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120kV TEM Equipped with an Ultra High Resolution Lens and its Application

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Transmission electron microscopy (TEM) operated at low acceleration voltage is particularly suited for investigation of low contrast specimens such as biological specimens, because the TEM provides high scattering contrast images even though low spatial resolution and low beam-penetration force. The Hitachi HT7700, which is a 40-120 kV TEM designed based on an electron optical design enable high contrast imaging and a fully digital imaging design concept, is widely used in a biomedical field.

We have developed an ultra high resolution objective lens (UHRLENS) to extend the application in nanomaterial field of HT7700 [1]. The HT7700 mounted with the UHRLENS provides lattice resolution of 2Å with on-axis illumination at 120 kV. A high resolution image acquired with the UHRLENS is shown in Fig. 1. The lattice fringes of gold (100) with a spacing of 0.204 nm were observed clearly. A single crystal LaB_6 cathode is preferable as an electron source with high brightness. In addition, a tungsten filament is used as an electron source capable of operating in a relatively low vacuum level in case of the *in-situ* observation using a specimen holder mounted with gas injection nozzles [2]. The element composition analysis function can be added by mounting an energy dispersive X-ray (EDX) analyzer.

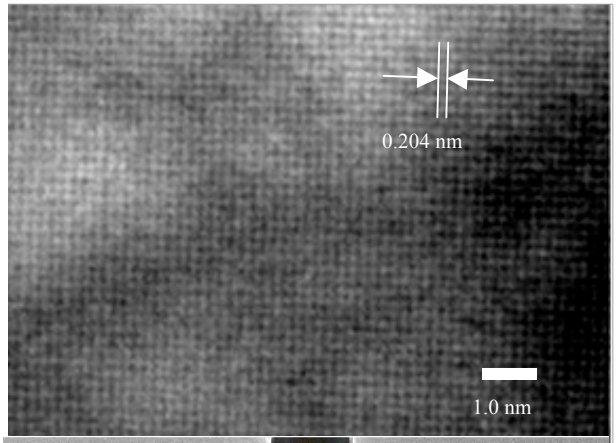
In the field of nanomaterials characterization, it is necessary to analyze the crystal structure of particles and to identify the materials included in a defined target area. We have used a selected-area electron beam diffraction (SAED) technique with a microfabricated SA aperture hole rather than nano-probe diffraction to analyze the crystal structure of nanomaterials [3].

A new automatic operation function, called “nano analysis function”, is produced to improve operability for acquirements of the SAED. This function enables automatic acquirements of SAED at plural analysis positions pre-designated by a user. The analysis position of the SAED is precisely controlled by an image shift coil mounted just below the objective lens. The minimum diameter of SA aperture is 1 um, which corresponds to the diameter of the selected area of 18 nm on the specimen. Figure 2 shows a TEM image (a) of an asbestos specimen with the corresponding SAED patterns (b) acquired by the nano analysis function. The selected area of each analysis position is displayed by a circle on the TEM image. The diffraction patterns of the acquired SAED images can be analyzed with an optional function of Hitachi EMIP software called “diffraction analysis function”. Figure 3 shows an example of a result. This function enables automatic measurement of diffraction spot intervals and assumption of elements contained in the selected area of the specimen from the database.

Reference:

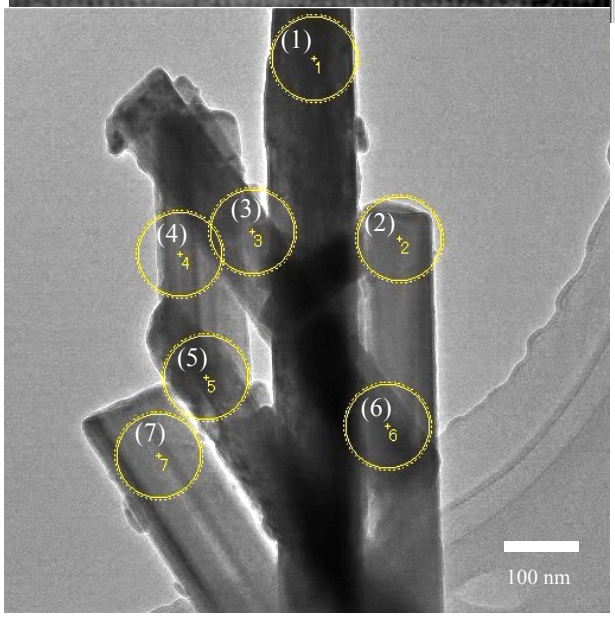
[1] Kubo, T., *et al*, 2013. Microsc.Microanal. 19 (Suppl 2), 1328.
[2] Yaguchi, T., *et al*, 2015. Microsc.Microanal. 21 (Suppl 3), 1817.

[3] Kamino T., *et al*, *Proc.of IMC* **18**, Prague, Czech Republic (2014) IT-6-P-1552.



Specimen: Au single crystal
Magnification: 1000kX
Column mode: HR mode
Acceleration voltage: 120kV

Fig. 1 High resolution TEM image acquired by HT7700 mounted with UHRLENS



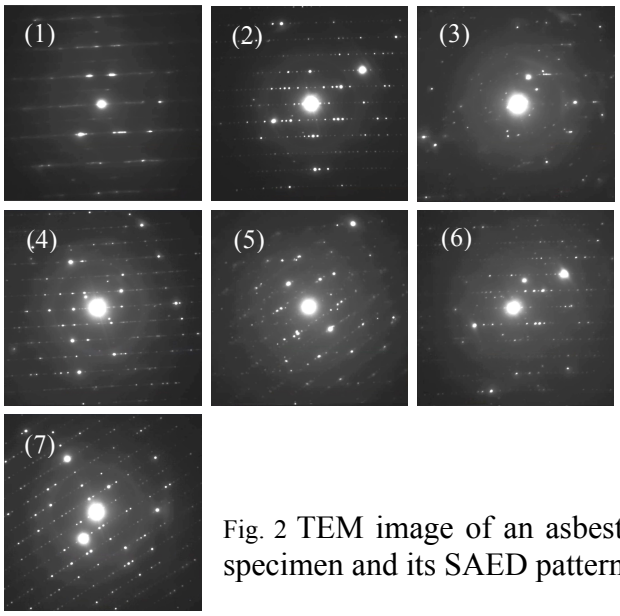
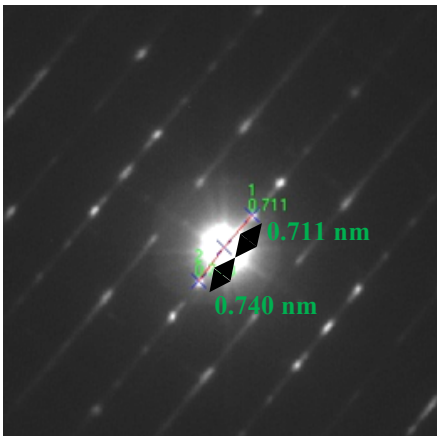


Fig. 2 TEM image of an asbestos specimen and its SAED pattern




```
No. D-spacing Candidate1
 1:   0.711    Chrysotile 0.730
 2:   0.740    Chrysotile 0.730
 3:

Statistics(Candidate1)
Lattice plane      D-spacing
Chrysotile(002)    0.730
```

Specimen: Chrysotile

Fig. 3 An example of the SAED pattern analysis by using the diffraction analysis function

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