Study on Automatic Analysis Method for NaCl Crystal Growth Process in Aqueous Solution

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Summary

In this study, we searched for an image analysis method that does not use machine learning to automatically detect crystalline regions and evaluate crystal growth from liquid-phase TEM images, where it is difficult to evaluate crystal growth due to low electron dose observation and reduced contrast in liquid-phase samples.   We actually prepared and observed liquid-phase samples of NaCl aqueous solutions using the wet-cell method developed in our laboratory, photographed the crystal growth, and analyzed the images.   We compared lattice fringe detection by detecting lines in the spatial domain with lattice fringe detection by detecting bright spots that show periodicity in the spatial frequency domain, and determined an appropriate algorithm for detecting crystalline regions.   The size of the crystalline region can be measured by counting the number of pixels in the corresponding region, and crystal growth can be evaluated from the rate of change.   As a result, for crystal lattice images with a certain degree of periodicity intensity and length, lattice fringe detection and crystal growth evaluation could be performed with the same or higher accuracy as manual lattice fringe detection, so it can be said that we have established an automatic liquid-phase TEM image analysis method that does not use machine learning and is effective as a method for evaluating crystal growth for such crystal lattice images.

Problems with the liquid-phase TEM image automatic analysis method for crystal growth in aqueous solutions developed in this study include the inability to simultaneously detect multiple lattice fringes in different directions, and the detection of noise when the intensity of the bright spots indicating the periodicity of the lattice fringes is low or when the lattice fringes are not visible, resulting in the inclusion of crystal regions that do not actually exist in the evaluation of crystal growth.   However, by setting a threshold for the intensity of the bright spots to be detected, detecting multiple bright spots above a certain intensity, and not detecting bright spots below a certain intensity, further accuracy can be expected for the evaluation of crystal growth in crystal lattice images with a certain degree of periodicity intensity and length.   For crystal lattice images where the detection results for crystal growth are unstable depending on the intensity and length of the periodicity, we believe that it will be possible to evaluate crystal growth on a wider time scale by diverting the detection results of crystal regions using the method developed in this study as annotation images for machine learning and combining them with segmentation by machine learning.