doi:10.1017/S1431927611003898
Microsc. Microanal. 17 (Suppl 2), 2011

An Extension up to 4 keV by a Newly Developed Multilayer-Coated Grating for TEM-SXES Spectrometer

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We have been developing a soft X-ray emission spectroscopy (SXES) instrument for TEM. SXES combined with microscopy should be a hopeful method to reveal physical properties and chemical bonding states of identified small specimen areas of various compounds. Original SXES instruments for conventional transmission electron microscopes basically designed to detect from 60 eV to 1200 eV (or 2000 eV in extended version) [1]. For applying to material science, a much wider energy range is necessary. Thus, a new SXES development for electron microscope has started to obtain an energy range from 50 eV to 3800 eV. An extension in lower energy region was achieved by a new aberration corrected (varied-line-spaced: VLS) grating [2,3].

Conventional gratings in soft-X-ray energy region have gold surface. Au has M-absorption edge at 2.2 keV and shows only a small reflectance higher than the energy. Thus, a new multilayer-coated (MLC) VLS grating with a groove density of 2400 l/mm has designed and manufactured for obtaining SXES spectra up to 4 keV at a grazing incident angle of 1.35 deg. The material pair of the multilayer is W and B_4C. The period length and total number of periods are about 5.6 nm and 20, respectively.

Figure 1 shows a photo of a newly constructed SXES spectrometer attached to a transmission electron microscope of JEM2010. This spectrometer can set four gratings. Two types of detectors are attached. For examining the present new MLC grating, a back-thin-type CCD detector with a pixel size of 12 μm was used. The CCD is cooling down to –80 °C. by a thermo-electric device (MCP-CCD detector with a pixel size of 24 μm is used for lower energy region).

Figure 2 shows L-emission lines of single crystal Te obtained by using the new grating and the CCD detector. Beam current and detection time were 12 nA and 20 min, respectively. Not only two intense lines of Te-Lα (3769eV) and Lβ (4030eV) but also four small structures of L*l*, Lη,

$L\beta_3$ and $L\beta_{2,15}$ have been assigned [4]. At the same setting of the MLC grating, Pt-Mα (2050eV), Pd-Mα (2839eV), In-Lα (3287eV) were also obtained. This confirms that the newly designed MCL grating works for 2-4 keV.

This development is conducting as one project of Collaborative Development of Innovative Seeds (Practicability verification stage) by Japan Science and Technology Agency.

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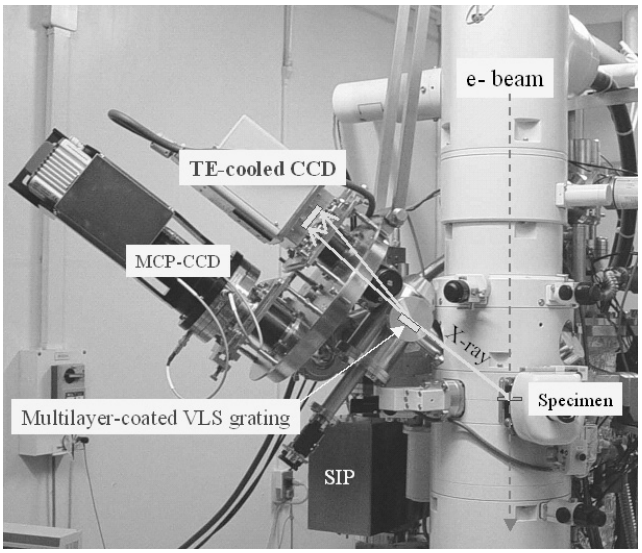

FIG 1

SXES spectrometer attached to a transmission electron microscope of JEM2010. In this experiment, a newly designed and manufactured MLC aberration corrected grating for 2-4 keV was installed. A back-thin-type CCD detector with a pixel size of 12 μm was used.

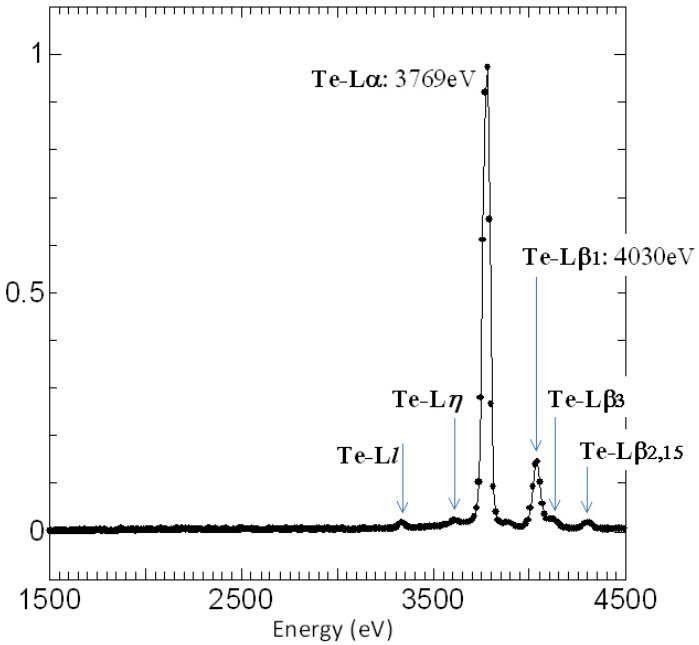

FIG 2

L-emission lines of Te obtained by using the new MLC grating and the CCD detector. Beam current and detection time were 12 nA and 20 min, respectively. Not only two intense lines of Te-Lα (3769eV) and Lβ (4030eV) but also four small structures of L*l*, Lη, $L\beta_3$ and $L\beta_{2,15}$ have been assigned.

https://doi.org/10.1017/S1431927611003898 Published online by Cambridge University Press