Observation of roughness at iron-surface by neutron reflectometry

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A new method of observation of the surface roughness of metallic iron has been developed. Various types of surface roughness of iron materials in air and at solid-solid interface were investigated using a neutron reflectometer, MINE-2. Wave length of the beam was adjusted to 0.88 nm. At first, the iron with surface roughness shown in Fig.1 (a) was used, where the roughness was measured by a contact-type roughness gauge and by a two-dimensional optical roughness gauge. To make the interface, the iron surface was covered with Si-block and with Al-block. The surface of the Si-block was optically flat and the surface of Al-block was polished to have roughness of Rmax=0.07 μm. Incident angle of the beam to the iron surface was 0.6 °, which is sufficiently smaller than the critical angle of iron, 0.805 °. The direction of the incident beam was perpendicular to the stripe of abrasive trace. Off-specular distribution of the reflected beam was observed by an IP (imaging plate), which was placed on the arm at 1.2 ° from the direct beam. 1 pixel of the IP was 50 μm × 50 μm. Distance from the sample to the IP was 620 mm. We were able to obtain the two-dimensional image of the reflected beam. Measured distributions of reflected beam for three cases are shown in Fig.1 (b). Assuming Gaussian distribution, the obtained half-widths were 69.3 pixels in air, 72.2 pixels with Si-block and 76.0 pixels with Al-block. In the cases of interface, the width is slightly wider than that of surface in air.

Next, grating on the iron surface was prepared using a diamond bit as shown in Fig. 1 (c). The period of the grating was 50 μm and the depth of the grating was nearly 10 μm, although the grating is not perfect as shown in the photograph on the left-hand side. Measurement was made in air. Incident angle of the beam to the surface was 0.4 °and the beam was perpendicular to the stripe. The reflected neutron was detected by a He-3 counter moving against the incident beam. The result is shown in Fig. 1 (d). We see a broad distribution due to incomplete grating and small diffraction peaks on it corresponding to the period of the grating.

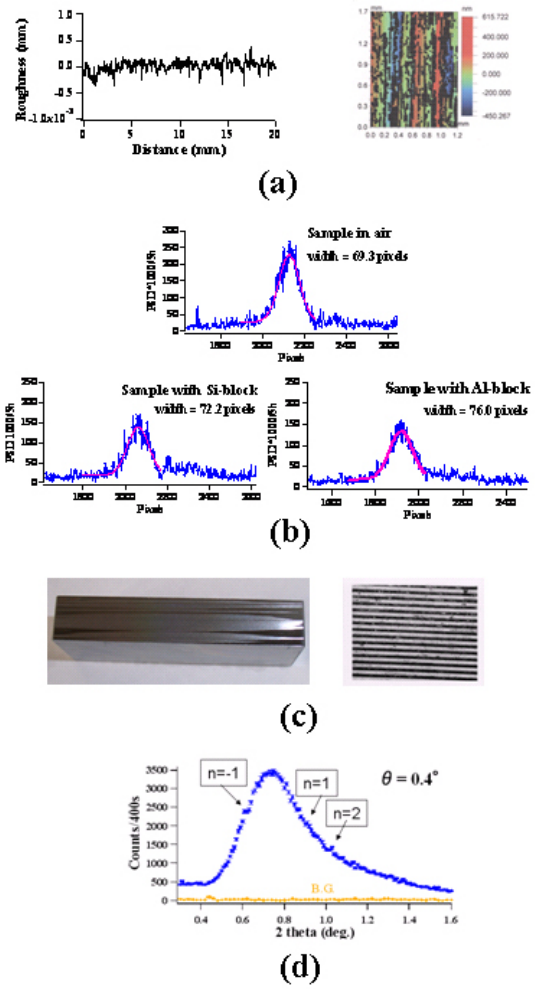

Fig. 1. (a) The roughness on the iron surface, (b) distribution of the reflected beam for three different cases of the surface, (c) grating engraved on the iron surface and (d) distribution of the reflected beam from the grating.