HITACHI SCIENTIFIC INSTRUMENT
TECHNICAL DATA STEM

SHEET NO. 2

SUBJECT: MICROSCOPIC ANALYSIS OF GMR HEAD USING THE HD-2000

INSTRUMENT: THE HD-2000 ULTRA-THIN FILM EVALUATION SYSTEM
THE FB-2000A FOCUSED ION BEAM SYSTEM

CONTENTS:

1. INTRODUCTION

Fig. 1 shows the HD-2000 Ultra-thin Film Evaluation System which is capable of high resolution imaging of subnanometer areas in the order of atoms and molecules using STEM operation mode. It has been found useful for materials characterization of semiconductor devices and many other advanced materials. We will report on site-specific thin specimen preparation using GMR (Giant Magnetoresistive) head as one of the representative samples of today.

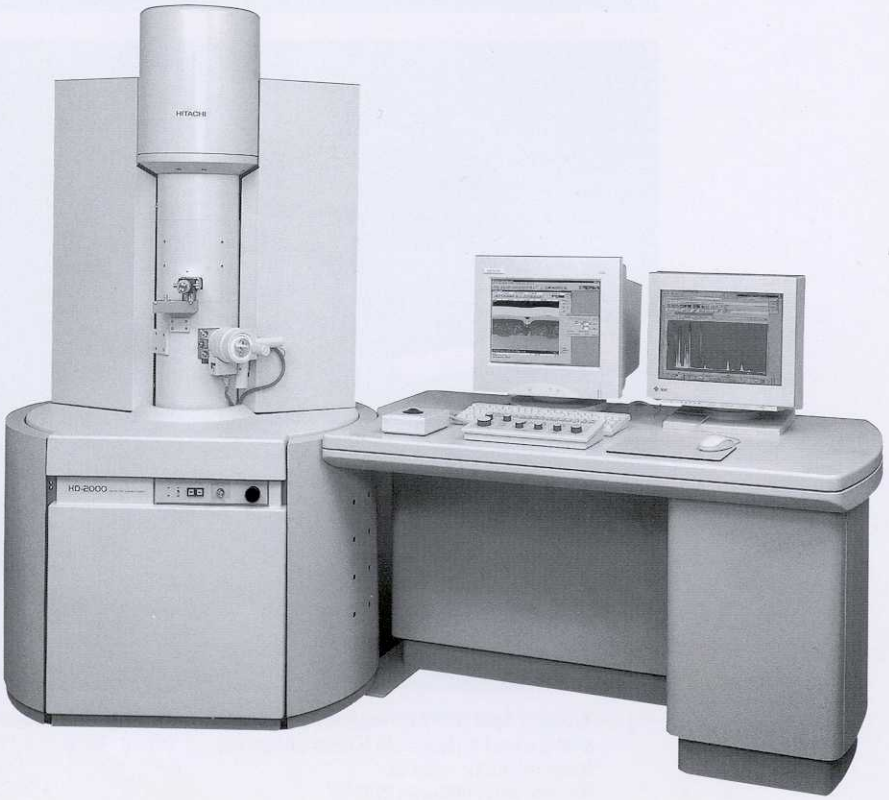

Fig. 1 A general view of the HD-2000

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2. OBSERVATION OF METALLIC MULTI-LAYERS OF GMR

Fig. 2 shows images of a thinned GMR specimen recorded with the HD-2000. Fig. 2a is a bright field STEM image which is similar to those available with conventional transmission microscopy. Fig. 2b is a dark field STEM image. Fig. 2a shows crystalline particles and orientations. Fig. 2b is an image reflecting atomic numbers and densities of materials. The dark field mode of the HD-2000 is available at a click of the mouse and displays various images, each of which has different information. Specimens for this observation have been prepared using the Hitachi FB-2000A focused ion beam system.

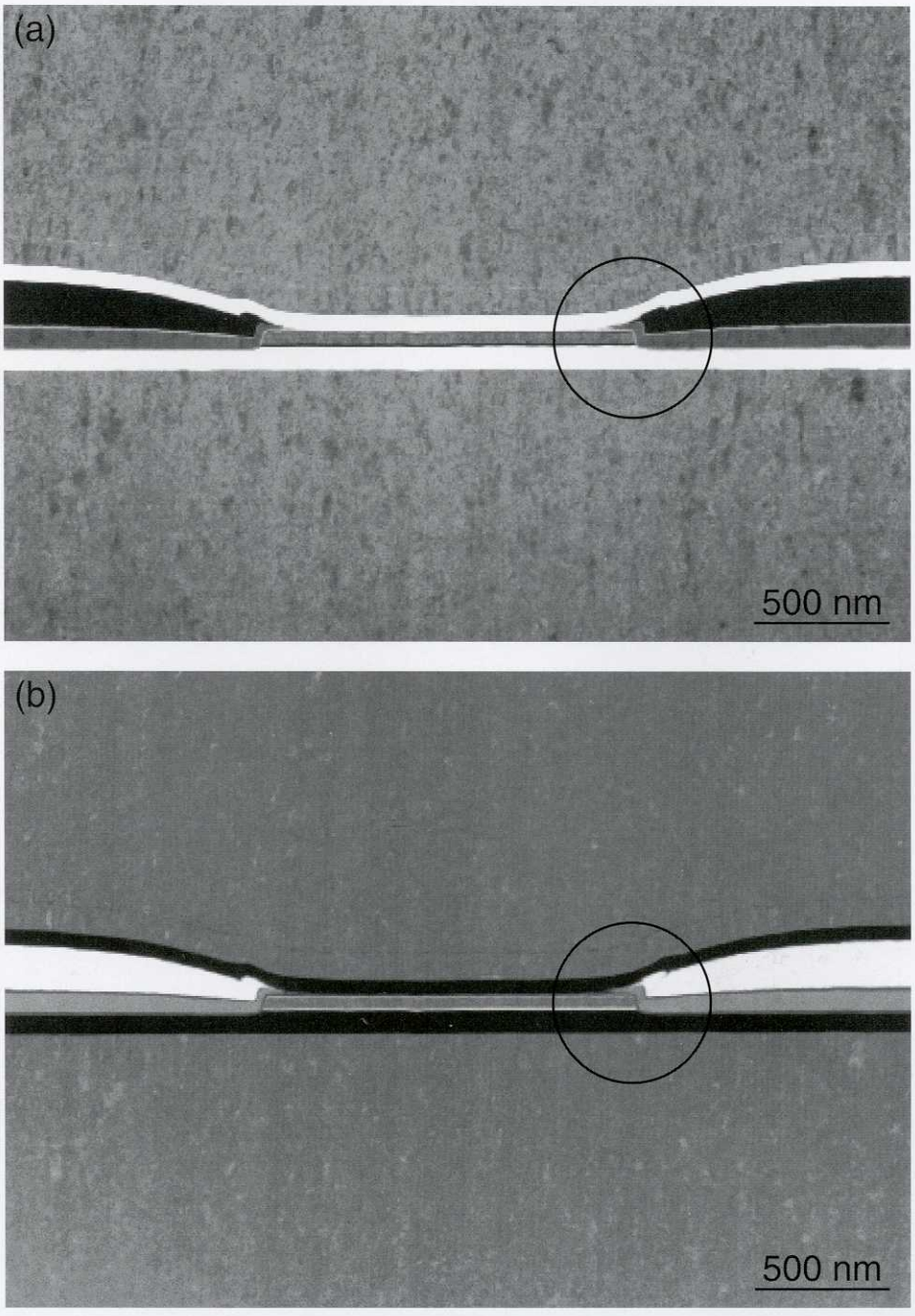

Fig. 2 A bright field STEM image (a) of a GMR specimen prepared using a focused ion beam system and a dark field STEM image (b)
Magnification: ×35,000
Accelerating voltage: 200 kV

Figs. 3a and 3b are higher magnification images of circled areas in Figs. 2a and 2b respectively. Fig. 3a is a bright field image and Fig. 3b a dark field image. Fig. 3a shows grain size and directions of crystal growth in each layer. Fig. 3b shows each layer at high contrast. The high contrast image is one of the features of dark field STEM imaging using the HD-2000.

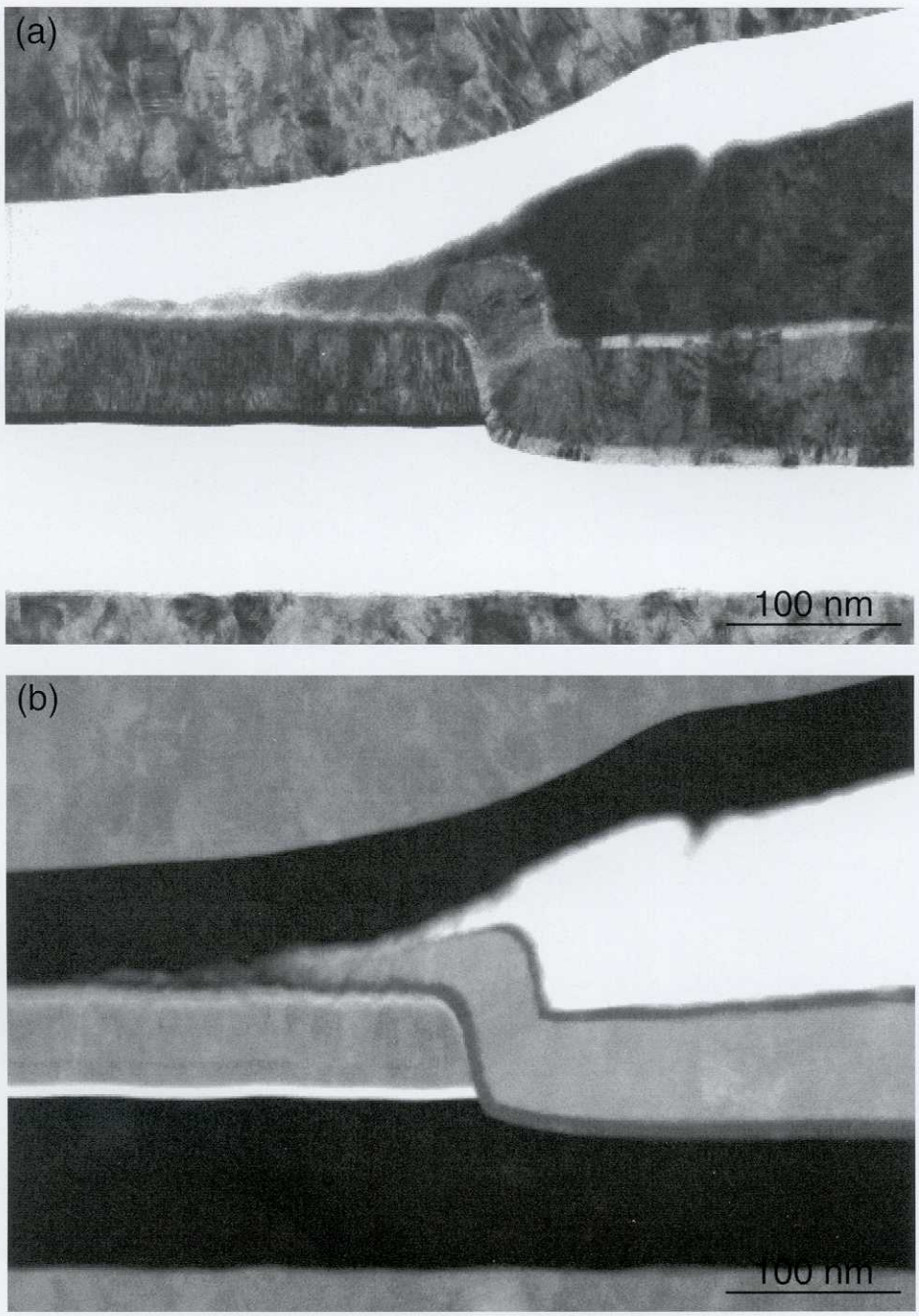

Fig. 3 A bright field STEM image (a) of a GMR specimen prepared using a focused ion beam system and a dark field STEM image (b)
Magnification: ×250,000
Accelerating voltage: 200 kV

Figs. 4a and 4b are a bright field STEM image (a) of metallic multi-layers of GMR specimen and a dark field STEM image (b) of the same area. Fig. 4a shows crystal grains grown like pillars. Fig. 4b shows a protective layer of a heavy metal at high contrast as shown by an arrow. This layer is located at a lower part of metallic multi-layers of GMR specimen.

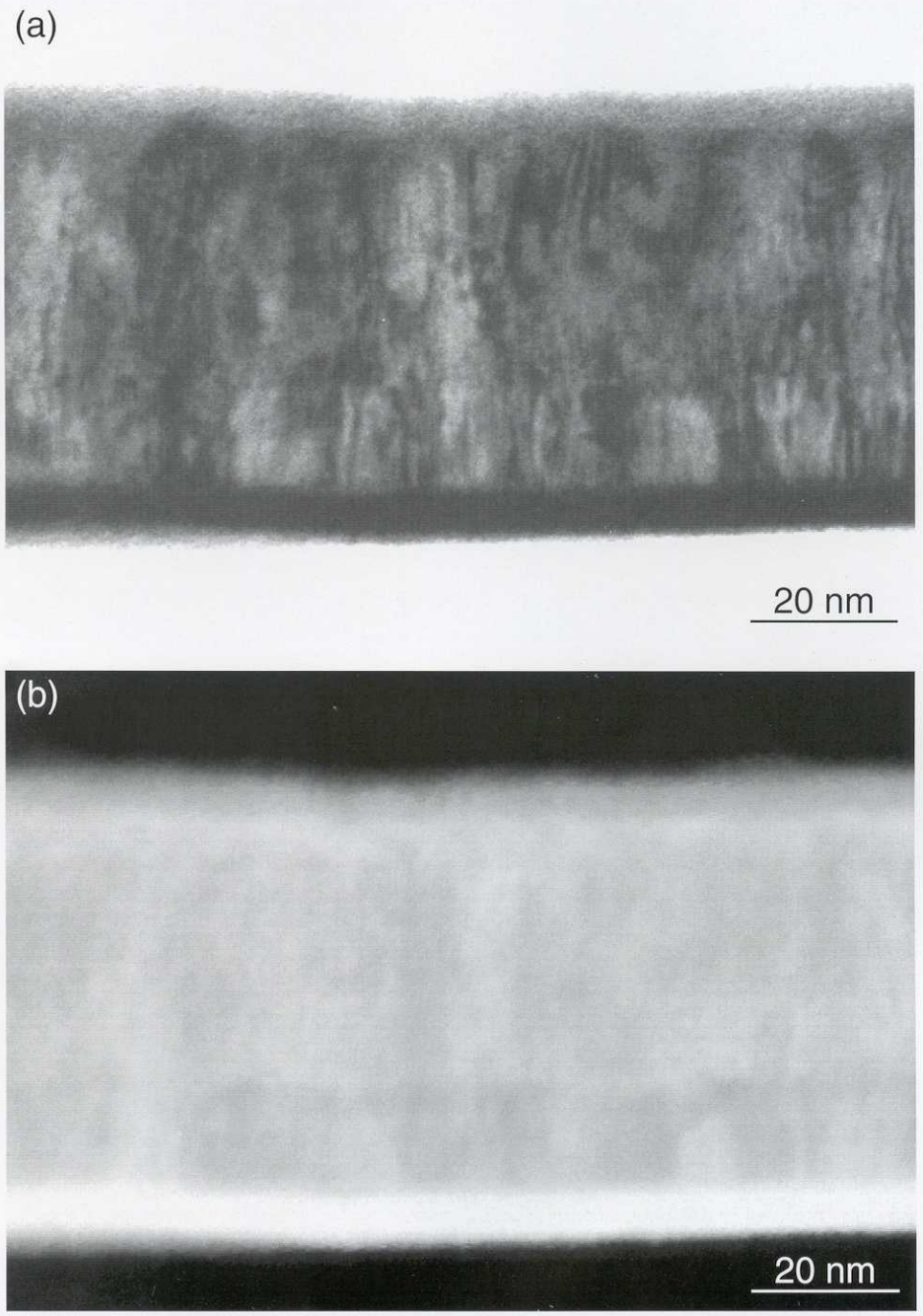

Fig. 4 A bright field STEM image (a) of a GMR specimen prepared using a focused ion beam system and a dark field STEM image (b) of the same
Magnification: ×1,000,000
Accelerating voltage: 200 kV

3. ELEMENTAL ANALYSIS OF METALLIC MULTI-LAYERS OF GMR

3.1 X-ray mapping image

Fig. 5 is an X-ray mapping image showing metallic multi-layers of GMR specimen. Cobalt layers of 1 nm and 3 nm thick and a copper layer in-between are shown clearly separated from each other. The HD-2000 allows these mapping images in about 5 minutes and these images are useful for checking uniformity of each layer.

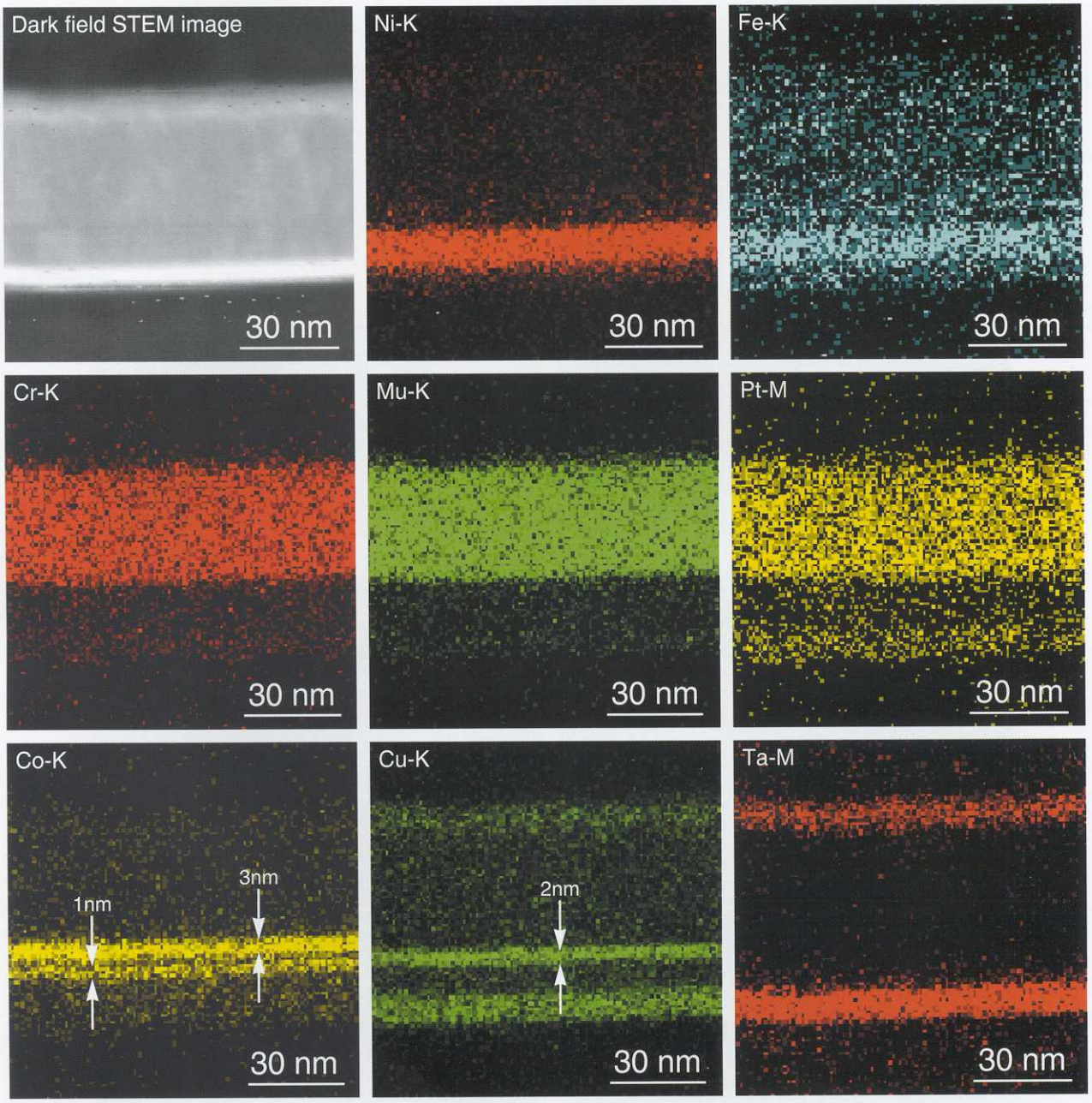

Fig. 5 X-ray mapping image
Probe size: 0.5 nm
Probe current: 200 pA
Acquisition time: About 5 minutes
Image pixels: 128 × 128

3.2 X-ray line analysis

Fig. 6 shows examples of line analysis using a metallic multi-layer specimen of GMR. This analysis is useful for reviewing composition changes of one layer to another.

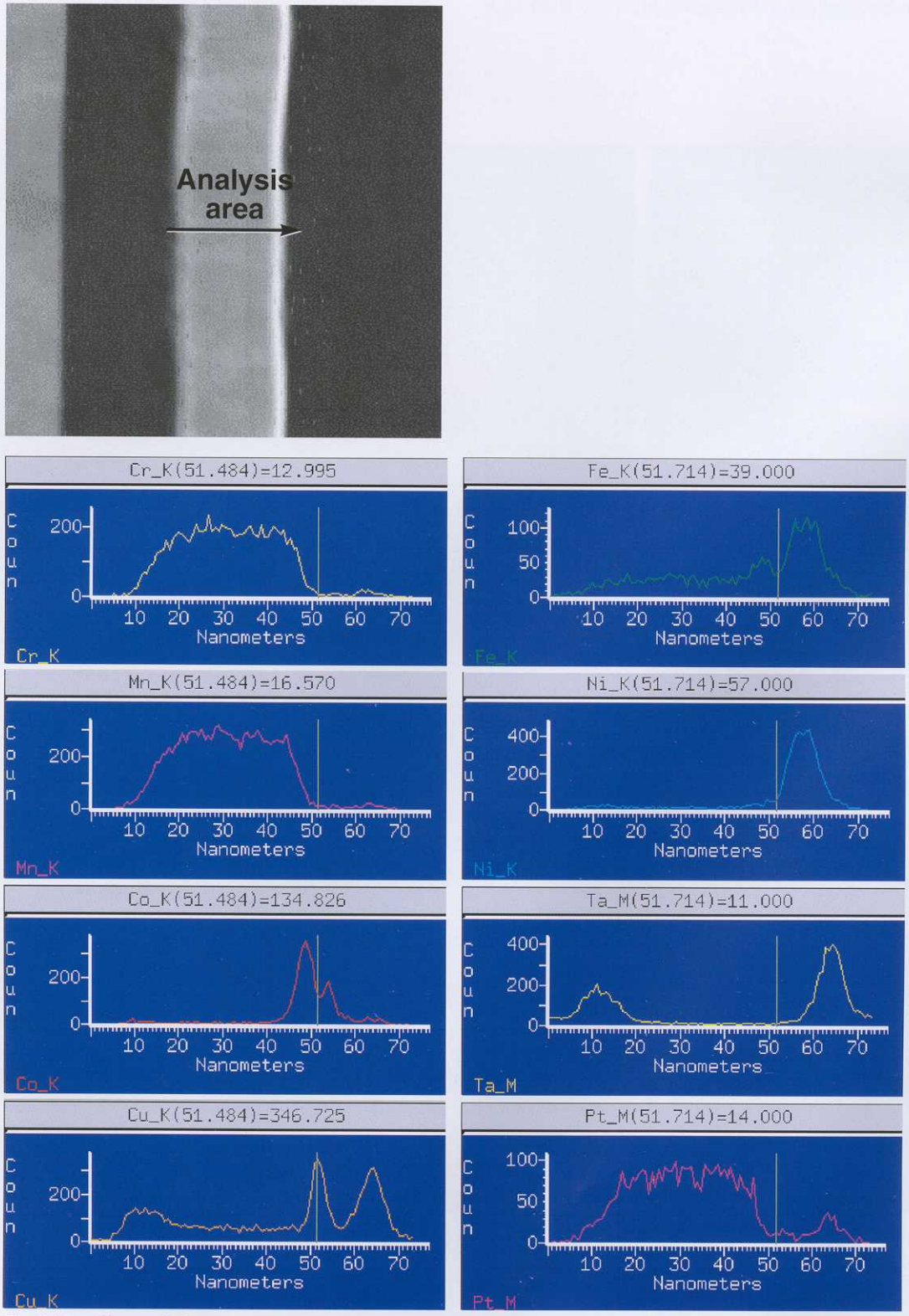

Fig. 6 X-ray line analysis
Probe size: 0.5 nm, Probe current: 200 pA, Acquisition time: 50 seconds
Analysis point: 100 points, Image pixels: 128 × 128

4. CLOSING

We have shown images of a GMR specimen using the HD-2000. It is useful for measuring thickness of each layer, reviewing uniformity and examining compositions of each layer of a specimen which includes metallic multi-layers. The measurement, review and examinations of these layers in the order of nanometer have not been possible up to this time. We trust that a combined system of the HD-2000 and FB-2000A will play a leading role for characterization of various materials.