Research Note

SEM Technique for Displaying the Three-Dimensional Structure of Wood

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ABSTRACT. Samples of green *Liriodendron tulipifera* L. were bandsawed into 1/4-inch cubes and boiled in water for 1 hour. Smooth intersecting radial, tangential, and transverse surfaces were prepared with a handheld, single-edge razor blade. After drying, the cubes were affixed to stubs so that the intersection point of the three sectioned surfaces was uppermost. Specimens were then coated with carbon followed by gold-palladium. A three-sided reflective shield measuring 6.5 cm long by 4 cm deep and 4 cm high was made of thin-gage polished sheet metal and affixed to the goniometric stage in a position opposite the secondary electron detector. Holes in the bottom surface accepted the stubs which could be rotated about their axes. Micrographs illustrate that with the shield in place all three surfaces can be equally highlighted.

SINCE COMMERCIAL INTRODUCTION of the scanning electron microscope (SEM) in 1965, wood anatomists have eagerly depicted the structure of wood with a clarity frequently lacking in micrographs obtained by other means. As with the light microscope, the complete picture of wood's anisotropic structure is usually obtained from individual images of the transverse, radial, and tangential surfaces. In some cases, however, it is useful if all three surfaces of a single sample are displayed in one presentation. For example, the structure of the composite may be more readily visualized when the cellular elements are in proper spatial relationship with each other.

One problem encountered in obtaining secondary electron micrographs of three mutually perpendicular planes is that of equally "illuminating" all surfaces. While admittedly an oversimplification, the following analogy will serve for the present discussion.

In the SEM, the specimen is displayed on the screen as if viewed down the electron-optical column with illumination coming from the secondary electron detector (normally located to the side and at an angle of about 70° to the column axis). A textured plane positioned at right angles to the electron beam will appear as a flat, poorly illuminated two dimensional surface. In contrast, a surface tilted at 45° toward the detector will appear brightly illuminated and possess a three dimensional quality.

Consider now a cube positioned within the chamber so that the axis of the electron

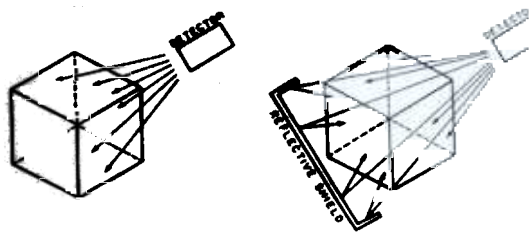

Figure 1. — Plan view of cube looking down the electron-optical column with illumination coming from the detector.

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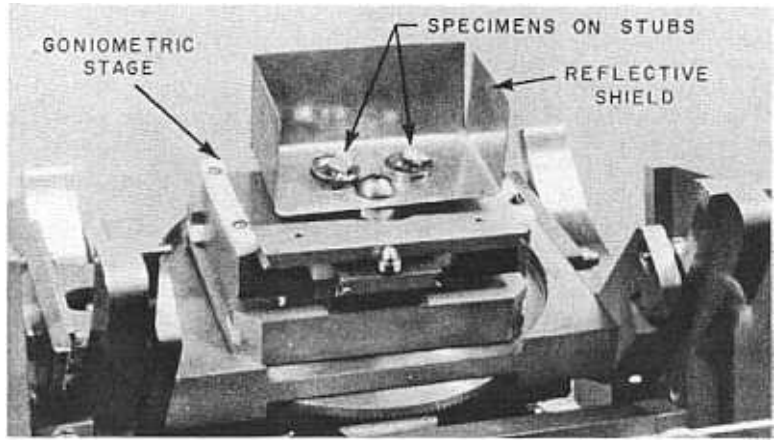

Figure 2. — Photograph of specimens and reflective shield installed on the microscope stage.

optical column intersects the two opposite corners where each set of the cube's three mutually perpendicular planes meet.

When so positioned, the three uppermost planes are equally visible when viewed down the column and at a desirable angle of tilt. By rotating the cube about its axis to the position shown in Figure 1A, two surfaces will be well illuminated by light from the detector. The plane of the third surface slopes away from the detector and remains dark or poorly illuminated. However, if a mirror is placed about the cube as shown in Figure 1B, a portion of the light from the detector is reflected to the third surface providing for improved illumination.

Methods and Results

Samples of green yellow-poplar *(Liriodendron tulipifera* L) were first bandsawed into

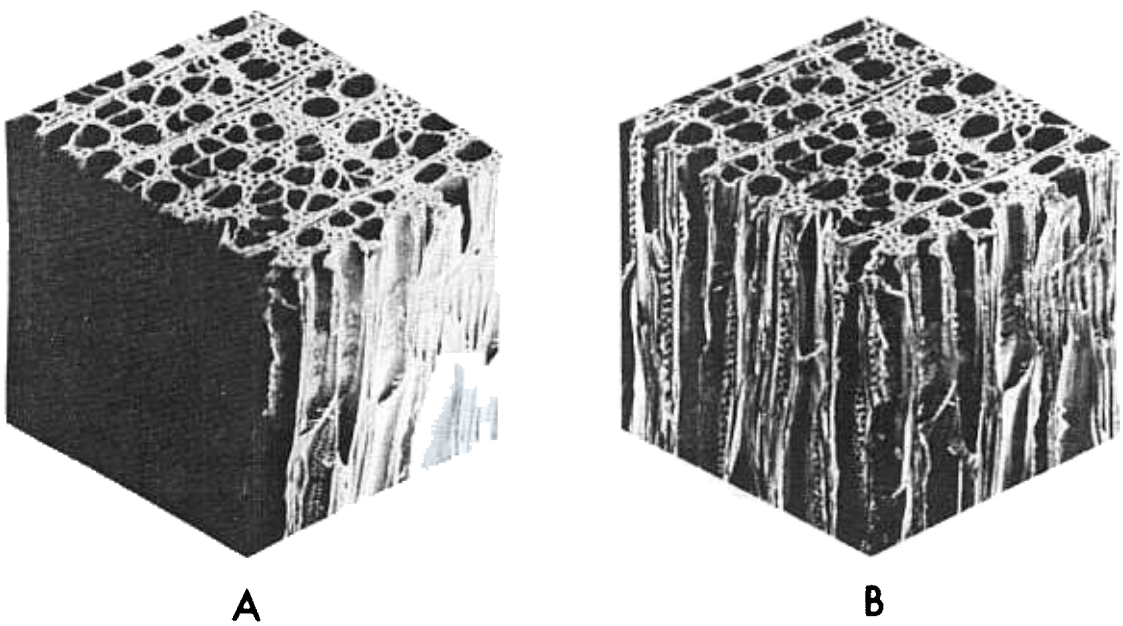

Figure 3. — Secondary electron micrographs of the transverse, radial, and tangential surfaces of yellow-poplar produced without (A) and with (B) a reflective shield.

1/4-inch cubes and boiled in water for 1 hour. Smooth intersecting radial, tangential, and transverse surfaces were prepared with a handheld, single-edge razor blade—a new blade was used for each cut. A binocular microscope aided in accurate positioning of the respective planes. After drying, the cubes were affixed to stubs with putty so that the intersection point of the three sectioned surfaces was uppermost. Specimens were then coated with carbon followed by gold-palladium.

A three-sided reflective shield measuring 6.5 cm long by 4 cm deep and 4 cm high was made of thin-gage polished sheet metal. Holes in the bottom surface accepted the stubs, which could be rotated about their axes to alter the position of specimens with respect to the reflective surfaces of the shield. Figure 2 shows the completed assembly on the goniometric stage of an Advanced Metals Research (AMR-900) SEM.

Figure 3 shows secondary electron micrographs illustrative of those obtained without (A) and with (B) a reflective shield; the working distance was 20 mm. The specimens were properly oriented about the column axis, and the relative positions of the detector and shield are as shown in Figure 2. The acceleration potential was 11 kV, and a 200 micrometer final aperture was used. Th outer edges of the original rectangula micrographs were trimmed so that th specimens appear in the figure as cubes.

In Figure 3A, anatomical details of th radial and transverse surfaces are apparen but differences in electron collection efficienc have resulted in unequal exposure. Electro collection from the tangential surface i extremely poor, and virtually no structure i visible. A micrograph of somewhat improve quality was obtained when the workin distance was increased to 50 mm, but i lumination of the tangential surface remaine inadequate. The micrograph of Figure 3I shows the same specimen viewed with th reflective shield in place. All surfaces appea equally illuminated and structural details ar abundantly visible.

Details of this technique are likely t differ for other instruments. For example, shield of somewhat different geometry may b needed, working distances may vary, or othe aperture dimensions may prove more effe tive. It also seems likely that a simila reflective shield could prove useful with othe types of specimens as a means of reducing th intensity of highlighting.