A critical unit volume required to obtain reliable features of 3D image data set

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1. Introduction

3D characterization of microstructure is now getting much attention in materials science [1][2] because it is only experimental method to reveal an actual morphology of complicated microstructures. In the 3D study, there are five categories; (1) data acquisition, (2) data processing, (3) data analysis, (4) modeling, and (5) data storage/sharing. Data analysis is required to quantify the features of 3D image data set. To obtain reliable properties such as volume fraction of second phase in the 3D volume, the measured volume should be as big as possible. However there is no established procedure to determine the critical unit volume enough for obtaining reliable quantified properties of 3D image data set.

Thus this study aims to establish a reasonable procedure to determine a suitable unit volume to be analyzed.

2. Experimental procedure

Computed image data set with unit volume of 8262000μm^3 (180x180x255μm) showing multiple-sized particles (Fig.1) was used for this analysis. Volume fraction of the particles, f_V, was measured by changing a unit volume (V_{unit}, arrowed in Fig.1) and its position. Increment of V_{unit} was 5^3 μm^3 until V_{unit} reaches 180^3μm^3. The position of the frame was decided following random number deduced by computer and the volume fraction was measured 1000 times for each unit volume by changing the position of the frame. To realize this analysis reproducibly a program (Fig.2) was originally developed that runs in AVIZO/AMIRA 3D rendering software.

3. Results and discussion

Fig.2 shows a center of gravity coordinate of the measured frame. It seems that the frame position is distributed randomly. Fig.3 suggests that f_V is scattered when V_{unit} is small, while it becomes concentrated with increasing V_{unit}. This tendency is also confirmed in Fig.4 that demonstrates that standard deviation of f_V becomes saturated with increasing V_{unit}. From Fig.3 or 4 we can conclude that the critical V_{unit} to obtain reliable features of 3D data set is around 1331000μm^3 (110^3μm^3) in this case. This procedure is likely applicable to any actual 3D microstructures.

4. Summary

A potentially effective procedure was developed to determine a critical unit volume required for obtaining reliable features of 3D image data set.

References

[1] Symposium on Three-Dimensional Tomography of Materials, MRS spring meeting, 2011, San Francisco, California.
[2] International Conference on 3D Materials Science 2012, TMS, Seven Springs, Pennsylvania.

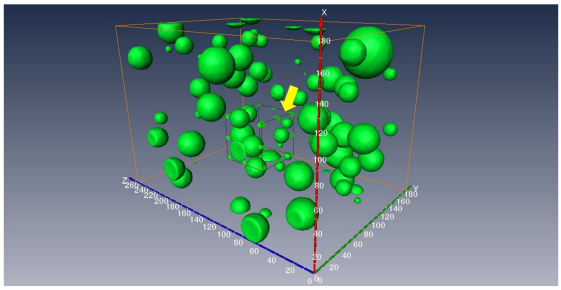

Fig.1 Computed image data set of multiple-sized particles in unit volume of 8262000μm^3. An arrow indicates a frame of reduced unit volume.

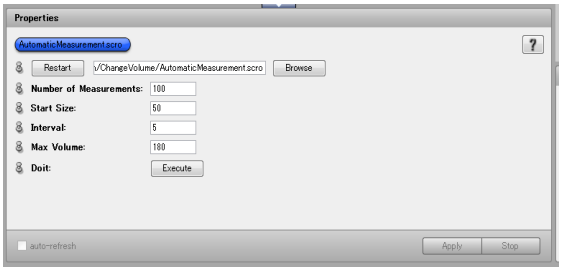

Fig.2 User interface of the developed software

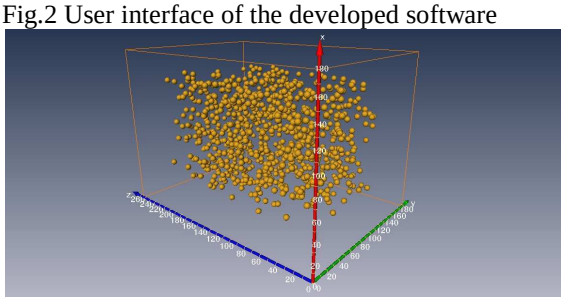

Fig.2 A center of gravity coordinate of measured frame.

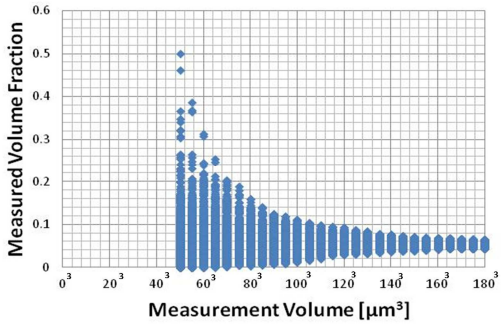

Fig.3 Measured volume fraction as a function of unit volume.

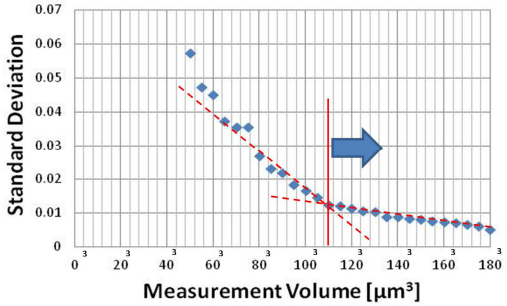

Fig.4 Standard deviation of measured volume fraction as a function of unit volume.