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

Title of Project : Structure-controlled synthesis of single-walled carbon nanotubes and application in energy devices

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Research Area : Engineering
Keyword : carbon nanotube, energy applications

【Research Purpose and Background】

A single-walled carbon nanotube (SWNT) is a one-dimensional structure derived exclusively from covalently bonded carbon. Due to its many novel physical properties, the SWNT has long been at the center of nanotechnology. While the importance of this material has driven fundamental research many fields, the path to practical realization of potential applications remains a major challenge. The primary reason for this is due to a lack of synthesis techniques founded on applied research. The combination of synthesis techniques capable of producing made-to-order SWNTs with research based on a concrete vision for realization is also needed.

This research project will focus on the application of SWNTs to energy devices. By refining our synthesis method of high-purity SWNTs, and further expanding our characterization capabilities, we will develop SWNTs as a functional material. SWNT-based devices will be developed by employing the basic engineering practices of optimization based on control of the underlying structure.

【Research Methods】

We will improve our alcohol catalytic CVD method [1,2] to establish synthesis methods by which the SWNT morphology and diameter distribution can be controlled. Nanoscale patterning [3] of SWNT growth with variable architecture will also be realized by engineering the substrate to control the catalyst location (Fig. 1). Density gradient ultracentrifugation will also be studied as a post-synthesis separation technique, with the goal of clarifying the separation mechanism and improving its overall efficacy. Based on these methods, we will pursue photovoltaic (Fig. 2(A)) and fuel cell

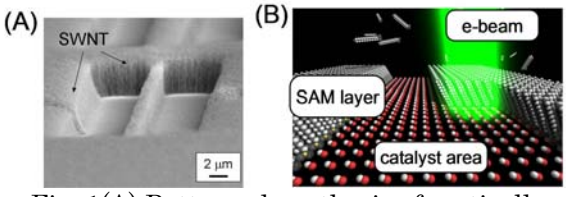

Fig. 1(A) Patterned synthesis of vertically aligned SWNTs, (B) selective SAM removal using an electron beam.

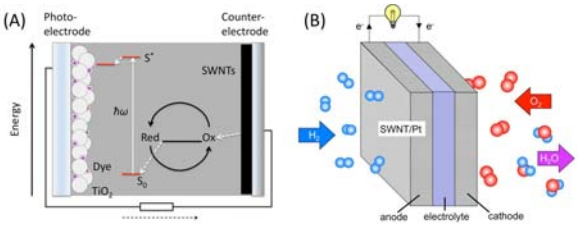

Fig. 2 SWNT arrays as the counter-electrode in (A) a dye-sensitized solar cell, and (B) a proton-exchange membrane fuel cell.

(Fig. 2(B)) applications.

【Expected Research Achievement and Scientific Significance】

By employing structure-controlled SWNTs in applications such as photovoltaics and fuel cells, the aim of this project is to alleviate the impending energy problem. By combining our three specialties SWNT synthesis, spectroscopic characterization, and numerical analysis, we are not merely testing new nanomaterials in devices, but seamlessly combining evaluation, planning, and optimization with understanding of nanoscale phenomena. The energy applications addressed here are expected not only to improve understanding of fundamental nanomaterials and physical chemistry, but also to expand into various related disciplines.

【Publications Relevant to the Project】

[1] S. Maruyama, R. Kojima, Y. Miyauchi, S. Chiashi, M. Kohno, *Chem. Phys. Lett.*, **360**, 229-234 (2002).
[2] Y. Murakami, S. Chiashi, Y. Miyauchi, M. H. Hu, M. Ogura, T. Okubo, S. Maruyama S, *Chem. Phys. Lett.*, **385**, 298-303, (2004).
[3] R. Xiang, T. Wu, E. Einarsson, Y. Suzuki, Y. Murakami, J. Shiomi, S. Maruyama, *J. Am. Chem. Soc.*, **131**, 10344-10345 (2009).

【Term of Project】 FY2010- 2014

【Budget Allocation】 167,300 Thousand Yen

【 Homepage Address and Other Contact Information】
http://www.photon.t.u-tokyo.ac.jp/~maruyama/Kakenhi/KibanS.html