

Om Litium-ion batterier og medførende fareaspekter for fritidsfartøy

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Fritidsbåtkonferansen 2021

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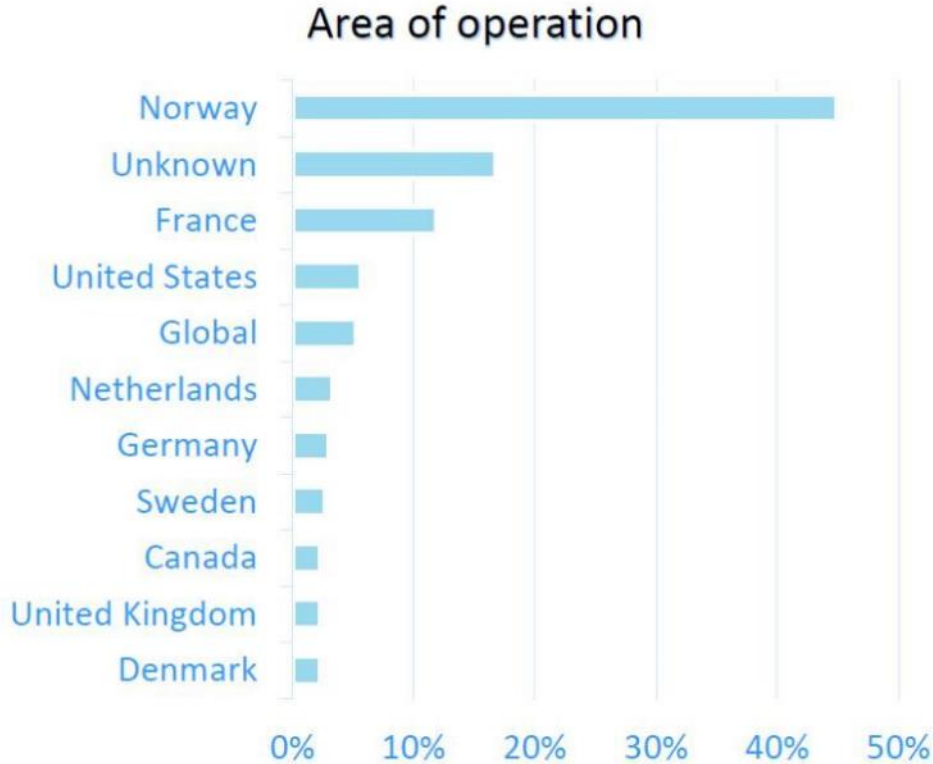
Why lithium-ion battery safety ?



SEVERITY

Location of maritime lithium-ion boats

Country of operation



Ref: Maritime battery forum ship database 2019 (not included leisure boats and naval vessels)

Heile bildekket bula ut etter at batterirommet på ei ferje i Sunnhordland eksploderte



https://www.nrk.no/hordaland/her-jobbar-brannmannskapa-etter-eksplosjonen-pa-ferja_-_vil-koste-20-millionar-a-reparere-1.14740587

MS «Brim» 2021

- Katamaran med hybrid fremdrift
- Røykutvikling i batterirommet 11. mars 2021 mens båten var til sjøs
- Slept til kai i Tønsberg
- Mulig eksplosjonsfare i det røykfylte batterirommet håndtert ved å sende nitrogen inn og pumpe gasser ut

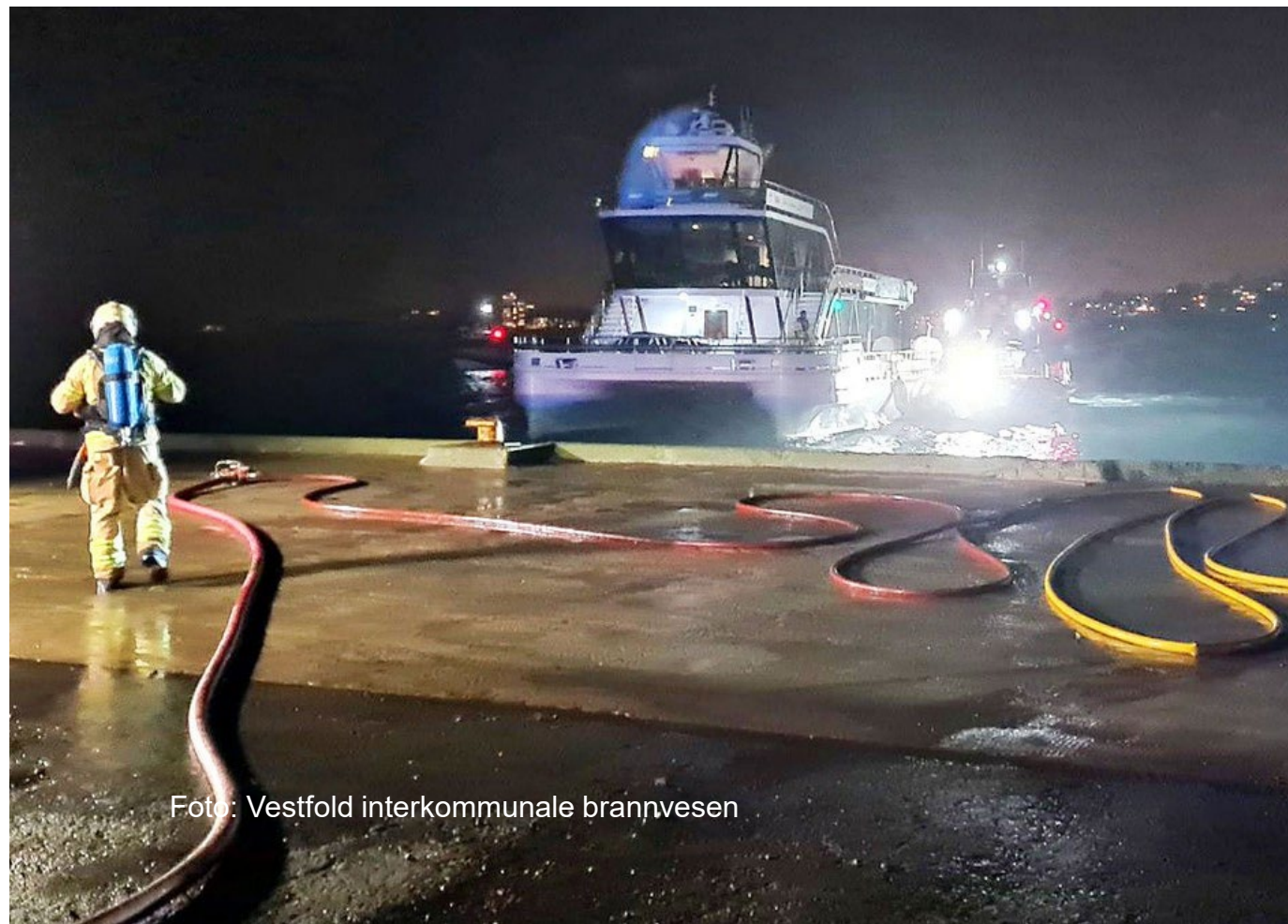


Foto: Vestfold interkommunale brannvesen

«Carila Sis», Sneek i Nederland 2019

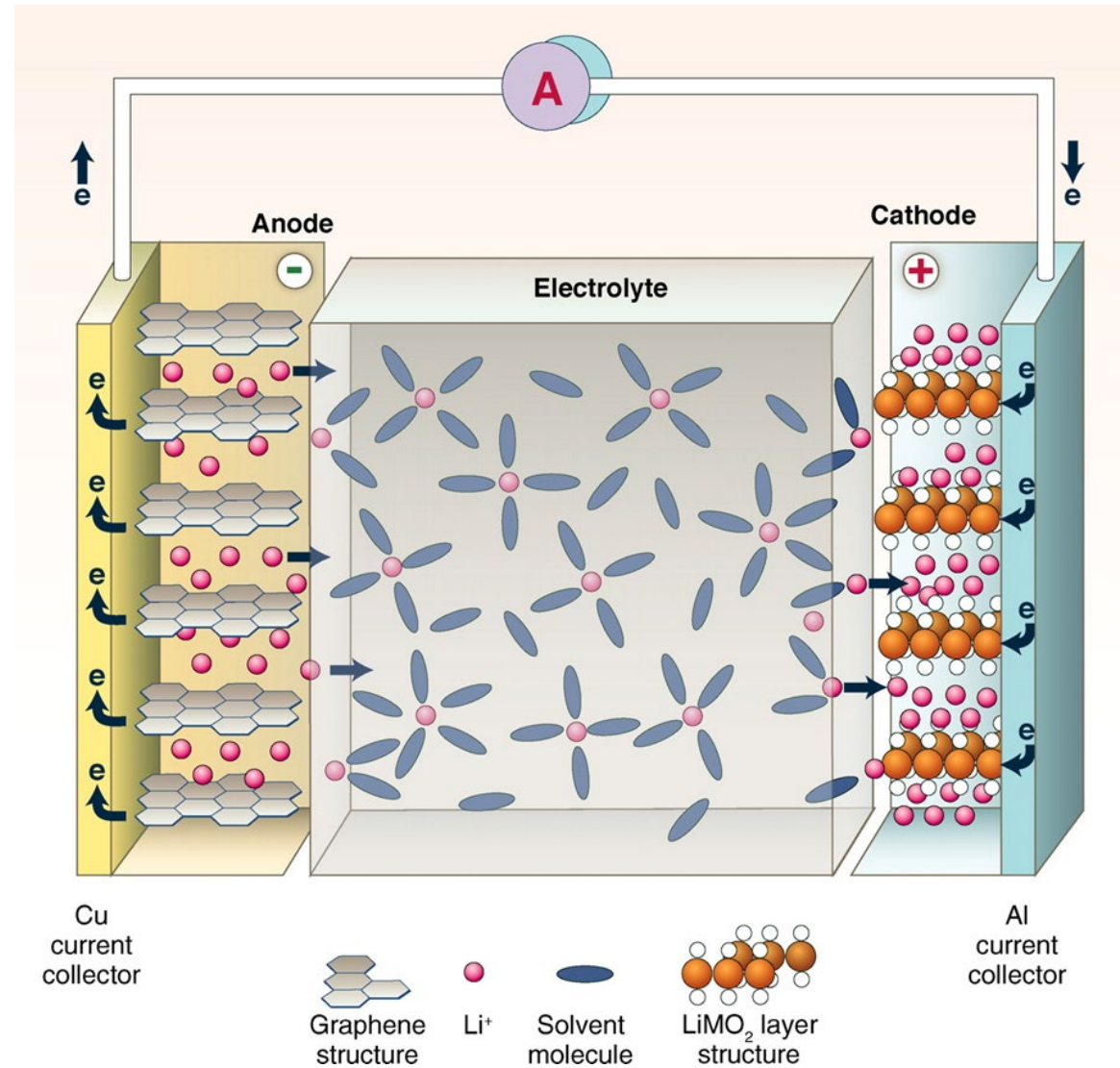
- 2 stk. 11,5 kWh Li-ionbatteri
- Brannmenn lagde åpning inn i kahytten og spylte med vann uten effekt
- Brannmenn åpnet dør til kahytt. Eksplosjon kort tid etter.
- To brannmenn ble kastet på sjøen av eksplosjonen - mindre personskader
- Brannvesenet har skrevet rapport og laget informasjonsfilm* om hendelsen

*<https://www.youtube.com/watch?v=ImOXKrl8Ezw>

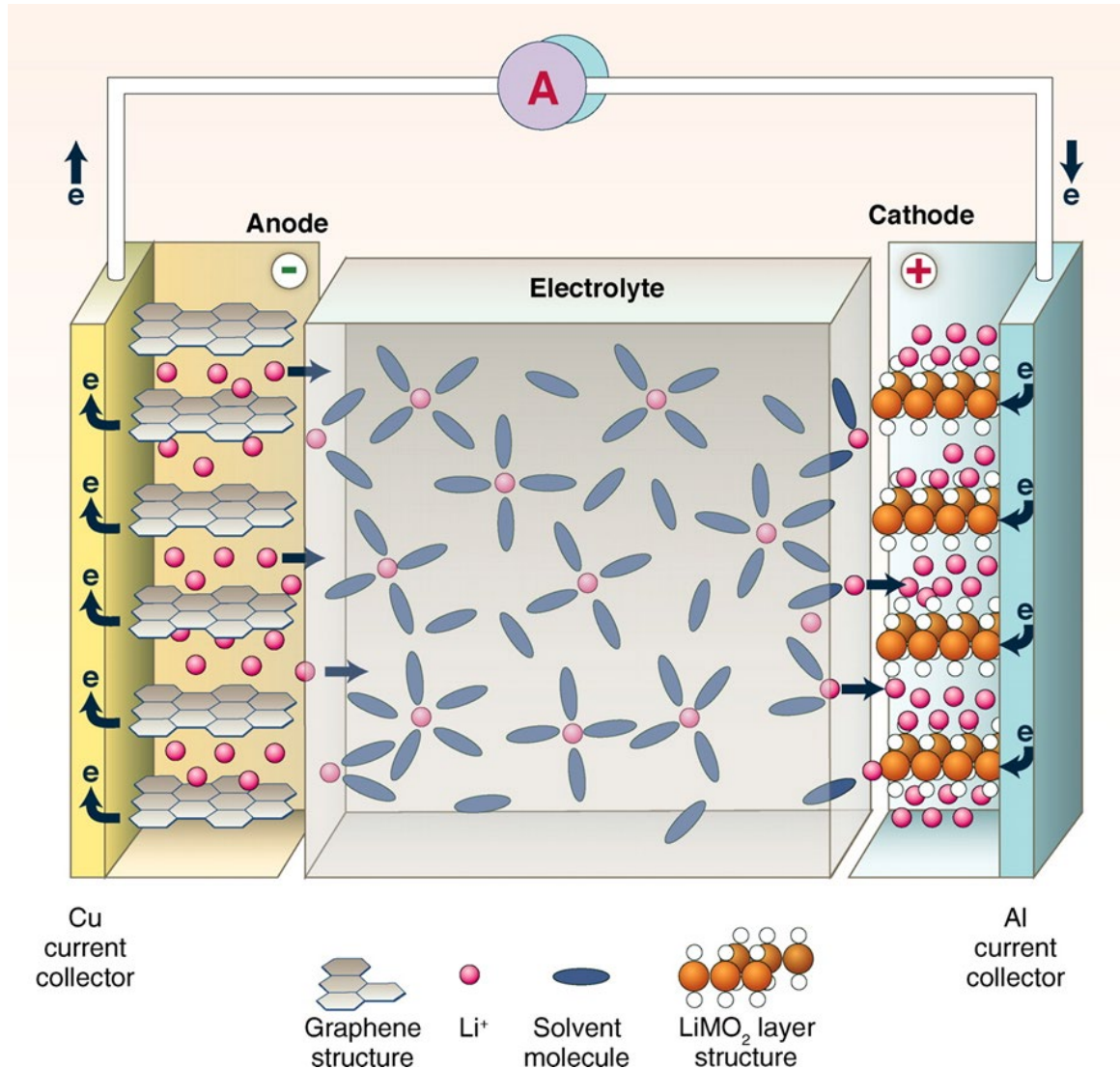


Foto: Brandweer TBO Nord Nederland

Lithium-ion cell (atom level)



Lithium-ion cell (atom level)

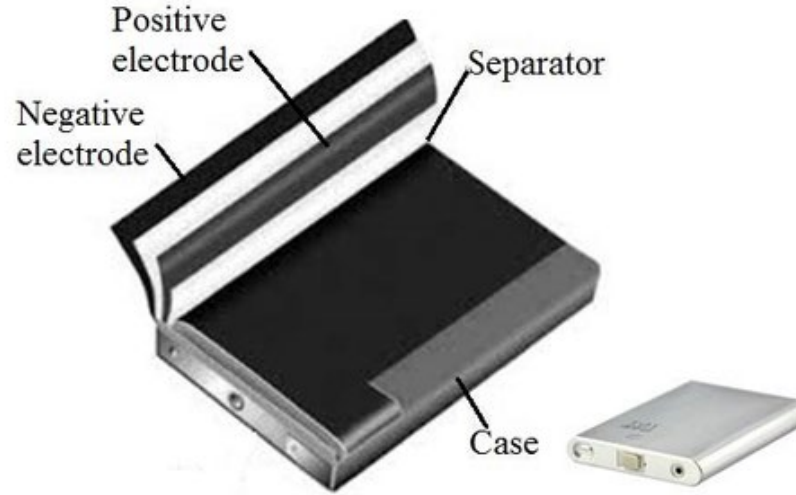


Lithium-ion cell

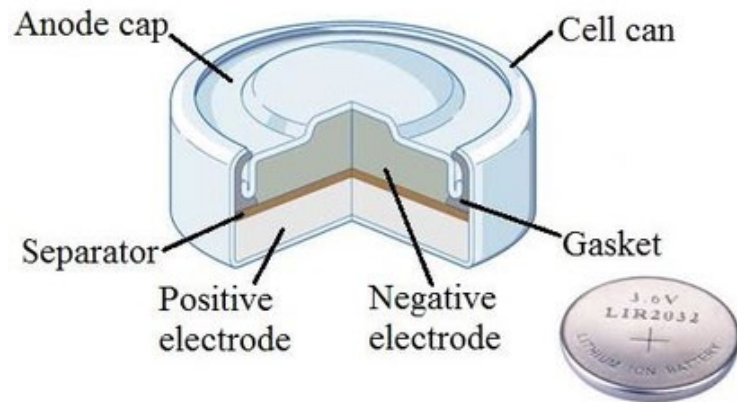
Cylindrical cell



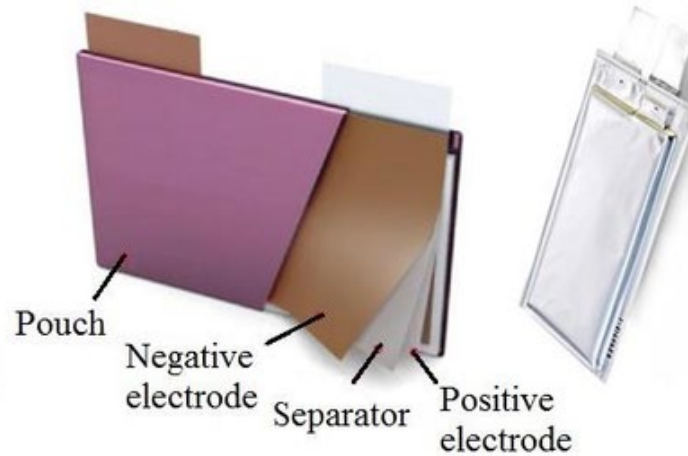
Prismatic cell



Button cell



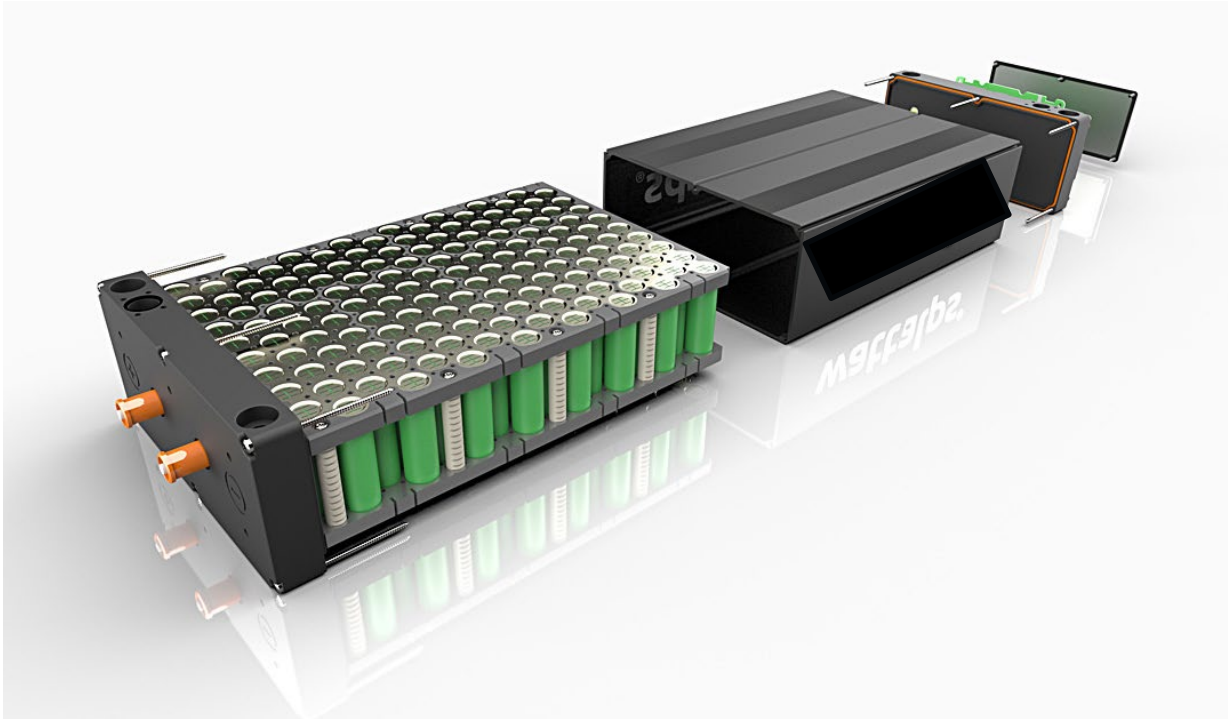
Pouch cell



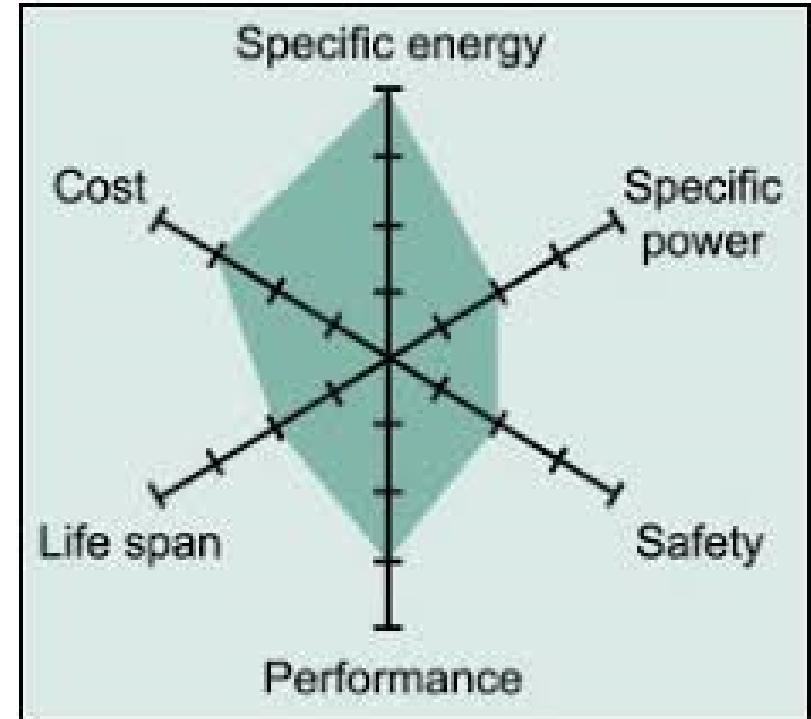
Cost over Quality ?

Cost is often a barrier to high quality products

Lithium-ion battery



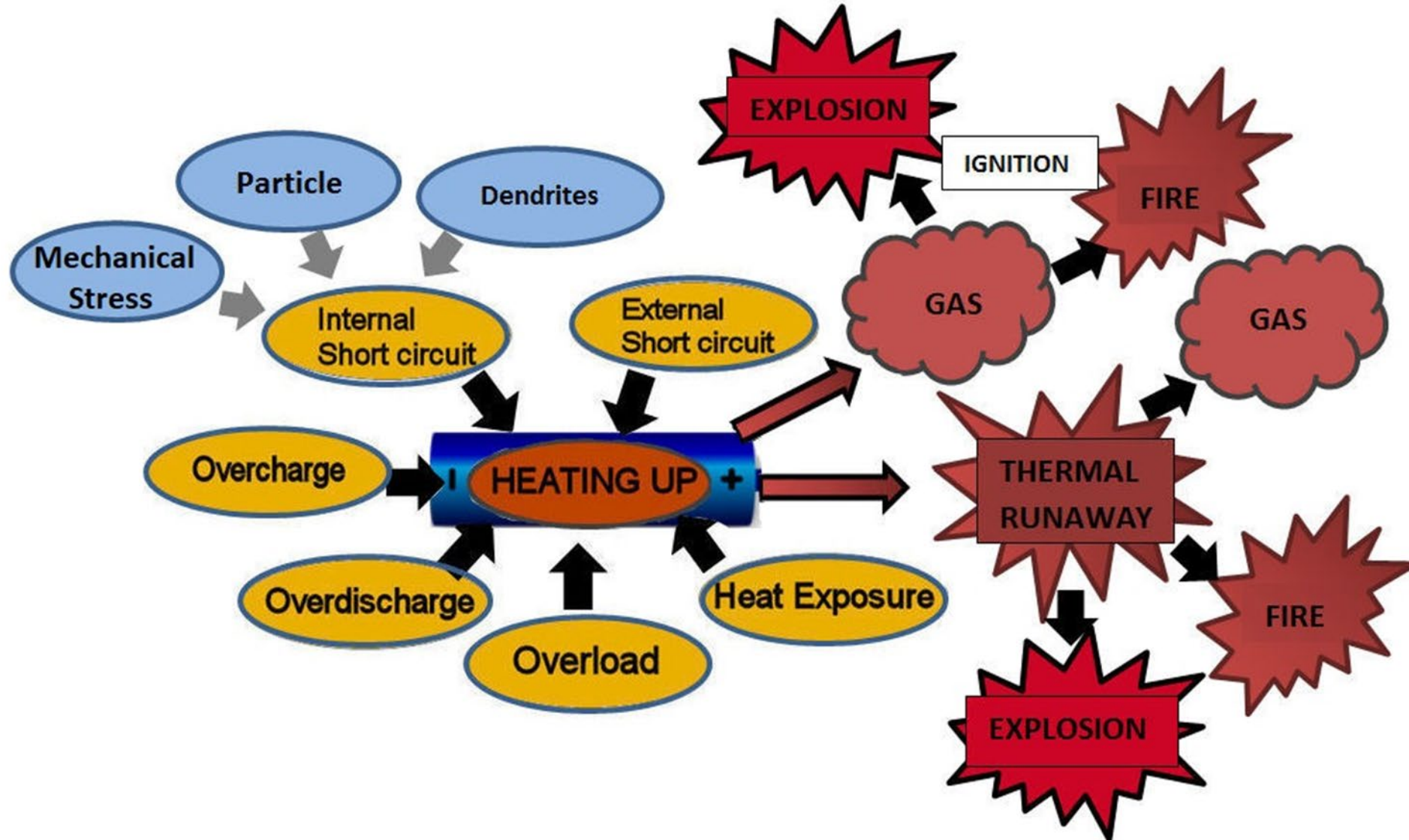
Pictures for illustration



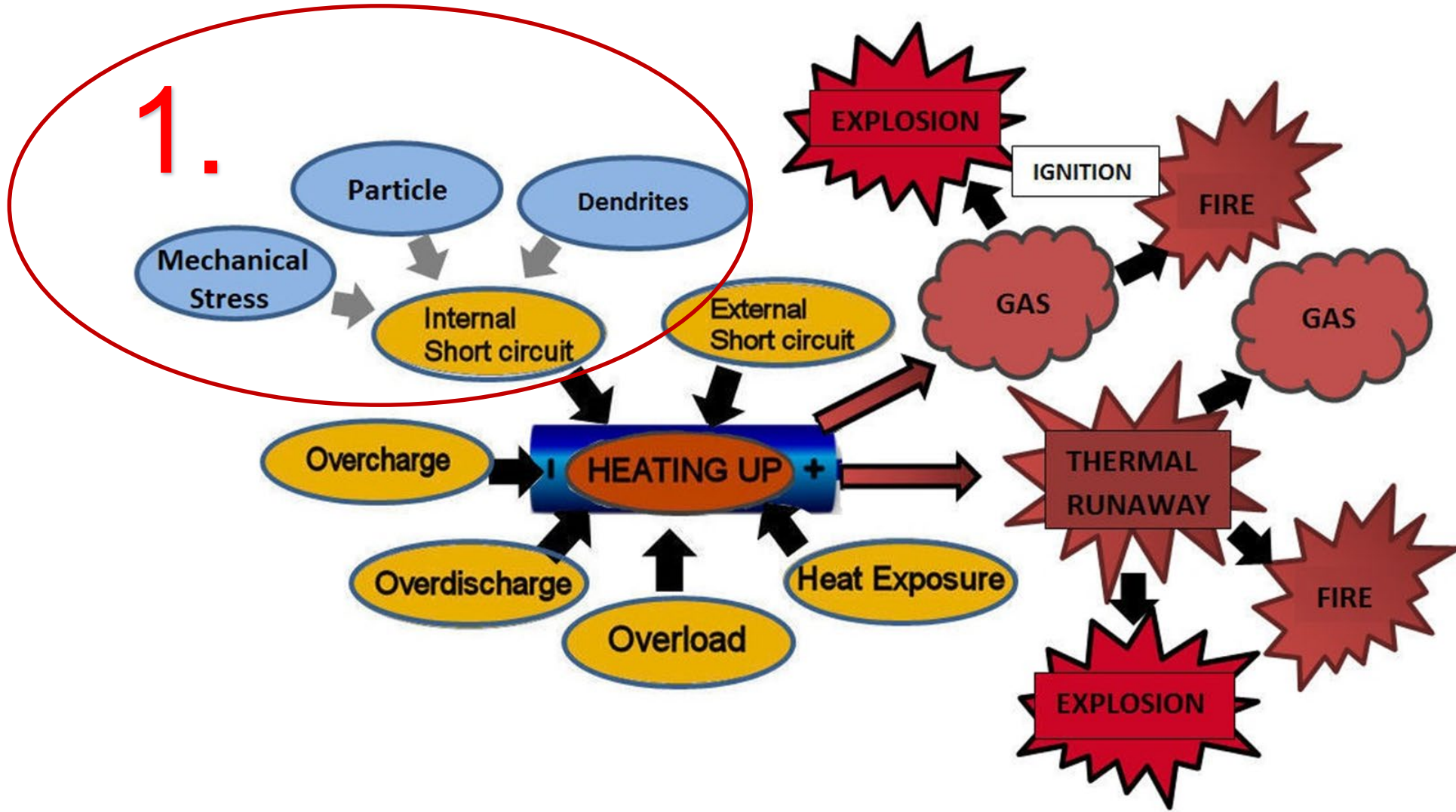
Pictures for illustration

Cost over Quality ?
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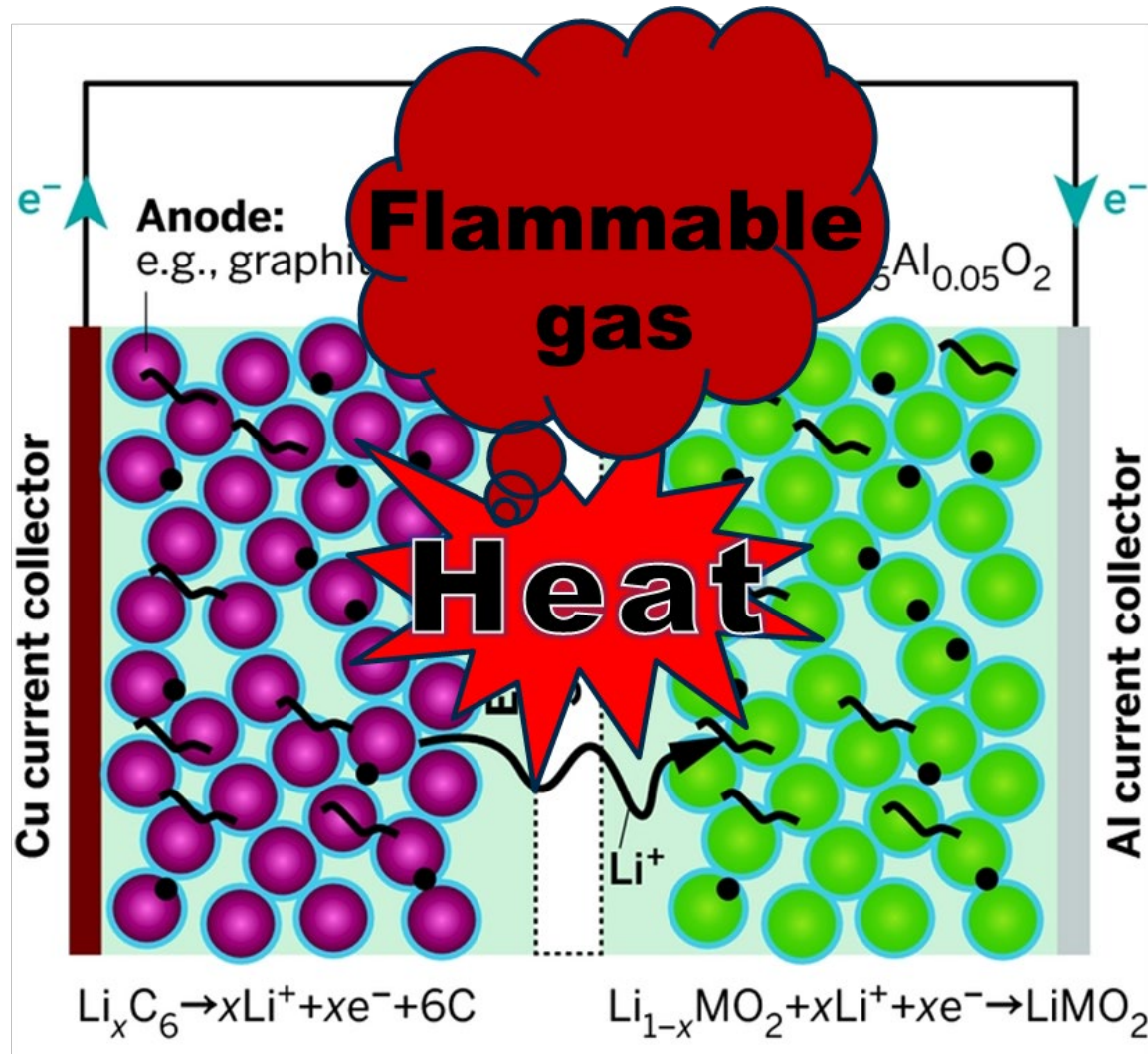
Safety aspects of lithium-ion batteries



1. Internal Short



Internal short circuit reaction



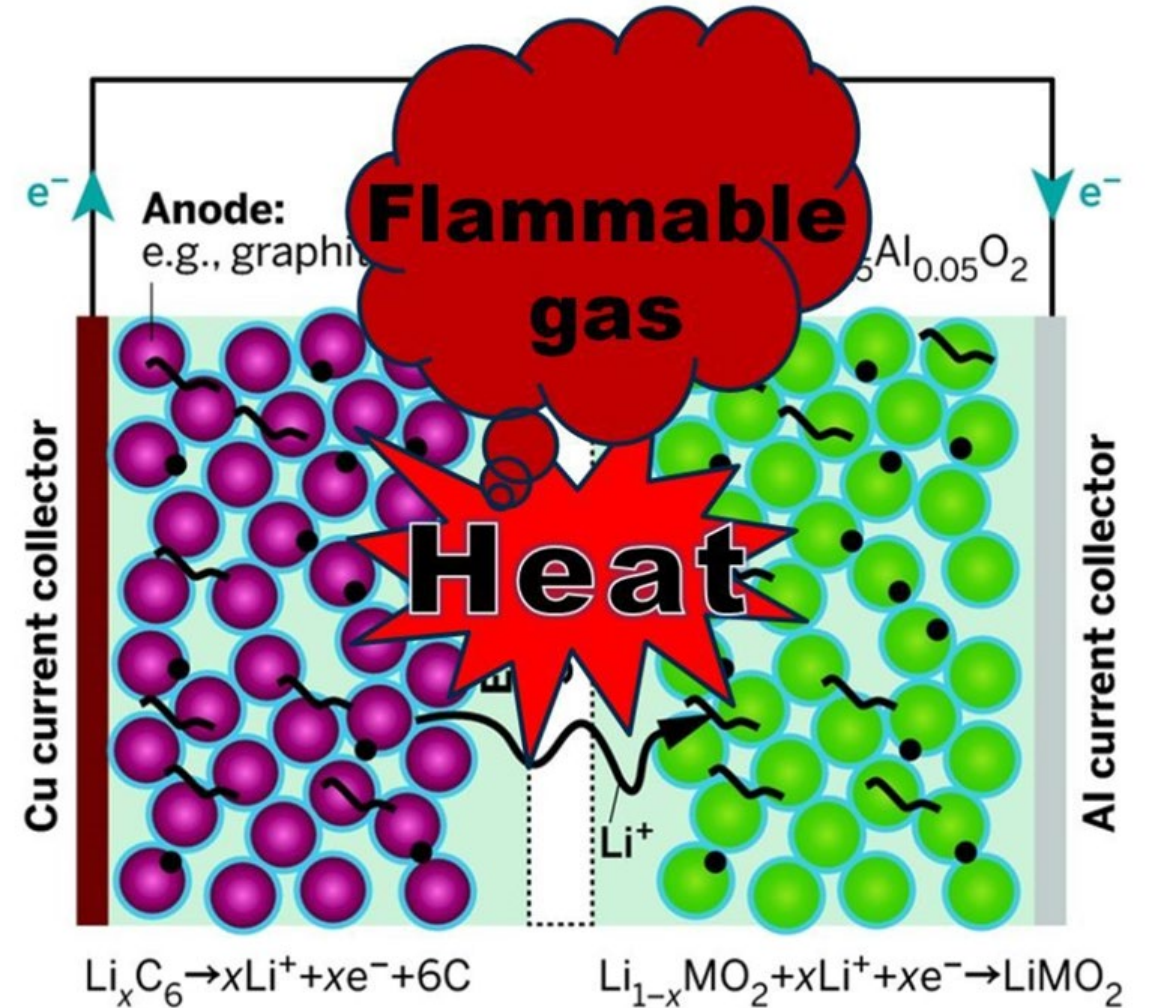
The Cu and Al current collectors were seen to melt within 0.003 s after the short initiated, melting point of Cu (>1085 °C)*

* Finegan, D.P., et al., *Characterising thermal runaway within lithium-ion cells by inducing and monitoring internal short circuits*. *Energy & Environmental Science*, 2017. 10(6): p. 1377-1388.

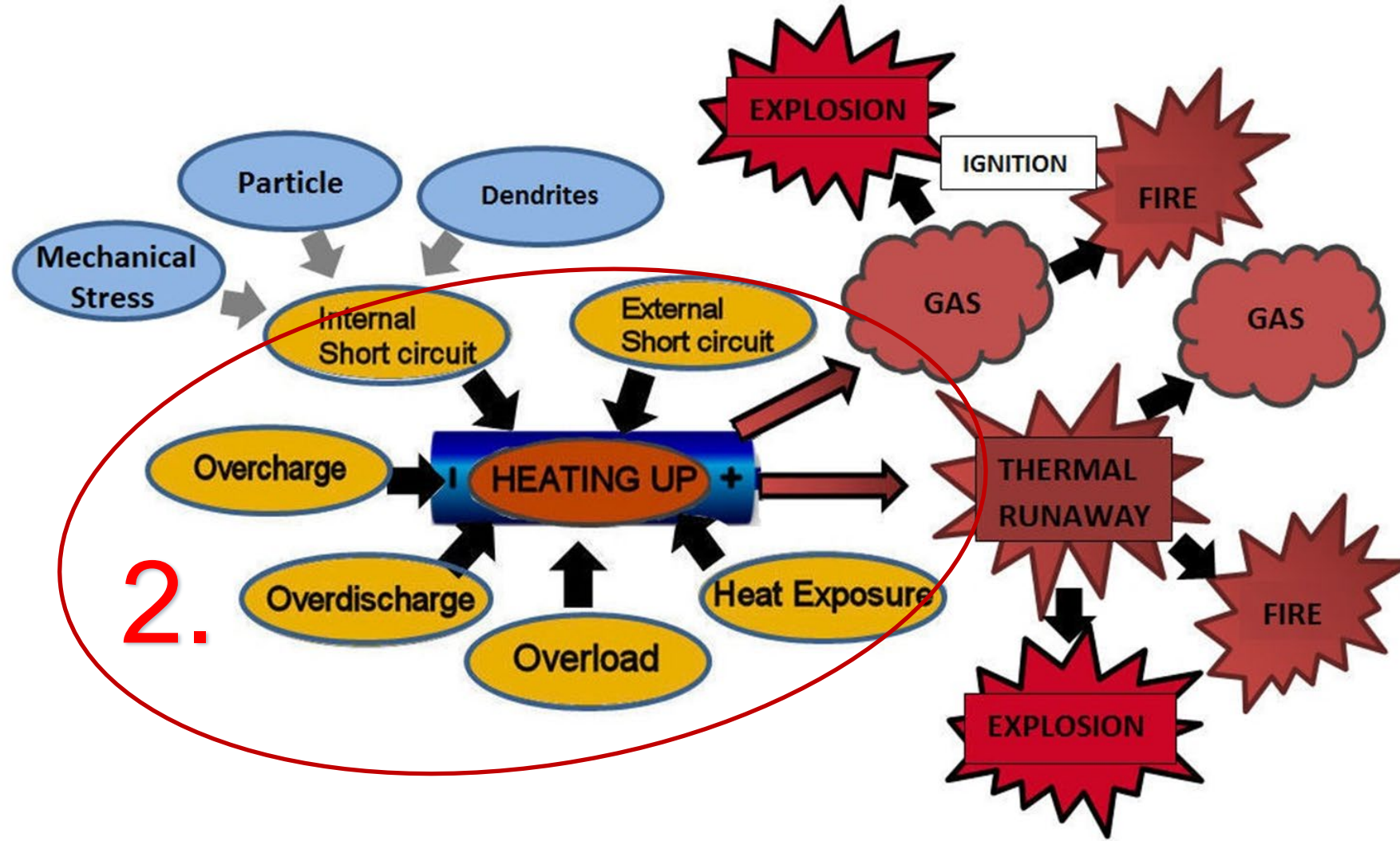
Internal short create heat inside the cell

Short circuit heating results:

1. Heating to 400-450 °C:
=> Autoignition of solvents in electrolyte (fire)
2. Heating to 250-400 °C:
=> Cell goes into thermal runaway
=> Exception, **pure** ironphosphate due to higher thermal stability
3. Heating to 30-250 °C: (MOST COMMON)
=> Reaction depends on the cells thermal stability



2. BMS System



2. BMS System

A battery management system (BMS) is any electronic system that manages and protect the battery from operating outside its safe operating area. Including balancing the cell within the safe border.

Lithium-ion failures in consumer electronics USA

- Foreign materials embedded into the cells and poor quality manufacturing certainly causes some fires (1/3)
- Mismatched cells put together into 12 to 48 volt battery packs with weak battery management strategies contribute to most of the major losses we have seen to date (2/3).

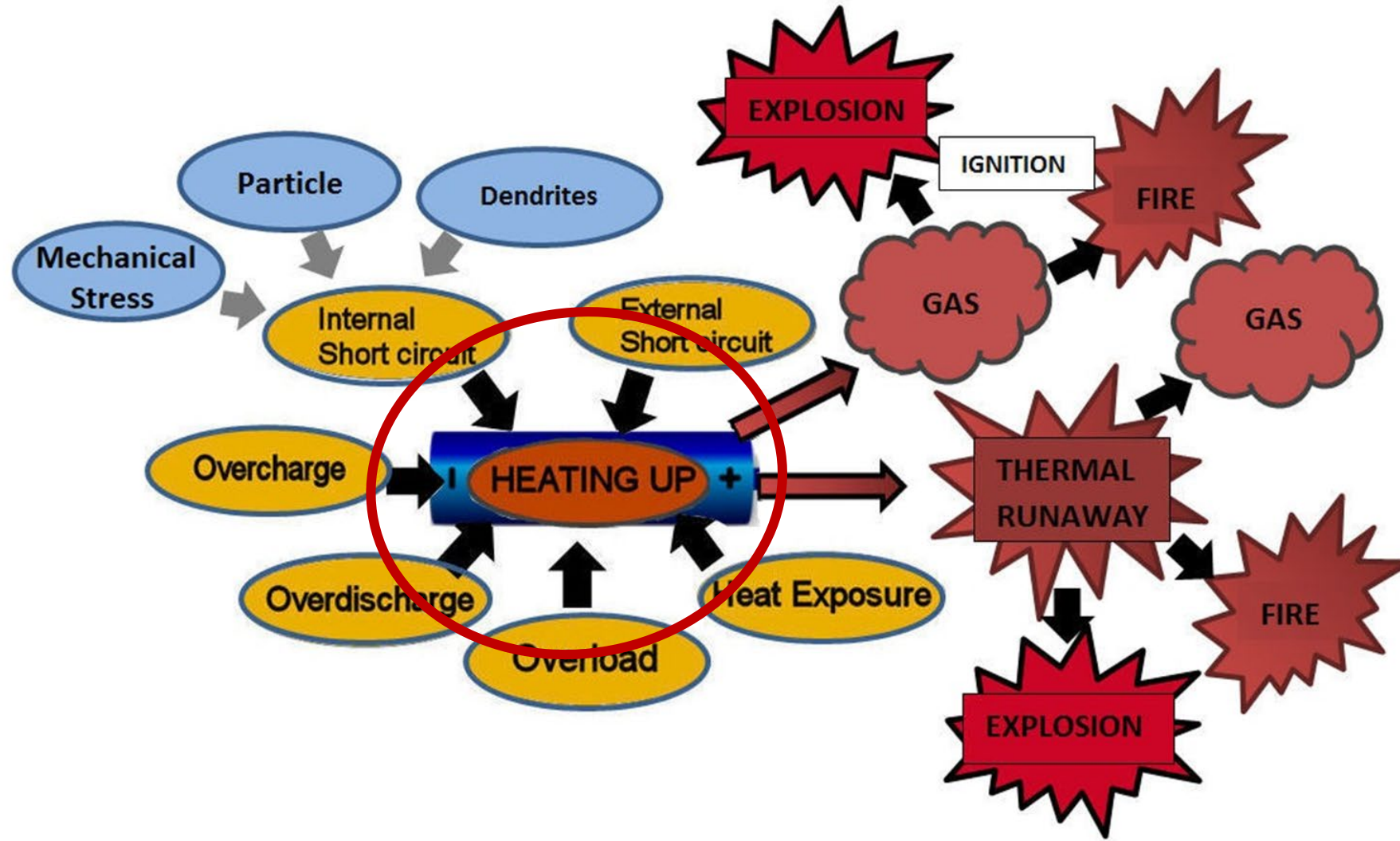
Presently the majority of the batteries produced are made by the Chinese. The cells, batteries and products which they export vary greatly with little relevant quality control, a lack of interest on overall safety.

** Eskra Technical Products, Inc. has assembled this work from some of the many hundreds of battery incidents it has investigated on behalf of its clients. 48th Power Sources Conference Denver USA 2018*

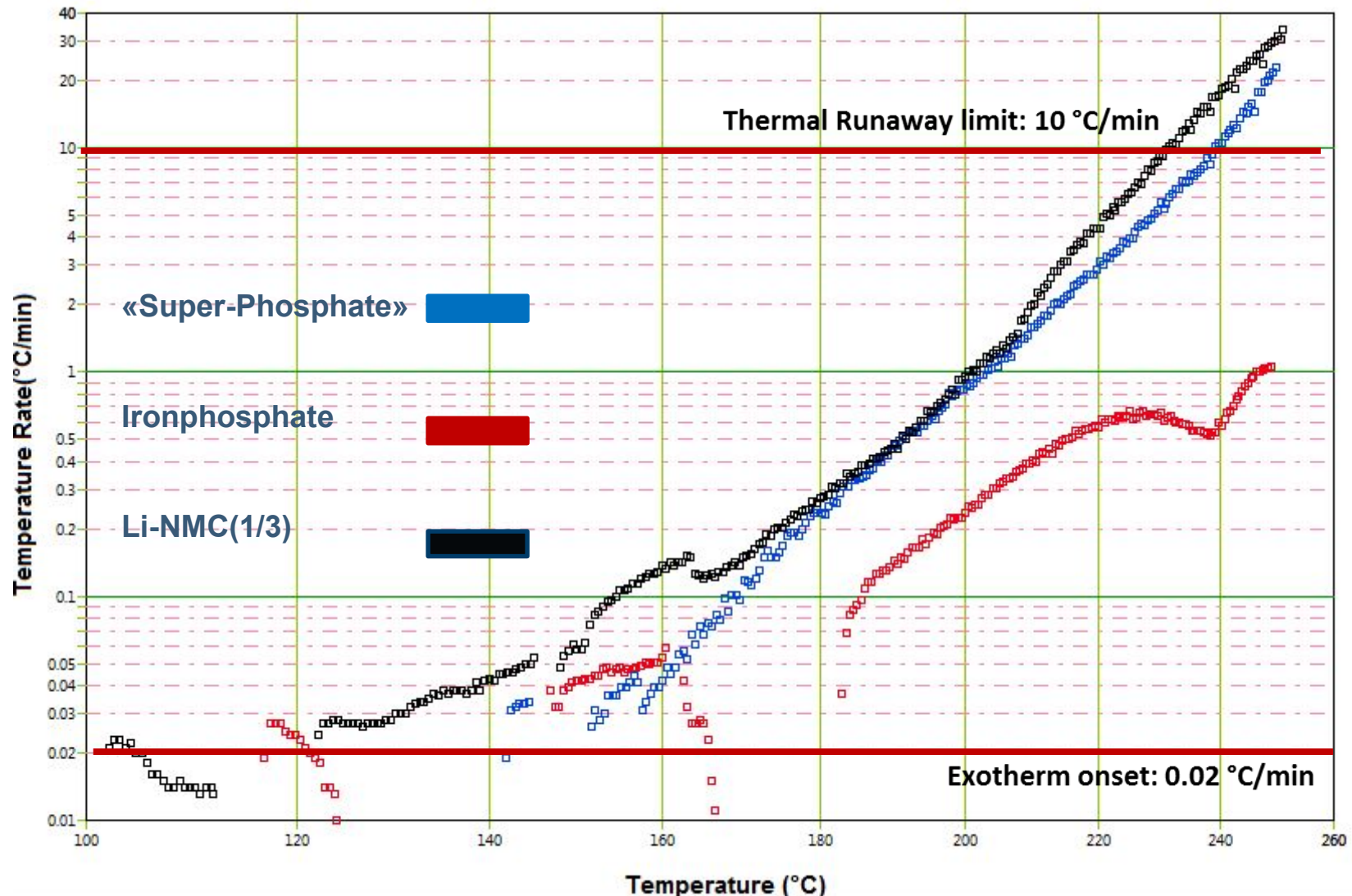
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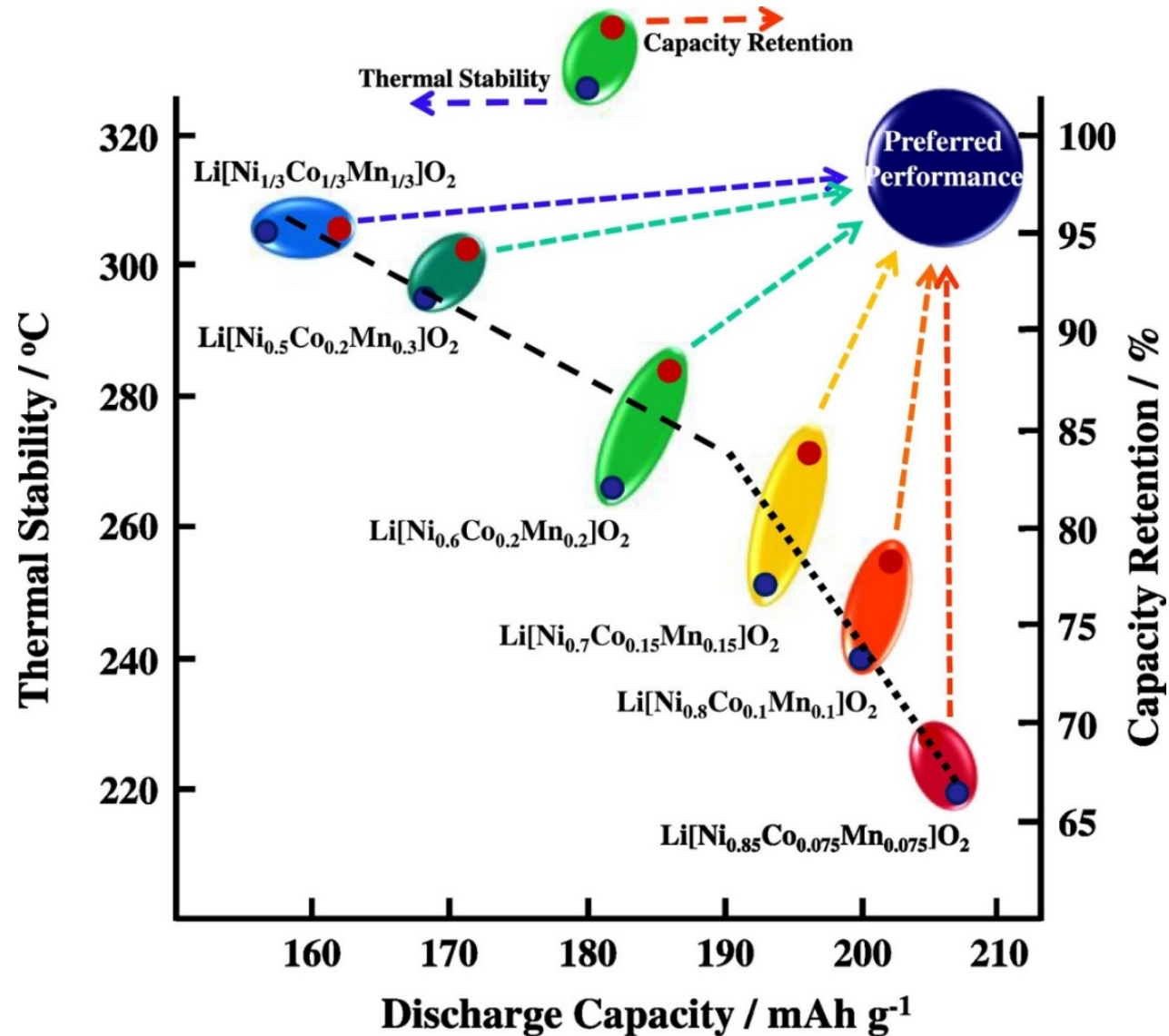
3. Thermal Stability



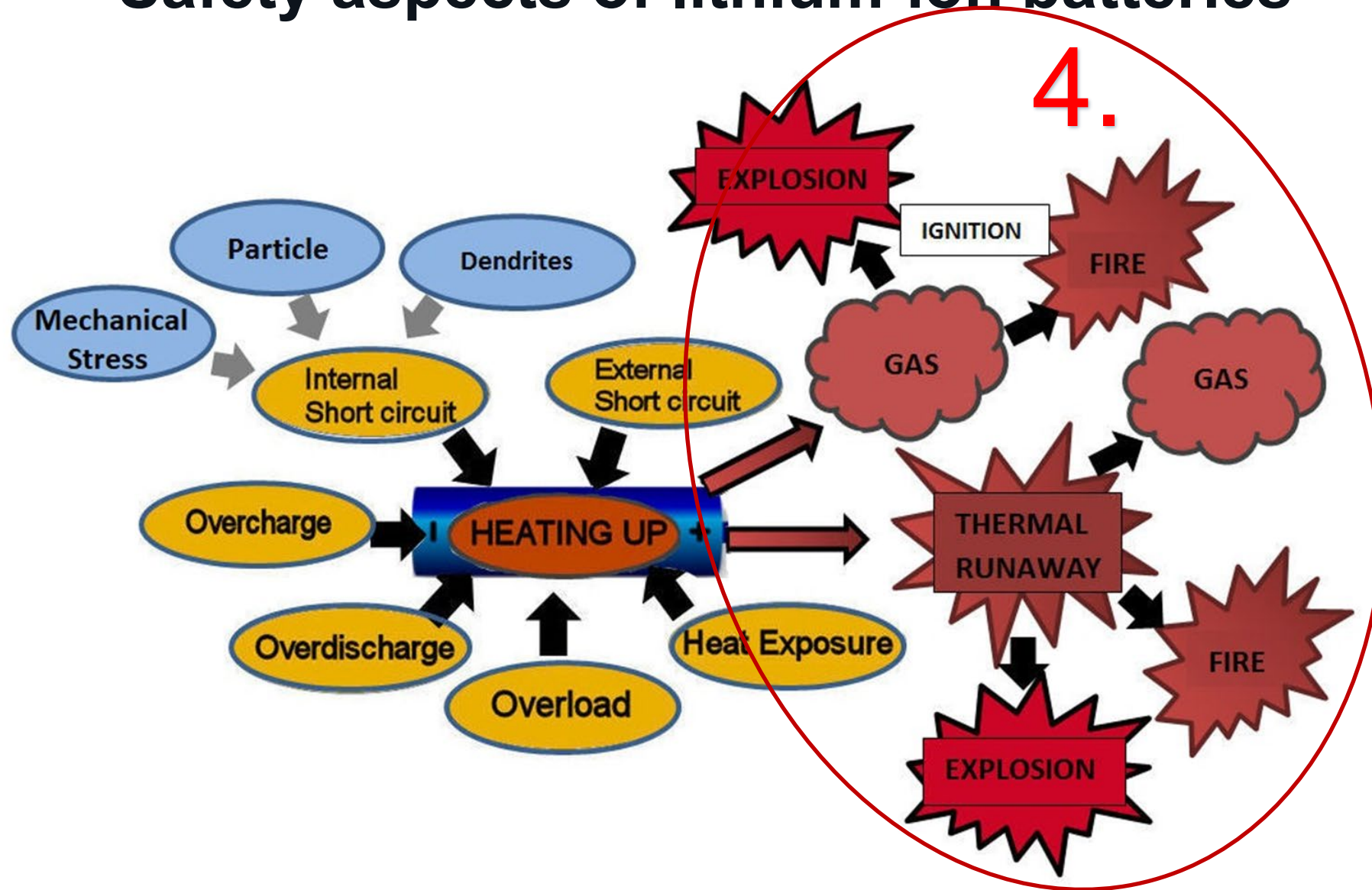
Comparison of thermal stability for different lithium-ion cells



Thermal stability versus capacity/temperature for NMC materials



Safety aspects of lithium-ion batteries



How to solve the lithium-ion safety aspects ?

- Short circuit detection
 - Today's technology are not able to detect/forecast all types of internal shorts for lithium-ion battery.
- Build safe battery solutions
 - Safe battery module design = controlling the environments
 - Verify with propagation tests

Building safe lithium-ion battery solutions for sensitive platforms

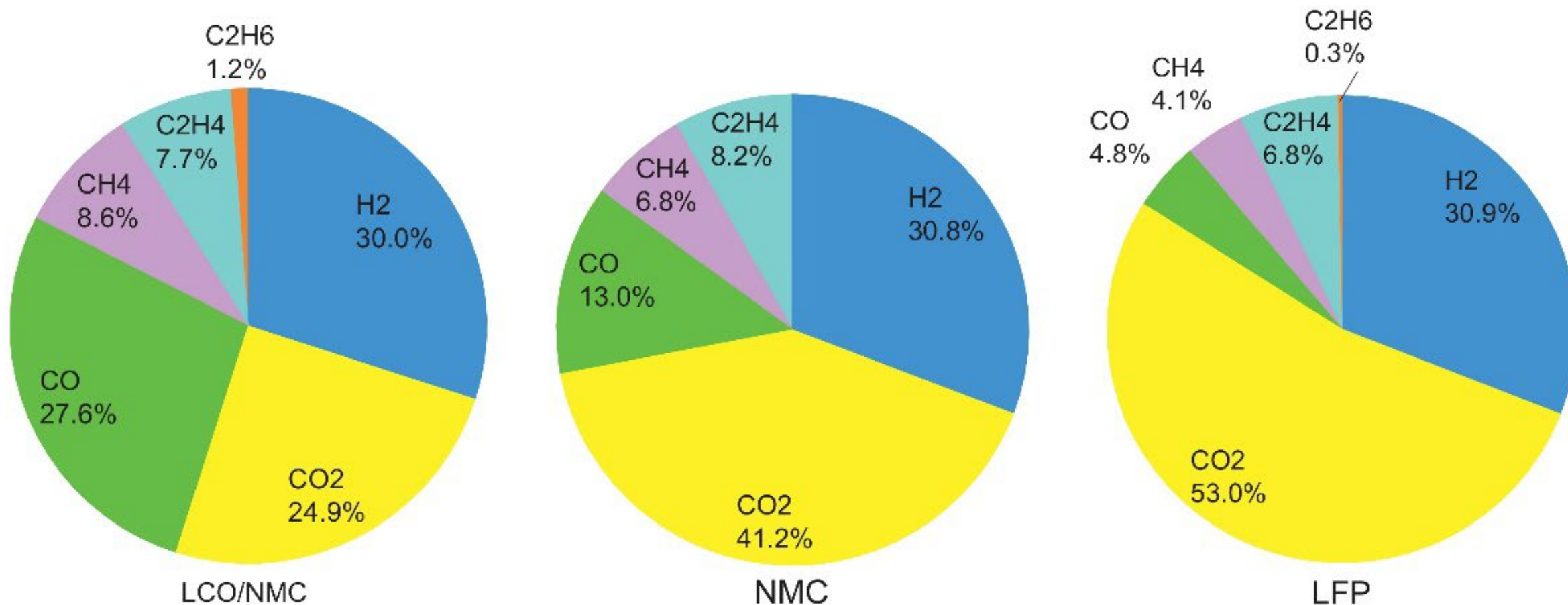
Challenges:

- **No propagation from cell to cell inside the module**
 - Manage heat from fire and cell
- Handling fire from the cell
 - The flame should not penetrate the battery module and access oxygen
- Handling solid ejects from the cell
- Handling particles from the cell
- Handling gases from the cell

Main problem: Creating a safe lithium-ion battery with acceptable energy density

Gasses from a lithium-ion cells during thermal runaway

Quantity: 1-2 liters per Ah



A review of lithium ion battery failure mechanisms and fire prevention strategies, Progress in Energy and Combustion Science 73 (2019) 95–131

Oppsummering

Det er viktig å ivareta sikkerheten til fritidsbåter

- Litium-ion batterier kommer som en alternativ miljøvennlig løsning
 - Krav til kvalitet på litium-ion batterier systemene er ikke regulert
- Resultatet kan bli billige litium-ion systemer uten krav til sikkerhet
 - Sjansen for hendelser øker på grunn av dårlig kvalitet
 - Hobby bygging av litium-ion batteripakker
 - Rask lading ved lave temperaturer er uønsket på litium-ion batterier
 - Ombygning av bly syre batterier til litium-ion batterisystemer
 - Ladesystemet kan være et problem
 - Maritimt segmentet kan gi fukt, kortslutning og korrosjonskader
- **På grunn av manglende regulering øker sjansen for hendelse med litium-ion batterier i segmentet fritidsbåter**

Thank you for your attention



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