【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering Ⅱ)

Title of Project : Comprehensive Science for Multi Functional Nanostructures Produced by Single, Double, Triple, and Multi-Atomic Particles

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Research Area : Engineering

Keyword : Single Particle Nanofabrication, Polymers, Protein, Ion Beam, Nanowire

【Purpose and Background of the Research】

Material fabrication in nm-scale has been successfully developed in industries, especially as electronic semiconductor devises. The major fabrication techniques have been based on the "lithography", making the fine patterns of polymeric materials via chemical reactions induced by "ultra-fine beams" of photons or charged particles. To date, the spacially focused energy ("beam") seems to be indispensable in this conventional "top-down" nanotechnology. The ultra-fine "beam" of charged particles, however, is intrinsically the "flow" of the large number of charged particles. It is obvious that the most sharp and the finest "beam" is one individual accelerated particle itself. The nano-fabrication of materials using isolated single particles has been successfully developed with the combination of polymer materials and high energy charged particles in recent years. Multi-functional nanostructures with any kinds of polymer materials are developed in the present study, using single-, double-, and triple-(multi-) atomic accelerated particles which are the first, second, and the third finest "beams" in the world, respectively.

【Research Methods】

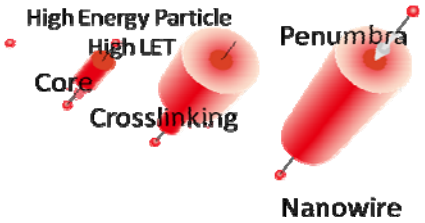

Fig. 1 Schematic view of single particle nanofabrication.

The core technology of the present study; single particle nanofabrication technique (SPNT) is schematically shown in figure 1. The total process of the technique is simple and completed within the next three steps; 1) fabrication of polymer thin films on the substrate, 2) penetration of high energy charged particles and promotion of cross-linking reactions along the trajectories, 3) removal of uncross-linked polymer materials from the surfaces. Only the parameter controlling the feasibility of SPNT is the efficiency of cross-linking reactions, thus the technique is possibly applied for a variety of polymer materials.

【Expected Research Achievements and Scientific Significance】

In the present research project, we expand rapidly the target of polymer materials as the respective functional nano-blocks in the following area:

1) Protein macromolecules and sugars as bio-compatible and biologically active blocks
2) Synthetic and conducting polymers as structural and electronic functional blocks
3) Polymer materials as the precursors for organic-inorganic conversion, leading to ceramic nanostructures
4) Cross-linked polymer nanostructures with metallic nanoparticles as highly active surface catalysts.

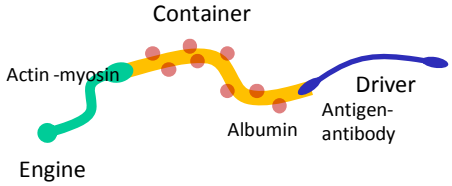

Figure 2. An image of multi-functional multi-block 1D nano-structure prepared by SPNT

Within the present research project, we suggest the present SPNT technique as a powerful, technically oriented, and cost-conscious candidate for nano-processing of *any* polymeric materials, promote the application in the field of not only the above materials but also of materials used for drug-delivery and electronics.

【Publications Relevant to the Project】

S. Seki , et al., *Polymer J.*, **39** (2007) 277; S. Seki , et al., *Macromolecules*, **39** (2006) 7446; *ibid*, **38** (2005) 10164; S. Tsukuda, et al., *Appl. Phys. Lett.*, **87** (2005) 233119; S. Seki, et al., *Phys. Rev. B*, **70** (2004) 144203

【Term of Project】 FY2010-2014

【Budget Allocation】 154, 900 Thousand Yen

【Homepage Address and Other Contact Information】

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