The Remote Control Scanning Microscope with Web Operation Interface (WebSEM)

Atsushi Yamada
Electron Optics Division, JEOL Ltd.

Introduction

Recently, a network has started to be used in observation instruments centered on an SEM (scanning electron microscope) for various purposes such as compiling the observed images into a database. In order to utilize such a network for integrated control of the results obtained from an observation/analytical instrument including an SEM, and also to perform observation efficiently, it has become necessary for operators and administrators (using client PCs) to share data. For this reason, it is necessary to be able to observe images from an SEM, or to operate the SEM, from a remote site. To meet these requirements, we have developed a system for remotely controlling an SEM connected to a network. In order to perform the remote control of an SEM, we have constructed a system based on the concepts set out below.

- The SEM can be operated on the client PC with the user interface constructed on a WEB Browser, regardless of the model of the SEM.
- The system can support multiple customers without installing special software on their client PCs.
- The client PC on a network can be connected easily to the SEM from anywhere.

Based on the above concepts, we have developed a remote control system for the SEM, which enables the SEM images and the SEM control functions to be displayed on a WEB Browser in an external client PC.

In this system, the operation interface is displayed on a WEB Browser; therefore, the SEM can be connected and controlled from anywhere at all, provided that a generally used browser (IE: Internet Explorer) is installed in the PC.

This system can be connected to FE (field emission) SEMs (JSM-6700F/6500F/6335F) on which an FE gun is installed, or with SEMs employing a thermal electron gun (JSM-5900/5900LV, JSM-5600/5600LV and JSM-5500/5500LV), from a client PC.

We have named this remote control system “WebSEM”, based on the above concepts.

Configuration of the WebSEM System

We describe the method of controlling the JSM-6700F that is connected to a LAN (Local Area Network), from a client PC that is connected to this network. Figure 1 shows a diagram of the hardware configuration in which the SEM is controlled from a client PC using a LAN.

The SEM, which is the server side, is connected to a video server for transferring live images, and is also connected directly to the LAN to permit communication between the SEM and the client PC. The client PC is connected to the network. If necessary, the simple operation panel can be connected to the serial port. Thus, at the server (SEM) side, it is necessary to add hardware to a standard SEM for image transfer and communication, however the client PC side does not need any special hardware. Also, the software necessary at the client PC side can be transferred from the server; therefore, there is no need to provide any special software in advance like the case of the hardware.

Figure 2 shows the contents of the signals for communication between the SEM (server) and the client PC. Both the image transfer part and the SEM control part of the JSM-6700F are connected to a LAN. In order to display the SEM image as a live display with 640 × 480 pixels, which is used as a means of high-quality image transfer via networks in the current image-transfer technologies, the original image with 1280 × 1024 pixels is resized to 640 × 480 pixels using a scan converter. The image signals are connected to a video server intended exclusively for image transfer, and the images are transferred from the video server to the client PC via the LAN.

As for the SEM control, the SEM is controlled by command-level communication between the SEM and a client PC. The interface for SEM control is displayed on the WEB Browser on the client PC, as shown in Fig. 3. The user interface consists basically of an SEM image display and the SEM control part. The SEM live image is displayed at 640 × 480 pixels. In this case, the OS (operating system) used in the client PC is Windows 2000 (or Windows NT), which is a standard OS having good capabilities of network security and stability.

The live image displayed on the client PC consists of 640 × 480 pixels, which is sufficient for observation or image adjustment (such as focusing). The saved image needs to have higher image quality or more information in the image (image density). To permit observation with higher quality, it is necessary that an image consists of 1280 × 1024 pixels. To achieve this, the WebSEM has been designed to provide the functions as follows (shown in Fig. 2). When an operator performs the image-saving operations from a client PC, a high-quality image is saved in the

Fig. 1. The block diagram of WebSEM remote control system with JSM-6700F.
hard disk on the SEM (server) side, and then it is automatically transferred to and saved in the client PC. A high-quality image is automatically saved on the client PC when the operator at the client PC just specifies the save button. Thus, it is possible to observe a live image and also acquire a high-quality saved image with comfortable operations.

User Interface

In the WebSEM, we have constructed a user-interface screen on the WEB Browser in an SEM to permit the SEM control from any PC connected to the LAN. Figure 3 shows the graphical user-interface (GUI). The WebSEM utilizes the GUI that is used in the JSM-6000 series and JSM-5000 series. This screen features a configuration that enables the SEM to be controlled by a mouse operation alone. The method of operating the user interface is described below. It is roughly classified into button operations and dragging operations using the mouse.

Figure 4 shows the setup buttons for the column, image adjustment and observation conditions. The menu part has image-saving button, scanning-speed select buttons, image freeze ON/OFF button, magnification select buttons, and auto function buttons. These button functions are used mainly for controlling a live image.

Below this group of buttons is the section used to adjust brightness, and focusing/astigmatism correction of the image. Operations of this image-adjustment section are made according to the method shown in Fig. 5. Figure 5 shows an example of contrast adjustment. To adjust the contrast, first click the mouse button at the contrast button, and a cursor will appear on the image screen. Next, drag the mouse up or down while keeping the mouse button pressed to change the contrast. At this time, the left mouse button is assigned to "fine step", and the right button to "coarse step". These buttons are used as necessary.

These operations can be used to other functions such as focusing, and each item is subjected to the adjustment on a live-image screen.

The button group on the right of the user interface of Fig.4 is used mainly to set the observation conditions. Using them, setting of the accelerating voltage including ON/OFF switching, magnification and other items are carried out. Clicking one of these buttons displays a setting dialog box shown at the right of Fig.4 (in the case of accelerating voltage). The Accelerating Voltage is selected from this dialog box, and then clicking the OK button completes the selection.

As described above, the basic operations of the SEM are performed using the buttons shown in Figures 4 and 5. When observing an image from a client PC under preset observation conditions, it is necessary to use the setup button shown at the right side of Fig.4. Selecting this setup button permits a direct setting of preset observation condition in a single operation. This is a very effective method for observing a specimen when the observation conditions for the specimen are known in advance.

By clicking the save button after setting the conditions for observation and image adjustment, a high-quality image can be saved (acquired) in the client PC automatically. After these operations, this image can be printed from the same client PC.

This system has a function of automatic stage shift. When the client clicks the right mouse button at the observing object on the observation-image screen to which the client wants to shift the stage, the position of the stage moves to the center of the observation image on the screen. The feature of this function is that the specified position always comes to the center of the screen. The image refresh speed depends on the traffic capacity
of the LAN. Therefore, this stage-centering function is useful for the client PC even when the image refresh is delayed.

**Operation Panel**

It is also possible to install an exclusive operation panel (Fig.6) on the client PC. The use of this operation panel provides the client with the feeling of directly operating the SEM, even when operating it on the client PC, thus improving operability. This is a particularly useful method for persons who are not familiar with controlling the SEM using a mouse. In consideration of operability, the operation panel is the same as that of the JSM-6700F and its functions are limited to those shown in Fig.6, including magnification, focusing and other items. However, since it is installed on the client PC side, the type of PC that can be used to perform SEM operations are limited.

**Application Example**

The following is an example of application of the WebSEM. Figure 7 shows the case of a clean room. The outside client PC controls the SEM that is installed inside a clean room. There are many cases in which operating the SEM in a clean room is important, but it is difficult to enter the room frequently. In the case of an SEM that is installed in such a place, the administrator PC is connected to the SEM when information on the observed specimen needs to be exchanged between the SEM operator and the administrator.

By connecting the client PC to the SEM, the client can observe the same image as that seen by the SEM operator, in real time. This enables the client to confirm the image information with each other. Also, as necessary, the administrator can operate the SEM and give instructions. These operations allow information to be shared at all times. In addition, prompt action can be taken if a problem is found in the specimen, thus permitting efficient work.

As a demonstration of the remote control system, at the Annual Meeting of Japanese Society for Electron Microscopy held between May 10 and 12, 2001 we operated an SEM using ISDN (8 lines used at a speed of about 1Mbps) over a distance of about 900 km between Fukuoka (the conference site) and Akishima (JEOL). (Fig.8)

**Summary**

We have completed the WebSEM that provides a user interface for SEM control and SEM image observation built on a WEB Browser to enable the SEM to be remotely controlled.

This system has many potential applications, such as the following.
- It is possible to observe SEM images and control the SEM regardless of its model, from any PC whatever.
- When the SEM is installed in places such as a clean room where entering is difficult, it is easily possible to check the SEM image from outside and issue instructions to the SEM that is inside the place.
- It is possible to carry out SEM education including operation training at an external site.

Amidst of the rapidly evolving network environment, it is expected that the remote control WebSEM system using networks will be increasingly utilized to a variety of fields in the future.