【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Creating Soft-Batteries by Simple and Rapid Processes and Innovating Capacity by Reversible Structure Change

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Research Project Number : 16H06368 Researcher Number : 50312997
Research Area : Engineering
Keyword : materials processes, secondary batteries, carbon nanotubes, three-dimensional interfaces

【Purpose and Background of the Research】

Electric energy storage has increasing demands for portable devices, vehicles, emergency power sources and renewable power. Batteries are currently made by coating active materials on metallic foils with conductive fillers and binders. These non-capacitive components account for significant mass fractions of current batteries. Mass and cost of batteries will be minimized if electrodes are built on stable separators with minimal use of such components.

We premise volume change of high-capacity materials and create porous/sponge electrodes with conserved/reversibly changing volumes using light-weight, flexible and conductive carbon nanotubes (CNTs). A chemical engineer leads the project with electrochemists to realize batteries with innovative capacity via simple, rapid, and high-yield production processes.

【Research Methods】

High capacity materials degrade due to volume change during charge-discharge. Huge energy and power densities have been reported for various nanostructures, however for impractically thin layers neglecting heavy and thick metal foils. Thick electrodes need to be produced by simple processes from inexpensive sources quickly at high yields.

We have realized several μm thick, gradient, porous Si-Cu films with excellent anode performance in 1 min by rapid vapor deposition (RVD) (Fig. 1). We will create three-dimensional current collectors of metal foils with directly connected CNTs and realize porous electrodes with conserved volume.

We have realized semi-continuous production of >100 μm-long, >99 wt%-pure few-wall CNTs in 0.3 s residence time at 70% yield by fluidized bed. Such CNTs form light-weight, flexible, sponge-like films via dispersion-filtration without any binders (Fig. 2). We will capture capacitive materials within them and create light-weight, practically thick sponge electrodes with reversibly changing volume. Finally, soft batteries with innovative capacity will be developed by combining these porous/sponge electrodes with separators/electrolytes.

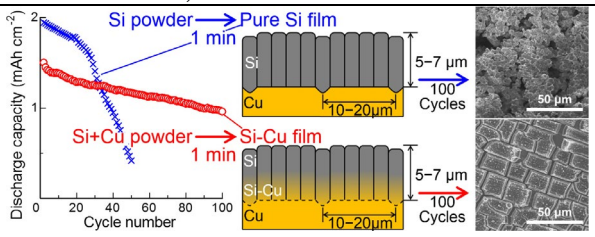

Fig. 1. Porous and gradient Si-Cu anodes by RVD.

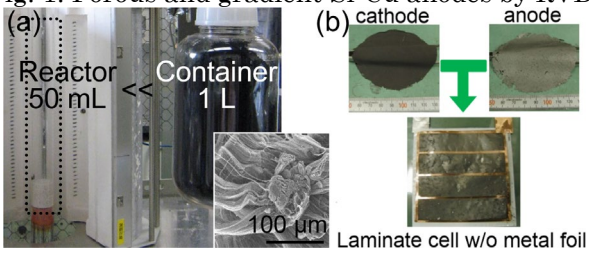

Fig. 2. Production of long CNTs for batteries.

【Expected Research Achievements and Scientific Significance】

Novel design with practical production process will realize soft batteries with innovative capacity at low cost. Porous/sponge electrodes will be applied to and improve current batteries.

【Publications Relevant to the Project】

・D.Y. Kim, H. Sugime, K. Hasegawa, T. Osawa, and S. Noda*, "Sub-millimeter-long carbon nanotubes repeatedly grown on and separated from ceramic beads in a single fluidized bed reactor," Carbon **49**(6), 1972–1979 (2011).
・K. Hasegawa and S. Noda*, "Lithium ion batteries made of electrodes with 99 wt% active materials and 1 wt% carbon nanotubes without binder or metal foils," J. Power Sources **321**, 155–162 (2016).

【Term of Project】 FY2016-2020

【Budget Allocation】 142,900 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.f.waseda.jp/noda/