FAST MOVING FRONTS - 2009

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Masaki Yoshio talks with *ScienceWatch.com* and answers a few questions about this month's Fast Moving Front in the field of Materials Science.

Article: Mixed silicon-graphite composites as anode material for lithium ion batteries influence of preparation conditions on the properties of the material
Authors: Dimov, N;Kugino, S;Yoshio, A
Journal: J POWER SOURCES, 136 (1): 108-114 SEP 10 2004
Addresses: Saga Univ, Dept Appl Chem, 1 Honjo, Saga 8408502, Japan.
Saga Univ, Dept Appl Chem, Saga 8408502, Japan.

SW: Why do you think your paper is highly cited?

The relationship between overall anode capacity and both: (1) silicon content in the Si-based composite anode and (2) mole fraction of lithium (x) in the LixSi alloy, was derived for the first time in a clear and straightforward manner in this paper. This derivation took into account the unique electrochemistry of silicon and served as a guidance rule for many works that followed in this area. This helps explain the paper's high citation index.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

There is one severe problem with the application of Si (or metal alloy) anodes, i.e., the big volume change during lithium intercalation/deintercalation, which causes capacity fading with charge/discharge cycles. Our discovery was that carbon materials work as a buffer matrix against the volume change of Si.

The paper introduces, in a quantitative manner, a new methodology to study composite Si anodes, namely a constant capacity cycling test. Such a methodology, systematically implemented in subsequent publications, has helped us to better understand the behavior of these anodes, and to find and develop better binder formulations and electrode preparation techniques.

"At the very beginning our methodology was misunderstood and sometimes criticized by other researchers."

SW: Would you summarize the significance of your paper in layman's terms?

At the very beginning, our methodology was misunderstood and sometimes criticized by other researchers. The basis of our quantitative approach was clearly described and explained in this paper. From this viewpoint, our paper paved the way for a rethinking of the research paradigm in this field and led to the discovery of new binding formulations which allow cycling of anodes undergoing large volumetric variation over the course of charge/discharge cycles.

SW: How did you become involved in this research and were any particular problems encountered along the way?

A decade after the commercialization of lithium ion batteries it seemed that the only way to improve their performance was to implement high-capacity anode materials. This is why we focused our efforts on this research area.

It might be somewhat surprising, but the main problem we faced along the way was related to the stereotypical research methodology widely accepted among researchers working in the field of the lithium ion batteries. Virtually everyone involved in such studies has followed the same research strategy for over two decades—to study the crystal lattice of the host material and modify it with respect to some properties of interest, for example: rate performance, capacity, cycle life, etc.

Silicon-related materials are exceptional because the silicon parent crystal lattice breaks down and forms an amorphous LixSi alloy over the first cycle and the methodology mentioned above simply cannot be followed. Despite this, many of the research groups were still trying to attack the problem from the viewpoint of the crystal lattice, its conservation, and modification. Therefore, the lack of a single clear strategy to follow was actually the main problem, which had to be overtaken by a new research strategy.

SW: Where do you see your research leading in the future?

The ultimate goal of any applied research is its practical implementation and, therefore, the best result would be to develop silicon anodes which meet present-day industrial standards.

SW: Do you foresee any social or political implications for your research?

Speaking generally, battery technology might become one of the key technologies in the near future. Successful implementation of high-performance batteries, particularly in hybrid electric vehicles, electric vehicles, and load-leveling systems, may help sustain the development of an environmentally friendly and sustainable society.

Masaki Yoshio, Professor Emeritus
Advanced Research Center
Saga University
Saga, Japan

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