The dynamics of calcite step movement in the presence of chiral amino acids

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Amino acid with chirality has been used as a modifier for calcite crystal growth and nucleation to understand the effect of D- and L-body molecules on anisotropic growth and dissolution rate of steps of calcite {101-4} faces. The change of the surface has been investigated by differential interference contrast microscopy and atomic force microscopy (AFM), both of which have a capability of resolving molecular steps on the crystal. Dramatic changes of growth hillocks and etch pits have been observed if the calcite solution contains 0.0001- 0.01 mol/l of amino acids. Smaller amount of amino acids concentration was enough for the change of morphology of steps.

We have employed interferometer newly developed phase-shift interferometer to measure the step velocity of growth steps of calcite. The concentrations of calcite and amino acid were varied from 0 to 0.8 and from 0 to 0.01 mol/l, respectively. In order to obtain the interface energy between solution and the crystal, which is the key parameter to determine the rate of various phenomena, such as nucleation rate or dissolution rate, nucleation experiments in microgravity has successfully been performed.

Normal growth rate and the slope of spiral hillocks in pure calcite solution (supersaturation is 0 to 0.8) have been measured by phase-shift interferometer. The normal growth rate has nearly a linear dependence on superatuaration, in which spiral growth hillocks have normally be observed. If surface diffusion model is assumed, 17.9 nm of surface diffusion length could be calculated from BCF surface diffusion model. When 0.01M L-aspartic acid is added to the solution, the dependency of step velocity on supersaturation had non-linear with the maximum velocity at supersaturation=0.2.

Surprisingly enough, the step velocity was calculated to be 680% larger than that of pure solution. It can be interpreted due to the reduction of interfacial energy which was indeed obtained from the nucleation experiment in microgravity. We therefore concluded from these observations that aspartic acid is a promoter rather than an inhibiter.

To visualize the real-time movement of each molecules of aspartic acid on the calcite surface, observation of fluorescent labeled molecules, instead of asparatic acids, by employing a highly sensitive fluorescence microscope has successfully been performed for the first time. This observation would give us precious information about the surface diffusion of molecules on the surface, which has indirectly been calculated from the growth rate measurement.