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3D STRUCTURE ESTIMATION FROM 2D IMAGES BY THE IMAGE ANALYZER

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Abstract. The micro-structure of metals has been inspected on their 2-dimensional images to know their physical characteristics. In this paper, some methods to estimate 3-D structures of metals from their sections and to make 3-D images of fractures from multi-tilt SEM images are suggested.

1. IMAGE ANALYZER

The Luzex image analyzers (a Nireco Corp. product) are applied to store 2-D images of sections and fractures of metals to 512×512×8 bit memory planes, to measure many 2-D parameters, to process gray images to educe features, to apply automatic processing software to make 3-D images.

Figure 1 shows a Luzex III system consisting of a Luzex main body, a 20 inch color display, a personal computer with a mouse, and a TV camera attached to an optical microscope which has an automatic stage and an automatic focus control system. Figure 2 shows the block diagram, and Figure 3 its inner operating blocks.

The maximum size of the memory plane in the Luzex III is 2048×2048×16 bit. Usually, we get 512×512×8 bit images from a TV camera on a optical microscope, and 1024×1024×8 bit images from an SEM. The image analyzer is constructed to conform to each case.

The image analyzer has many functions to process 2-D images such as gray image processing, gray image analyzing, binary image processing, binary image analyzing, and data processing. Figure 4 shows some parameters of binary image analyzing. Areas, Feret's diameters, cut-lengths (chords) and other diameters are quickly measured for each feature. We construct an exclusive software in the image analyzer to make stereoscopic images from multi-tilt SEM images and to estimate metallic crystal grain size from its sections.

This paper was presented at The Second International Symposium for Science on Form (October 19th–21st, 1988 at the University of Tsukuba, Japan).

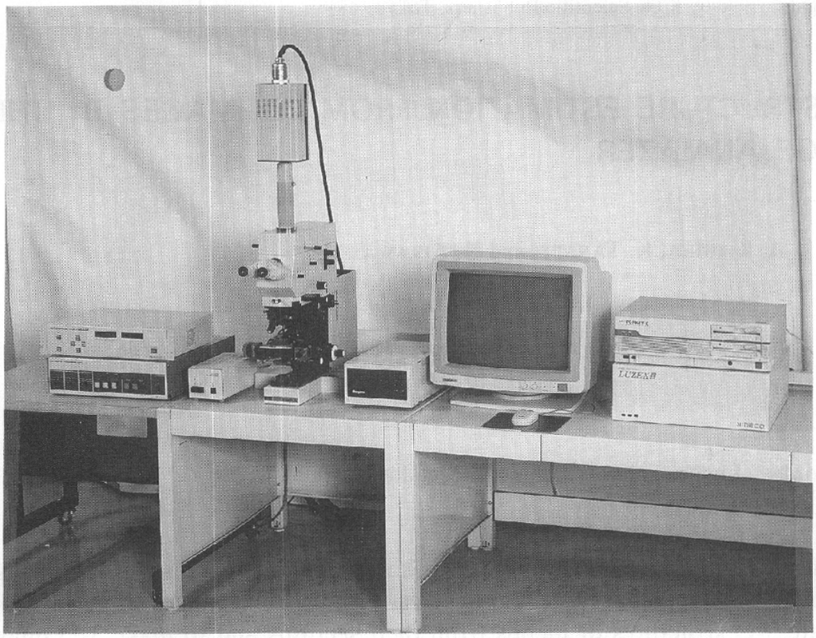

Fig. 1. Luzex III system.

2. 3-D METALLIC CRYSTAL MODEL GENERATION AND ITS SECTION MEASUREMENT

For metallic grain size measurement, we observe a sample of metal through an optical microscope of 100 to 400 magnifications. Stereology tells us that the average sectional area or average cut length has a linear relationship to the average volume of particles.

Dr. Oka and others simulate crystal growth in an ACOS 850-10 computer. $20 \times 20 \times 20$ unit cubes of the same size are assigned in an object space. One nucleus in each cube is located at random. Equi-axial crystal grains are grown around nuclei with a given speed to the extent that the object space has been filled with them. Figure 5 shows a completed object space, and an arbitrary cut sectional image is shown in Fig. 6(a). The grain boundaries image is quite similar to the JSPS standard graph in Fig. 6(b).

Sectional area distribution and cut length distribution are measured easily by the image analyzer, and the average area and average cut length are adequate to estimate the average volume of particles. Figure 7 shows an experimental result of cut length distribution of ASTM standard graphs and a section of the simulation model.

From 100 experimental section measurements, we got the following relationship.

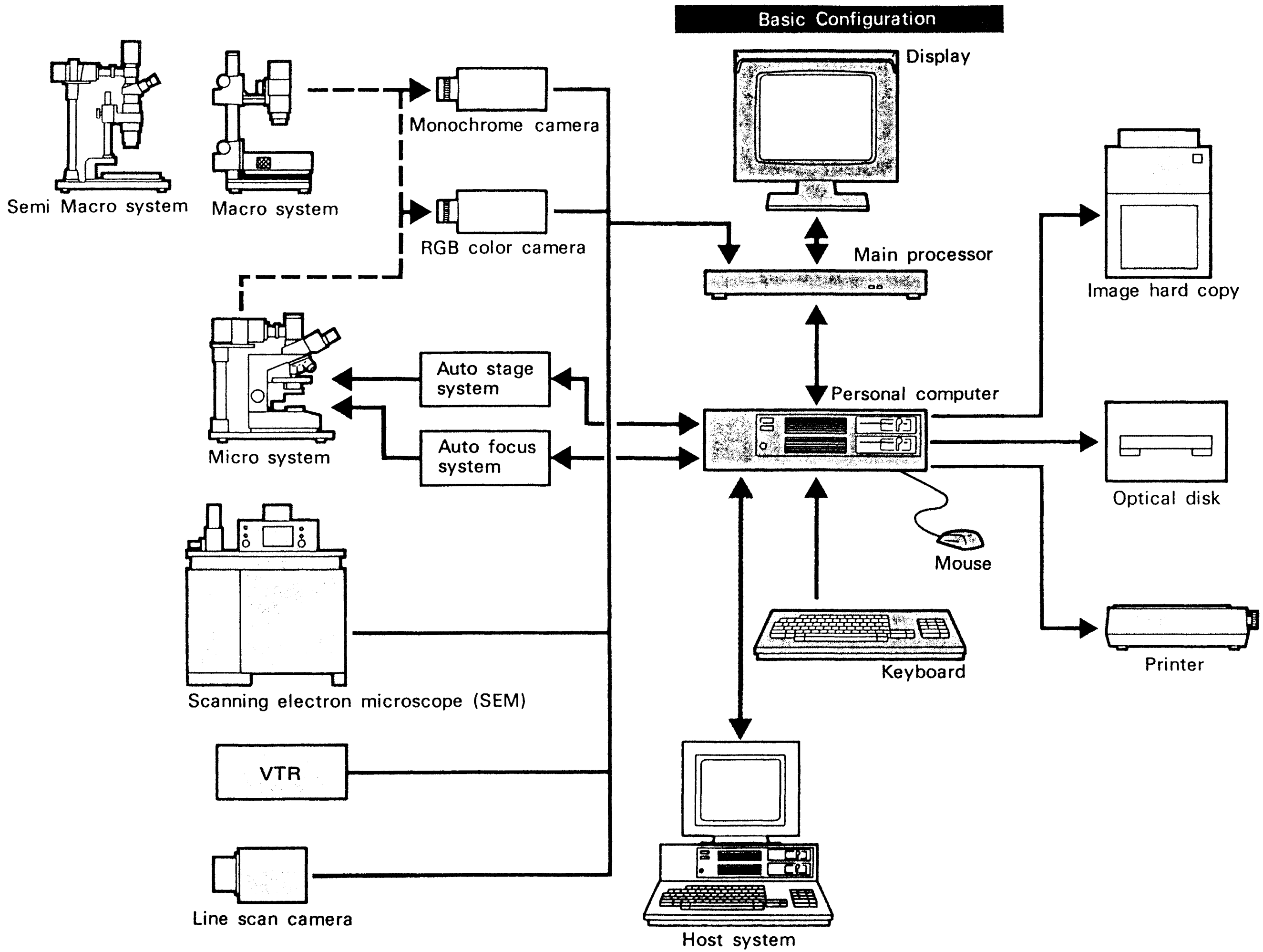

Fig. 2. System configuration.

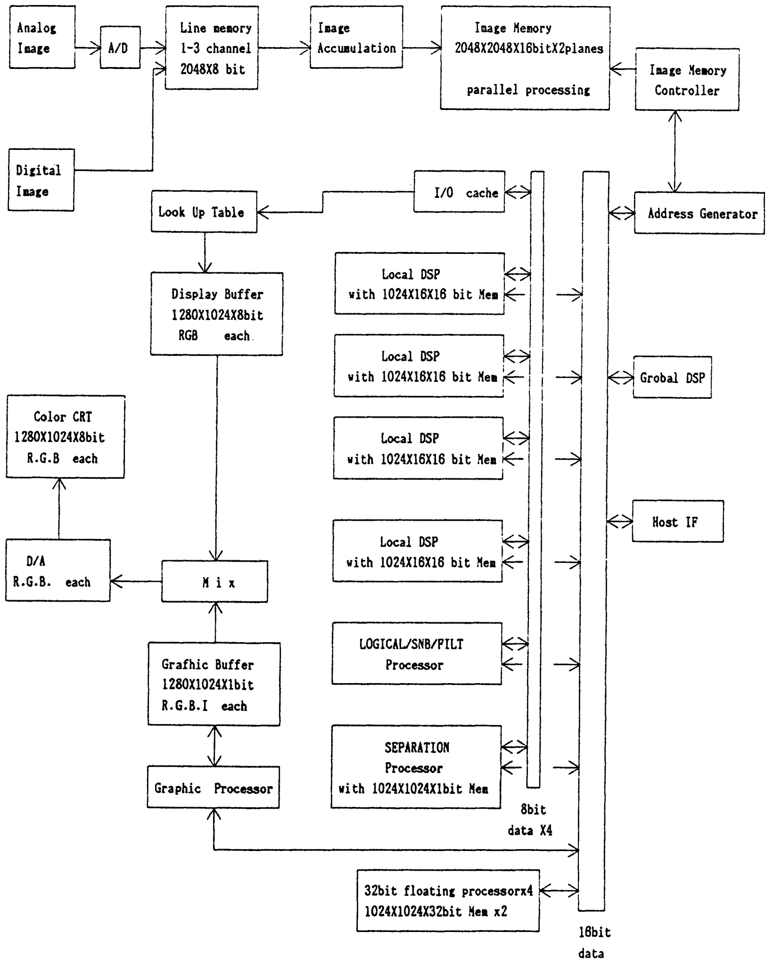

Fig. 3. Inner block.

$$V = 2.58\ L\hat{}3. \quad (1)$$

Here, V is the average volume of grains and L is the average measured cut length of a section.

As shown in Fig. 8., grain boundaries are not so clear as Fig. 6. model. So it is a practical way to measure grain size using cut length as the parameter.

3. STEREO VIEW FROM MULTI—TILT SEM IMAGES OF FRACTURE

Microscopic fracture face inspection is completed manually. There are several attempts to make 3-D images from two 2-D images of different tilt angles. The big

- Area: *A*
- Area including holes: *AH*
- Feret's diameter, horizontal or vertical: F_H/F_V
- Maximum chord, horizontal or vertical: C_H/C_V
- Mean chord, horizontal or vertical: MC_H/MC_V
- Length: *ML*
- Quasi-Length: *QL*
- Width: *W*
- Breadth: *BD*
- Orientation: *OR*
- Martin's diameter, horizontal or vertical: M_H/M_V
- Heywood's diameter: *HD*
- Center of gravity: *CG*
- Perimeter: *PM*
- Convex perimeter: *CPM*
- Projected length, horizontal or vertical: P_H/P_V
- Mean intercept: MICP H/MICP V
- Bone length: *BL*

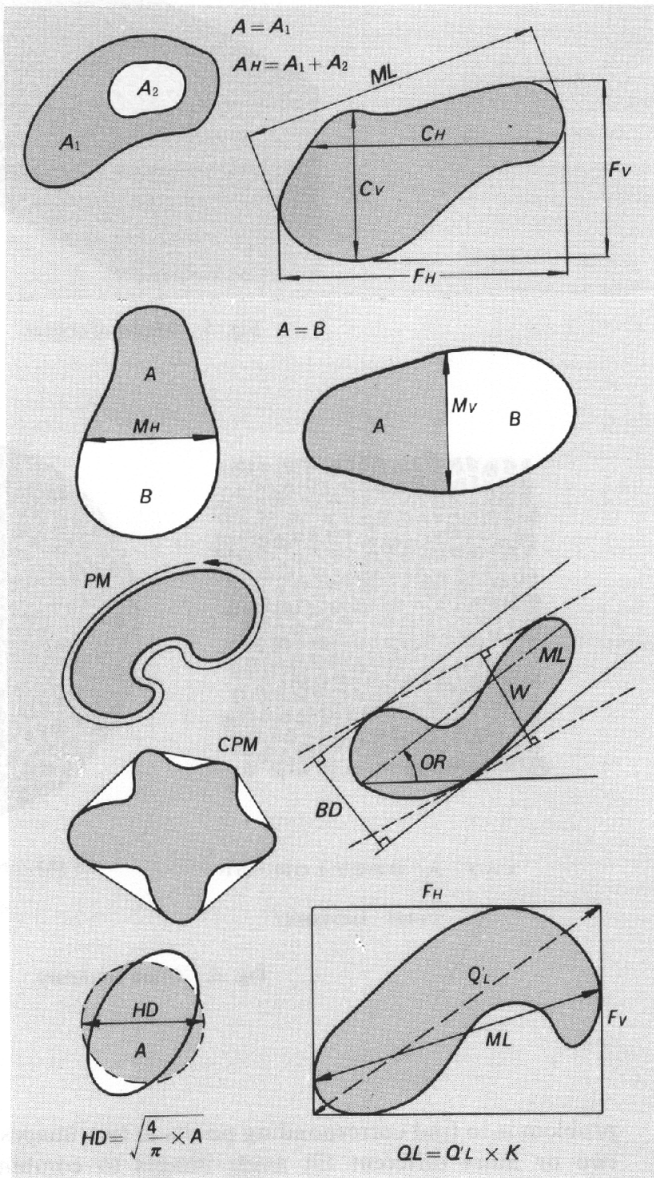

Fig. 4. Feature measuring parameters.

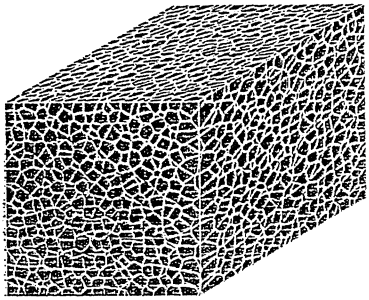

Fig. 5. Model of crystal.

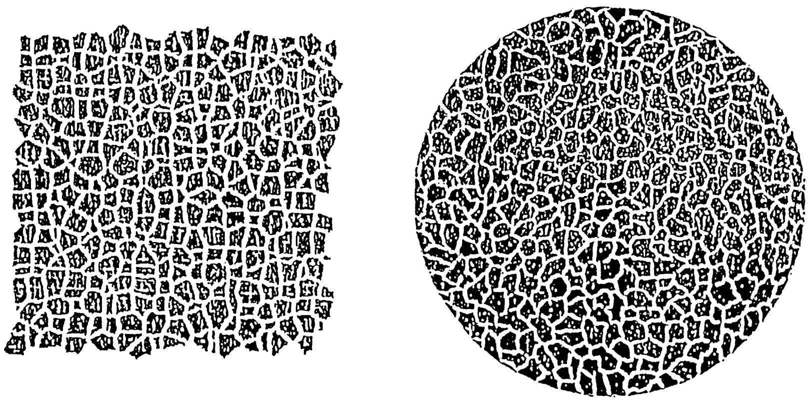

Fig. 6. Grain boundary.

problem is to find corresponding points in two images. We tried successfully to get two or more different tilt angle images to combine and found automatically corresponding points better than with former systems.

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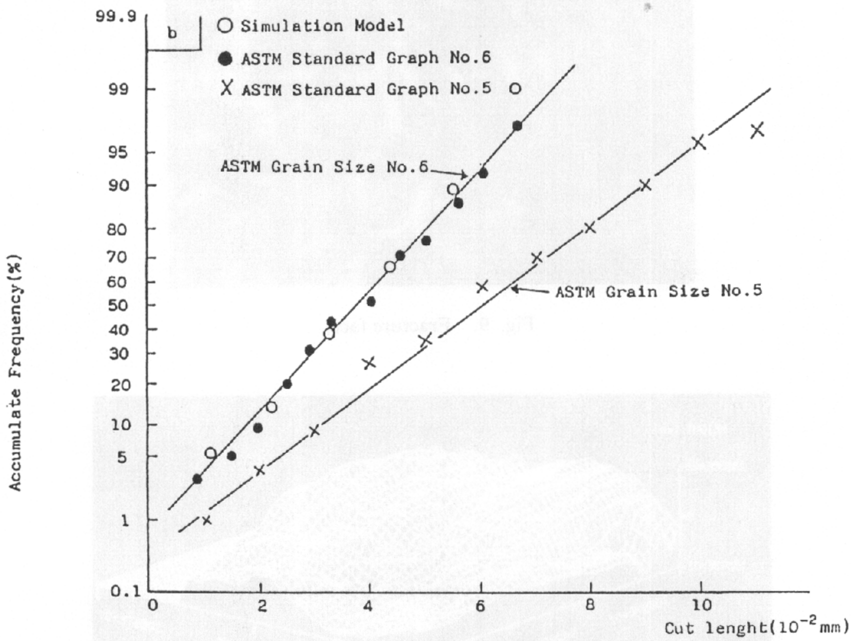

Fig. 7. Cut length distribution.

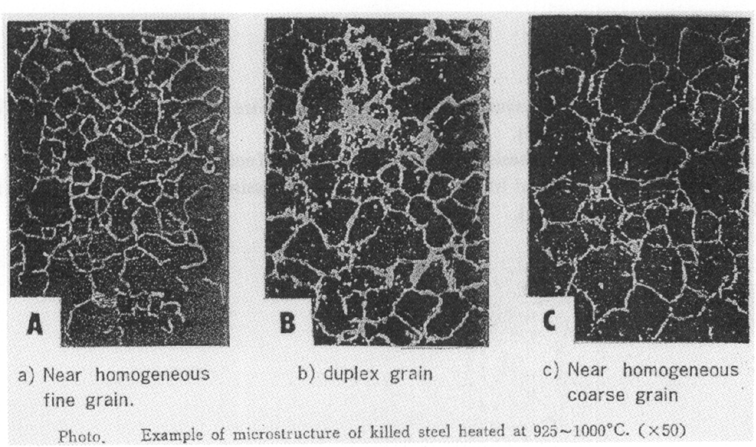

Fig. 8. Grain size difference caused by heated temperature.

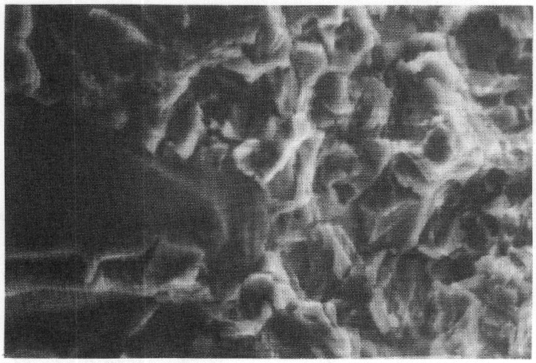

Fig. 9. Fracture face.

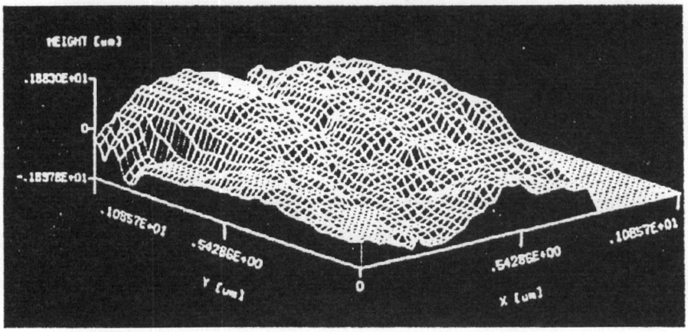

Fig. 10. Stereo view of the fracture.

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