Industrial Uses of National User Facilities - GE's experience and perspective

Yan Gao
GE Global Research
Niskayuna, New York

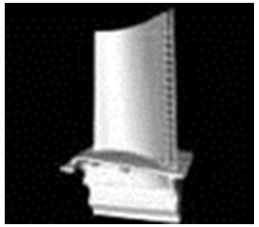
GE Global Research

- Located in Niskayuna, NY
- GE's centralized R&D facility in the US
  - Niskayuna, 1,800 technologists, multidisciplinary
  - Bangalore, Shanghai, Munich, Rio de Janeiro
- GE/GEGR's business and technology areas
  - Building, Powering, Moving, Curing
  - Materials: ceramics, composites, metal and alloys
  - Characterization to accelerate materials development

Ceramics

Composite

Metals



Areas of synchrotron applications by GEGR

- Catalysis (EXAFS)
- Polymer crystallization (in-situ SAXS/WAXS)
- Phosphors (XRD, XAFS)
- Nanomaterials (PDF)
- Hydrogen storage materials (in-situ XRD, high-resolution x-ray and neutron diffraction, EXAFS)
- Industrial sensors (in-situ XRD, SAXS, XAFS, TXM)
- Thermal barrier coatings (HE-XRD)
- Nickel-base superalloys (strain distribution by HE-XRD, high-resolution imaging, high-resolution XRD)
- Titanium alloys for aerospace application (HE-XRD)
- NaMX battery (HE-XRD, EXAFS, imaging)

GE's synchrotron activities at a glance

- **NSLS**
  - Energy-dispersive diffraction (X17B1)
  - High-energy diffraction (X17A)
  - In-situ diffraction during hydrogenation (X7B)
  - Powder diffraction (X14A, X16C)
  - XAFS (X18A, X18B, X19A)
  - SAXS (X27C)
  - Diffraction enhanced imaging (X15A)
- **APS**
  - High-energy diffraction – HEDM, strain (1-ID-C, E)
  - High-energy diffraction – PDF, in-situ (11-ID-B, C)
  - High-resolution diffraction (11BM)
  - SXAS and USAXS (ID-15, ID-5-D)
  - Single crystal diffraction (ID-15)
  - EXAFS (ID-5-B)
  - Microdiffraction (ID-34-E)

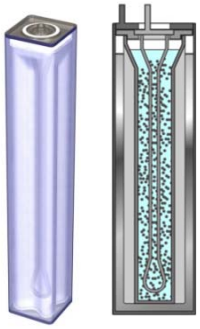
When it comes to industrial applications, not all the industries are the same

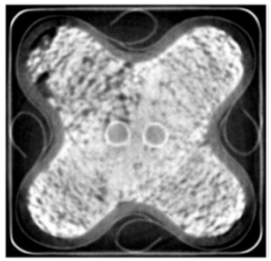
- **Pharmaceutical**: crystal structure (single crystal diffraction), polymorphism (high-resolution powder diffraction).
- **Semiconductor**: wafer quality (topography), surface characterization (reflectivity, texture, grazing incident XRD), interface and interconnect (micro-XRD).
- **Chemical**: catalysis (spectroscopy), reaction kinetics and pathway (in-situ spectroscopy and diffraction).
- **Industrial products**: metals and alloys, structural and engineering materials including ceramics and composite (high-energy x-rays and neutrons).

From materials to products

Product ← **System** ← **Component** ← **Material**

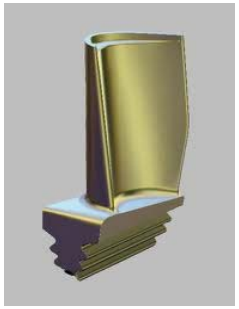
Durathon™ Battery





Cathode

GEnx Engine



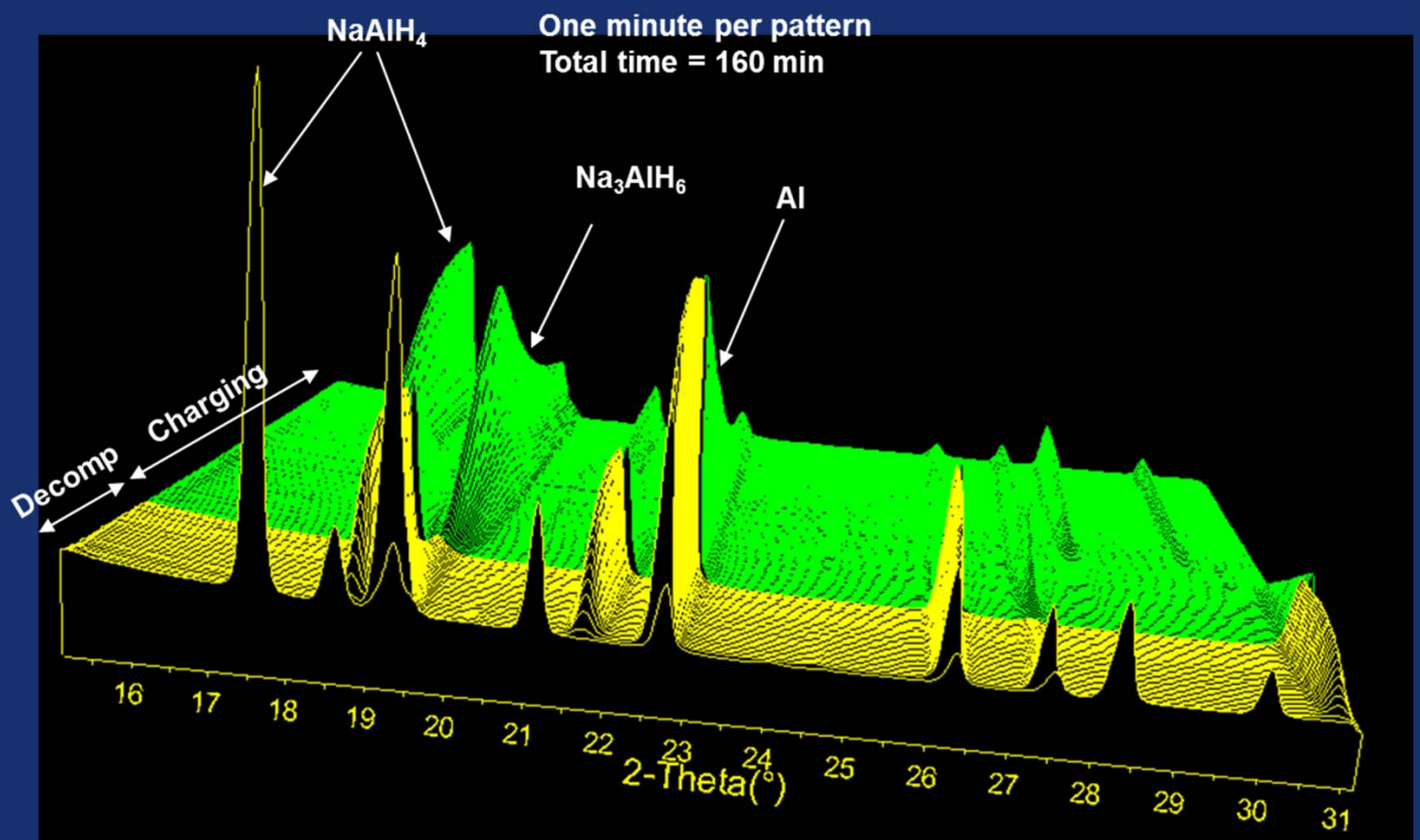
Turbine blade

Synchrotron plays important role in materials research

What makes industry come to synchrotron and what industrial users really want?

- National user facilities provide unique capabilities as extension of company's in-house characterization labs.
- Industrial users need results and solutions, not data.
- Depending upon types of industry, the impact of many industrial work at national user facilities may not be direct or immediate.
- Industrial users (usually) don't need most advanced beamlines (highest resolution, smallest beam, etc.); they need reliable and robust beamline with high productivity.
- Industrial users need support from dedicated and knowledgeable facility staff.

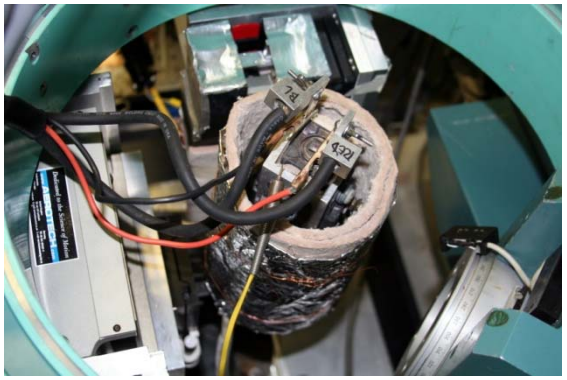
First in-situ de/hydrogenation of $NaAlH_4$ (X7B, NSLS, 2003)



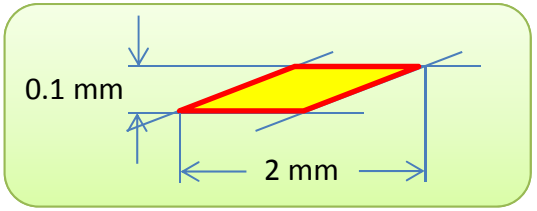
$$NaAlH_4 \leftrightarrows 1/3\ Na_3AlH_6 + 2/3\ Al + H_2 \leftrightarrows NaH + Al + 3/2\ H_2$$

Acknowledgement: J. Hanson (BNL)

In-situ energy-dispersive diffraction for battery



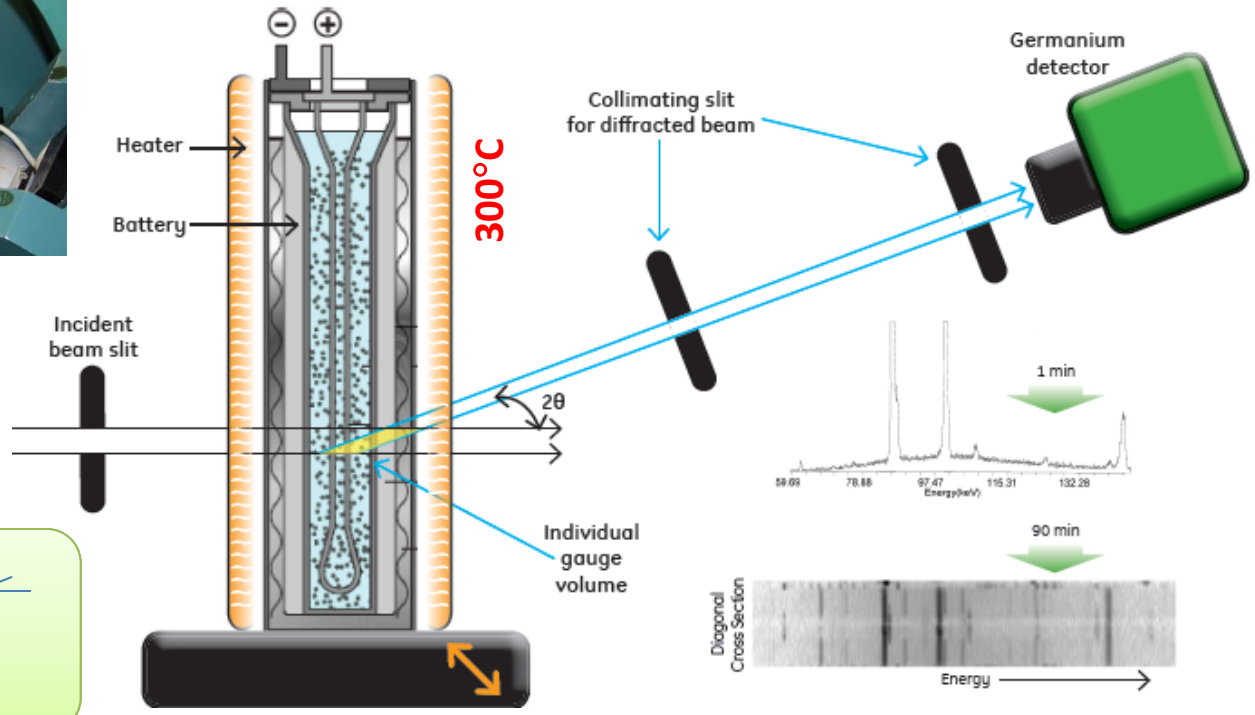
Setup at X17B1



Probe volume

To cycler

Charge/discharge time: a few hours



Sample stage

Data collection: 30-60 sec/pattern

Phase and strain mapping with spatial selectivity

Z. Zhong (BNL), Rutgers University, GE Global Research

imagination at work

When it comes to synchrotron sources, not all the facilities are the same

- **US synchrotron/neutron:** under DOE BES (Basic Energy Sciences), except for CHESS and NCNR.
- **ESRF, DLS, CLS:** more independent organization • with financial goals • European companies with different R&D models (e.g. Rolls-Royce) • different funding and training approaches for graduates and post-graduates (e.g. EPSRC in UK).
- **ISIS:** innovative policy towards proprietary use of neutrons – use first and pay later, with options to claim either proprietary or non-proprietary within 3 years.

GE's interests and NSLS-II

- **XPD1 and XPD2 (among Project Beamlines): high-energy diffraction using monochromatic beam (Summer 2015)**
- **Conventional capabilities from NxtGen beamlines in diffraction and spectroscopy (2017).**
- **What we <u>really</u> need but not on the map: HEX - high energy beamline (both monochromatic and white) for engineering applications, similar to I12(JEEP) in DLS, ID11 and ID15 at ESRF, and Sector 1 at APS.**
- **6BM at APS during the dark period – high-energy white beam capability.**

Industrial problems are more fun than you think!

- **Challenge your mind to overcome real-world constraints.**
- **Bring positive changes to your beamline: add more capabilities and improve measurement reliability.**
- **Bring more rigor to data analysis and interpretation, pushing the science forward .**
- **Provide training ground and opportunities for young scientists who may be interested in working for industry.**

imagination at work