792	4.12	2.705	7.11