Nanomaterial activities at CEA LITEN for low carbon energy technologies development

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Abstract
CEA LITEN, the Laboratory of Innovations for New Energies Technologies and Nanomaterials, located in Grenoble, is part of CEA, a French Governmental Research Organization devoted to both fundamental and industrial R&D in the field of energy, information and health technologies and defence. The activities of LITEN are structured around the production, storage and uses of energy with specific emphasis given to renewable energy sources such as solar energy or biomass, energy efficiency and advanced materials for energy application.

In this context the development of nanomaterials aims at increasing material efficiency, durability and safety, at reducing costs and environmental impact by reducing or even substituting toxic or rare metals. The approach of LITEN covers the entire development chain from the raw materials specification and synthesis, their processing, to their integration and test in full scale prototype. For that purpose several technological R&D platforms have been developed that allow either advanced characterisation of nanostructures or full scale production and prototyping.

Several examples of such integrated approach are given in the field of nanomaterial developments for high energy batteries, for fuel cell catalysts without noble metals, for high durability solid oxide cells, for low cost carbon conductors, and for and for increased safety of hydrides tank,

Layered $Li(Li,Mn,M)O_2$ are very promising positive electrode materials for high energy Li-ion batteries, however, upon cycling their complex structure undergo evolutions that affect the electrode performance. Atomic scale evolutions in the layered oxide have been studied by diffraction & HRSTEM experiments highlighting the formation of an additional layer between the electrode and the electrolyte upon cycling (Figure 1) [1].

Horizontal carbon nanotubes (CNT) interconnections with realistic size (50nm diameter and 20 µm lengh) and density (close to 10^{13} cm^{-2}) have been produced, integrated and tested electrically. The line resistivity is two orders of magnitude higher than copper which is among the best values ever published [2-4].

Currently available transparent electrodes for photovoltaic application suffer from major limitations like costly fabrication process and brittleness. An innovative technology based on random networks of metallic nanowires has been developed which involves a highly flexible and low-cost material with performances similar to the ITO reference. These electrodes have been used to fabricate flexible transparent capacitive touch sensors for demonstrating their potential [5,6].

Mono-like silicon production merges the two main silicon manufacturing growth processes for photovoltaic applications, the Czochralski monocrystalline and the directional multi-crystalline solidifications. This technology combines the low O_2 concentration and high productivity of the multi-crystalline wafers with the good crystalline and electrical quality of the mono-crystalline <100> oriented wafers. Successfully P- and N-type <100> oriented industrial 450 kg ingots were produced with more than 95% <100> controlled oriented areas paving the way for low cost and high efficiency silicon solar cells [7].

To understand degradation mechanisms occurring in Solid Oxide Cells, an original approach has been implemented that combines high technology characterization techniques (Synchrotron X-ray nano-holo-tomography and FIB-SEM) with a multi-scale model of electrode materials. Severe nickel agglomeration in Ni-YSZ cermet electrode has been shown to upon electrolysis operation (Figure 2). The associated decrease of electrochemical active sites has been quantified as well as its impact on the decrease of the cell performance [8-10].

References

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Figures

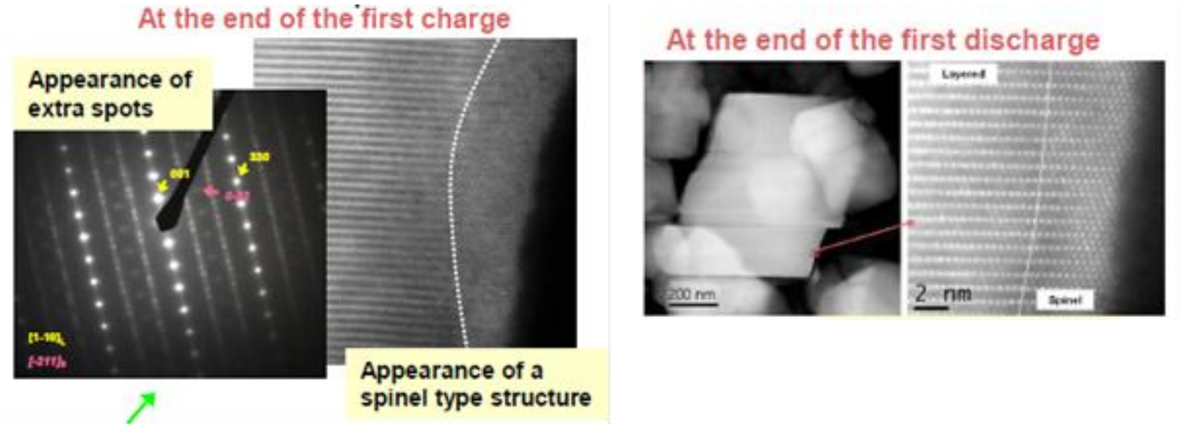

Figure 1: Atomic scale evolutions in the layered oxide have been studied by diffraction & HRSTEM experiments highlighting the formation of an additional layer between the electrode and the electrolyte upon cycling [1].

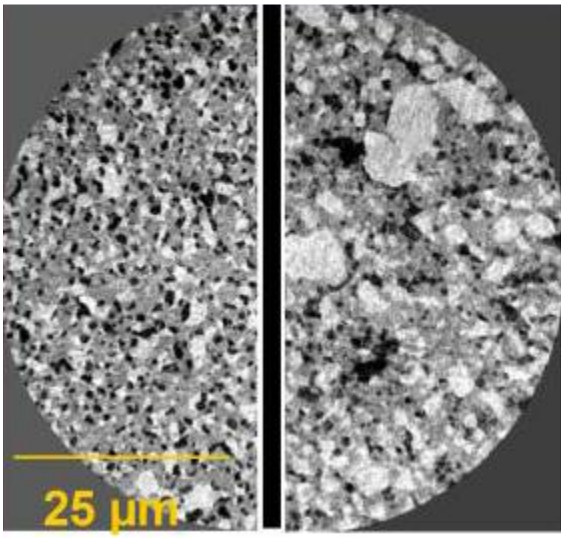

Figure 2: comparison of the microstructure of the H_2 electrode before (left) after (right) operation revealed by XRay nano-holo-tomography and showing strong Ni coarsening and TPB length decrease