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Light for Science

IT Hardware

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overview

Faster, smaller, lighter are key drivers for the development of new IT hardware components. Increased processing power in smaller devices requires a more detailed knowledge of chemical processes than ever before, development and testing of novel materials and the ability to detect the presence of contaminants at ever smaller levels.

The power supply for portable systems must meet similar demands – lighter, longer-lasting and smaller. Predicting the performance of potential rechargeable electrode materials such as $LiCoO_2$ requires detailed knowledge of the structural changes that occur during the recharging process.

The ability of synchrotron radiation to penetrate through layers of material, characterise materials on an atomic scale and use time resolved studies to study, for example, in situ phase transformations will provide a valuable tool, supporting further research and development in the IT industry.

Key Challenges

- **More components on smaller unit area**
  Moore's Law continues to hold as microelectronics becomes nanoelectronics, but the technical and engineering challenges of integrated circuits on this scale are considerable.
- **Improving performance of batteries**
  Continuing demand for mobile phones and laptops require longer lasting lightweight batteries that can still be relied upon for high performance over an extended time period.
- **Thin layer measurement**
  The synchrotron also enables the measurement of very thin surface layers and extremely low trace elements - important for the latest generation of silicon micro-devices.

The Synchrotron Solution

Total X-ray Reflection Fluorescence (TXRF) is the conventional technique for contamination detection. However laboratory-based X-ray tubes are at the limit of their detection range. The high intensity synchrotron X-rays enable detection at much higher resolution, and also support time-resolved studies.

Techniques

Total X-ray Reflection Fluorescence, Diffraction

Beamlines: I06 Nanoscience, I07 Surface and Interface Diffraction, and I16 Materials and Magnetism

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case studies

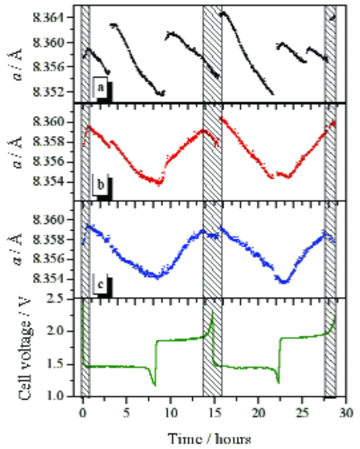
Faster, Smaller, Lighter

As the micro-electronics industry produces faster, smaller components, another dimensional problem arises: power supply. Consumer demand for smaller laptop and handheld personal computers and increasing CPU capabilities in mobile phones and other portable devices requires batteries that are also smaller, lighter and longer-lasting.

To improve the performance of batteries it is necessary to study the electrochemical reactions as the battery discharges. Scientists at the European Synchrotron Radiation Facility (ESRF) in Grenoble studied working Li-ion batteries in situ, using high intensity X-rays to follow the structural changes in the layered material through the discharge process.

$LiCoO_2$ is a leading candidate as an electrode material because of desirable properties such as good power rates, low self-discharge and very good cycle life. However, $LiCo0_2$ batteries still appear to fade following charge-discharge cycling.

Following this cycle in real time showed that the material undergoes structural variations qualitatively similar to other common electrode materials, although on a much smaller scale. This new knowledge provides manufacturers with a deep insight into technologies for providing lighter, longer lifetime batteries for the future.



The figure shows that $Li_{(4/3)}Ti_{(5/3)}O_{(4)}$, commonly considered as an almost ideal material, undergoes structural variations qualitatively similar to other common electrode materials, although on a much smaller scale

ESRF ww.w esrf.fr

Trace Impurities on Silicon Wafers

In 1965 Intel co-founder Gordon Moore stated that at the current rate of technological development the number of components per unit area of an integrated circuit doubles approximately every 18 months. Forty years on "Moore's Law" remains a driver for the micro-electronics industry.

Today a key constraint is the purity of the surface of the silicon wafer. One criterion for determining performance level is the number of contaminant atoms on the surface. However, innovative manufacturing processes have enabled component companies to reduce contamination levels to below the detection limits of existing the X-ray tubes used in laboratory measurements.

Illuminating a surface with X-rays causes atoms to fluoresce, producing a pattern characteristic of the elements involved. The intensity of the pattern indicates the concentration of the elements that are present. Using high brilliance X-rays generated by a synchrotron enables the detection of contaminants on silicon wafers of around to 10^7 atoms/cm^2, a considerable improvement over X-ray tubes.

This enables scientists to extend the capabilities of silicon wafers further, and to allow industry to push the boundaries further in refining their processing techniques.

Source: SSRL

Website: http://www.ssrl.slac.stanford.edu