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Advances in battery technologies: past, present and future

2025, July 21th - 26th

Classes & Seminar

Batteries are among the key technologies to achieve a deep decarbonization of our societies and limit climate change. In particular, the transportation sector—through electric mobility—and the power sector—through the storage of intermittent renewable energy sources—critically depend on batteries that have to be ultra-high-performance, reliable, safe, sustainable, and affordable. As such, accelerating the energy transition is therefore intrinsically linked to accelerate progress in battery research. Although the Li-ion technology has been the most spectacular breakthrough in electrochemical energy storage over the last century, further performance improvements are needed. This calls for rethinking the way we discover novel materials, engineer interfaces, design batteries with added-value functionalities, and develop cutting-edge monitoring strategies. This series of classes aims to present the fundamental aspects that could pave the way for this new way of thinking, while covering various recent and current advances, thus offering an almost complete picture of the field of battery research today. It will begin with a brief history of the Li-ion batteries, describing the science underlying the insertion processes and explaining how the nature of the positive (layered sulfides to layered oxides and polyanionic compounds) and negative electrodes (carbon → graphite → compositel C-Si) has evolved over the years. The proper design of electrolytes with the adding of proper additives together with the mastering of interfaces and interphases via coating techniques, or other methods, will follow, prior the pre-sentation of various technologies beyond Li-ion such as Na-ion, solid state battery, and Zn-MnO2 for instance. It will end with a description, using specific examples, of the science behind the emerging field of battery diagnosis which uses optical sensors for electrolyte screening (or detection of electrode degradation) or for live-monitoring the chemical dynamics of the "black box", that is the battery, under real-world conditions. For the sake of completeness, these classes will be interspersed with seminars organized by expert researchers in areas not fully covered by the main courses, such as redox flow batteries, mechanical properties of interfaces, organic covalent ionic conductors (COFs), data processing using machine learning (ML) tools, among others.

Monday, July 21st
CLASSES (09:30 - 12:00):
- The Li-ion battery technology: working principle and electrode materials
- How it works, where it comes from and where we are

Q&A SESSION
SEMINAR (14:00 - 15:00):
- Thermodynamics and kinetics in battery materials, by Biao LI (Peking University)

CLASS (15:15 - 16:30):
- From layered to polyanionic compounds and anionic redox materials

Tuesday, July 22nd
CLASSES (09:30 - 12:00):
- The Na-ion battery: how it differs from Li-ion and its road to commercialization
- Basics principles and various Na-ion chemistries

Q&A SESSION
SEMINAR (14:00 - 15:00):
- Advancing Redox Flow Batteries: Molecular Insights to Grid-Scale Solutions, by Yi Chun Lu (Chinese University of Hong Kong)

CLASS (15:15 - 16:30):
- Hard carbon vs. graphite and alloys

Wednesday, July 23rd
CLASSES (09:30 - 12:00):
- Electrolyte design for batteries
- What you need to know (basics and figure of merits) for designing new electrolytes

Q&A SESSION
SEMINAR (14:00 - 15:00):
- Mechanical properties of interfaces, by Biao Zhang (Poly U)

CLASS (15:15 - 16:30):
- Electrolyte additives and interfaces

Thursday, July 24th
CLASSES (09:30 - 12:00):
- Battery diagnostic: From electrochemical to optical methods
- FBGs, TFBGs and optical IR sensors for spying the dynamic chemistry of batteries

Q&A SESSION
SEMINAR (14:00 - 15:00):
- Machine learning for exploiting sensing data, by Jiaqiang Huanq (HKUST, GZ)

CLASS (15:15 - 16:30):
- From merging electrochemical and optical sensing to acoustic sensing

Friday, July 25th
CLASSES (09:30 - 12:00):
- Li(Na) Solid State Batteries: basic principles and challenges
- The long journey towards new inorganic ionic conductors

Q&A SESSION
SEMINAR (14:00 - 15:00):
- Covalent organic frameworks for the next-generation batteries: Design and applications, by Yoonseob Kim (HKUST, CWB)

CLASS (15:15 - 16:30):
- Problematic of interfaces and new trends in assembing process

Saturday, July 26th
CLASSES (09:30 - 12:00):
- Batteries technologies based on divalent elements cations
- Status of Mg(Ca)-ion chemistries, plus recent advances on aqueous Zn-MnO2 batteries

Q&A SESSION

Although all aspects of the program are covered, the duration of the various topics is flexible and can be adapted to suit the interest and questions of the audience.

COLLÈGE DE FRANCE
1530

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