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The Growth kinetics of self-organizing lattice pattern by the three-point DNA motif

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DNA strands can be artificially designed to form the functional building blocks called DNA motif based on the principle of complementary base sequence. Various types of motif have been developed and raised the DNA nanotechnology that make possible to fabricate periodic and aperiodic patterns using the method of molecular programming. This study aimed to clarify the crystal-growth mechanism that enables to fabricate the more perfect and larger area DNA patterns. It is reported that a well-designed motif, called the three point star forms a large-area lattice pattern, because of their unique structure of absorbing lattice strain. According to the theory of crystal growth, the approach to obtain the perfect and large area pattern is to clarify the kinetic factor of growing DNA lattices and to control the factor precisely. However, there are few papers reporting the growth mechanism that relates the kinetic factor with the perfection of DNA lattices. In this study, the effects of motif kinetics on the lattice pattern were evaluated as a function of the temperature gradient of sample annealing. The strain of the formed lattice was analyzed using AFM images of the lattices.

The three point star motif was formed using the three kinds of DNA single strands. Each DNA strand was prepared in TAE Mg buffer (40mM Tris, 20mM acetate, 2mM EDTA, 12.5mM magnesium acetate) and mixed each other under predetermined concentrations of DNA strands. The yield of the aimed motif was maximized by adjusting molar ratios of each strands using gel-electrophoresis method. To determine the annealing profiles, we measured the ultraviolet absorbance of the DNA samples with decreasing (annealing) and increasing (melting) temperature between 95-20 degree (0.3 degree/min). Using the results, melting temperature and undercooling temperature of DNA lattices were determined, and then the annealing profiles were determined compared with the reference profile that showed the undercooling of lattice formation. The characterization of structural perfection was determined using AFM images. A drop of DNA sample solution was put onto the mica surface, and AFM images were taken by the tapping mode in the buffer solution. The strain of the lattices as a measure of the degree of the lattice perfection was analyzed by measuring the vertex angles of the hexagonal lattices divided by triangles.

It was found that lattice melting point was 44 degree, and undercooling was 1 degree below the melting temperature at cooling rate, 0.3 degree/min. This result indicates that some kind of kinetics possibly affect the lattice formation. To confirm the effect, we examined the correlation between lattice strain and cooling rate. The results showed the lattice strain decreased with decreasing cooling rate, indicating the strong correlation between the kinetics and the lattice perfection. The results were discussed from the base-pair mismatch between the motifs.