



Horiba: solutions for Advanced carbon materials characterizations

From R&D laboratories to process optimization and quality control: answer to all the challenges of the materials for energy applications

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June 2025

HORIBA

Leader in optic,
spectroscopy and
material
characterization
since more than
200 years



1819 - J.B. Soleil build the 1st Fresnel lens

1950 - 1st Horiba pH meter



1964 - MEXA 1 - car
emission analyzer

1976 - 1st MicroRaman
MOLE™



1994 - world's first X-ray
microscope analyzer



Omoshiro-okashiku
Joy and Fun



8,665 employees around the world



**More than 900 people in R&D labs
In 32 R&D centers**



Offices & factories in 150 countries

**¥2.905B
sales (FY 2023)**



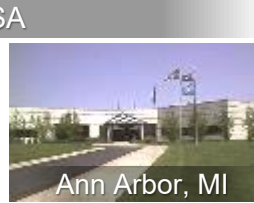
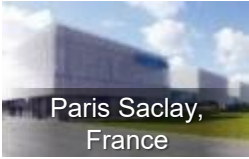
**HORIBA
Worldwide
company still
focus on
tomorrow**



**High end solution providers
combining knowledges &
experiences of 49 historical
compagnies**



HORIBA: a worldwide company



Cover all
actual
challenges



Energy et Environment



- Exhaust gas certification processes
- Next-generation vehicle development
- Fuel cell evaluation
- Water electrolysis system evaluation
- Water quality monitoring
- Air quality monitoring
- Process measurement & monitoring

**#Mobility, #Power generation,
#Environmental improvement, #Water...**



Bio & Healthcare



- Hematology testing
- Blood glucose testing
- Immunoassay
- Clinical chemistry testing
- Hemostasis testing
- Pharmaceutical / Food & beverage /
Cosmetics & skincare products development,
manufacturing, and quality control

**#Lab. testing, #Drug discovery/
manufacturing, #Cells, #Genes...**



Materials & Semiconductors



- Semiconductor manufacturing process control
monitoring
- Facility management and control
- Advanced materials research and development
- Advanced recycling of materials
- Semiconductor-related materials research,
development, and quality control

**#Advanced materials, #Semiconductors,
#polymers, materials for energy, #μplastics...**



HORIBA: solutions from “bricks” to turnkey solutions

Integrated Solutions



Provides custom turnkey solutions, perfectly integrated into the processes and needs of the customer

Laboratory Instruments



High specification instruments to Boost the R&D or to Optimize the production

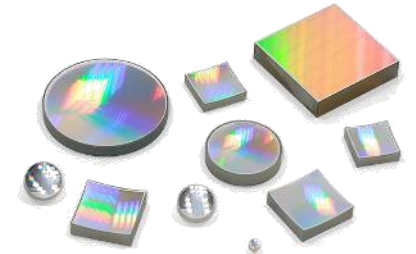


Process monitoring

Ready to use analyzers to manage efficiently every processes

Optical Solutions & Industrial Spectrometers for OEM

Components and customized design systems to Accelerate the time to market & to Improve the tool performance

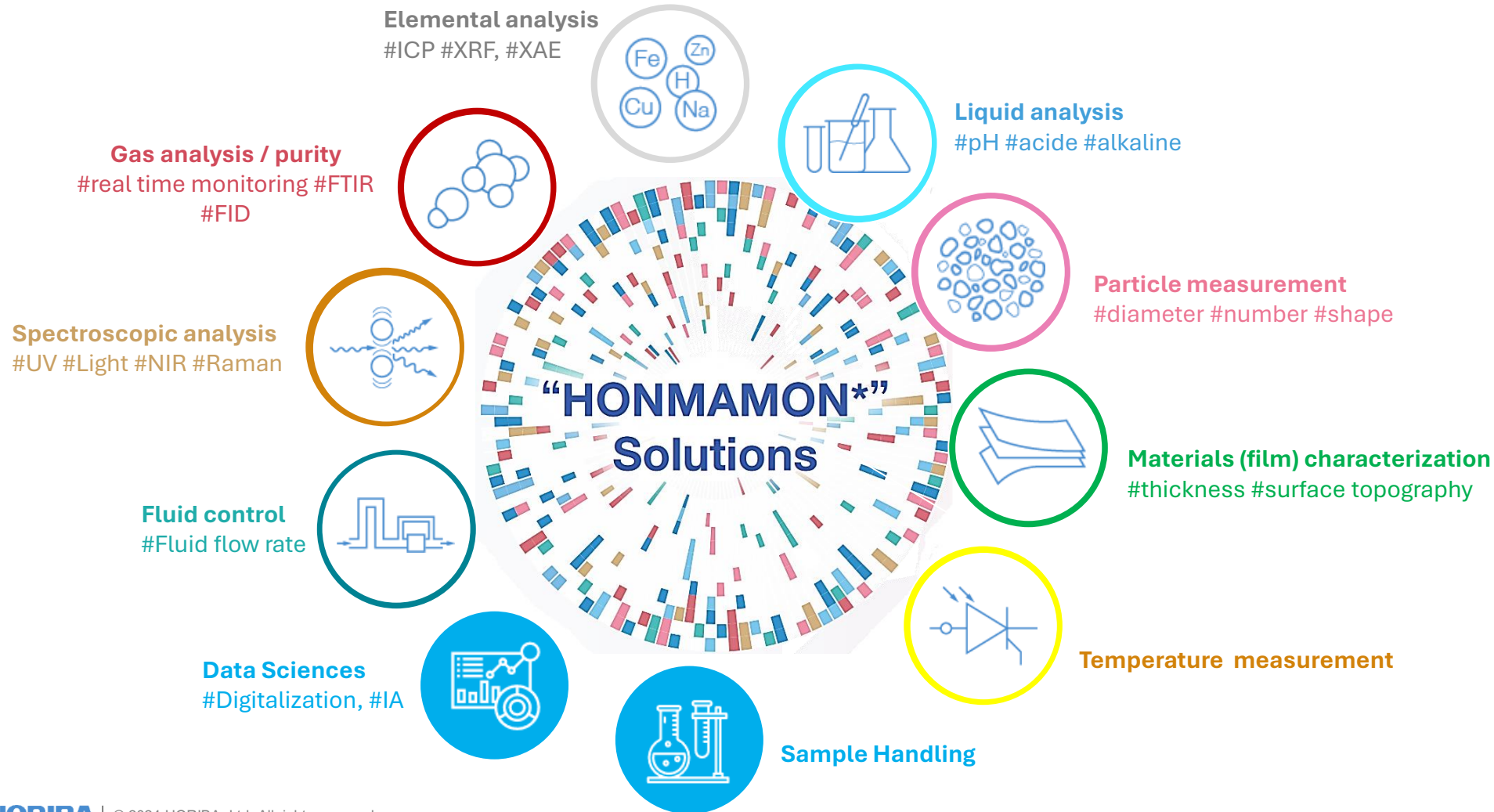


HORIBA: full range of knowledge to solve every challenges

A Full range of technologies...

... To

*characterize all
kind of samples*



Gases



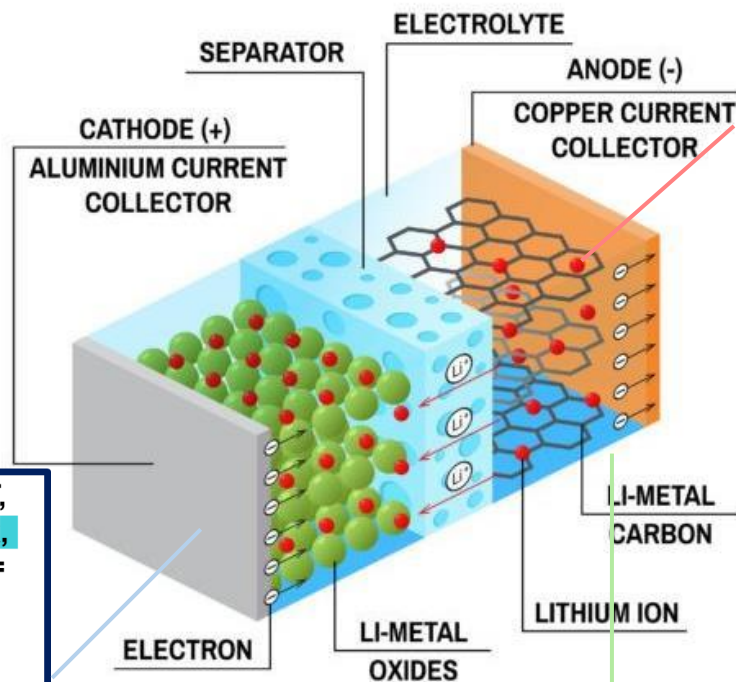
Liquids



Solids

Carbon advanced material: keys for energy applications

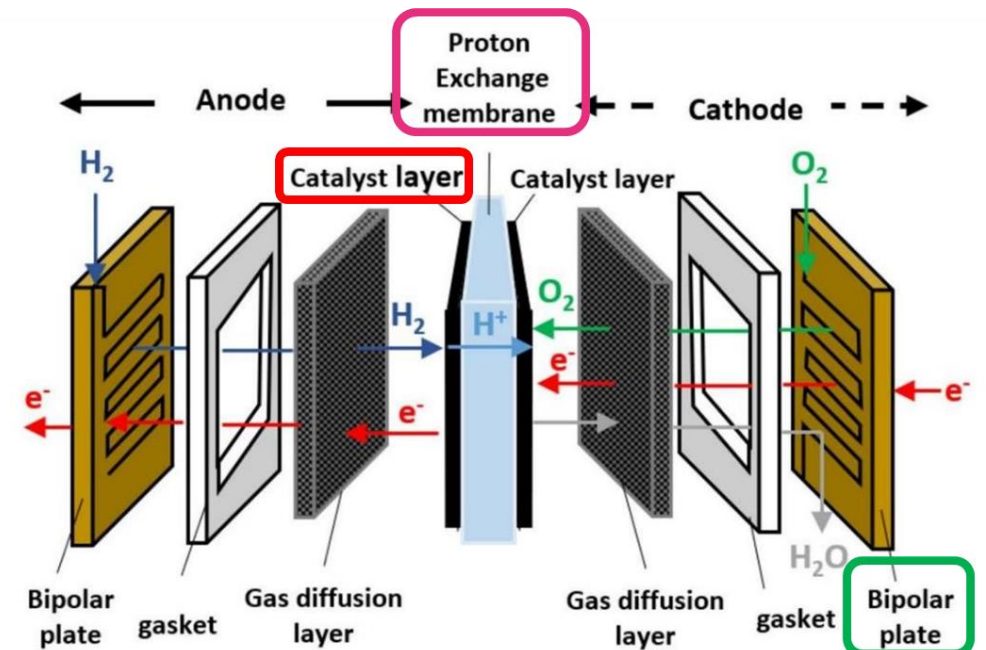
Intercalation Batteries



Carbon (CNT, carbon black, Graphen...) = conductive agent for CATHODE: **increases electronic conductivity** (power density)

Carbon (Graphite, Graphen for LiB or Hard Carbon for NaB) = **main ANODE constituting materials**

Carbon (CNT, Graphen carbon black...) = conductive agent for ANODE: **increases electronic conductivity** (power density)



Support materials

- dispersing metal nanoparticles
- Less expensive metal consumption
- Enhanced catalytic activity

Graphene oxide (GO) and reduced graphene oxide (rGO)

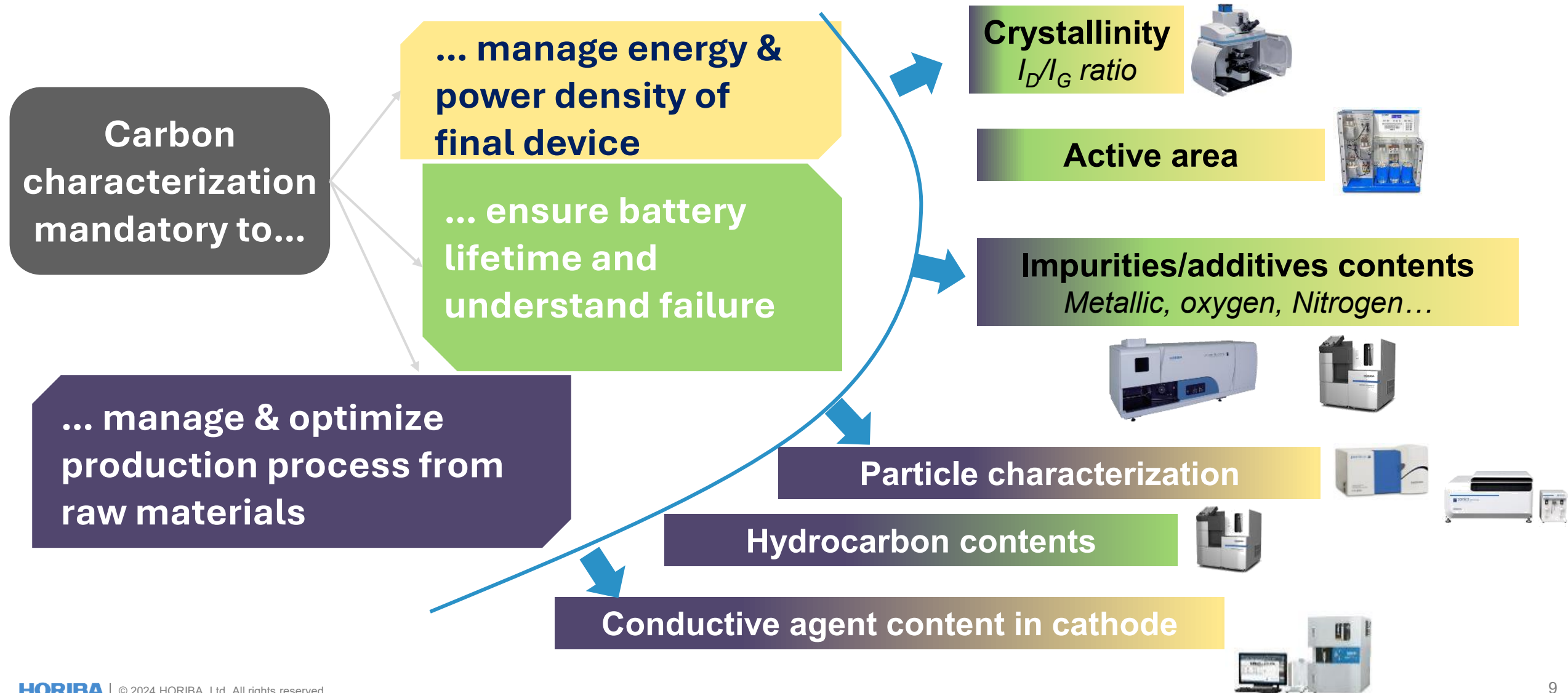
improved proton conductivity and mechanical properties
Reduce membrane permeation

Graphene coating

improved corrosion resistance

Fuel Cell / Electrolyzers

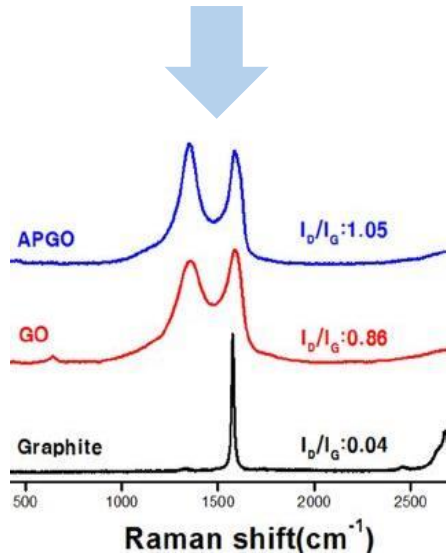
Cover all carbon studies required with automated, easy to use and scalable solutions



Example: crystallinity of the carbon materials

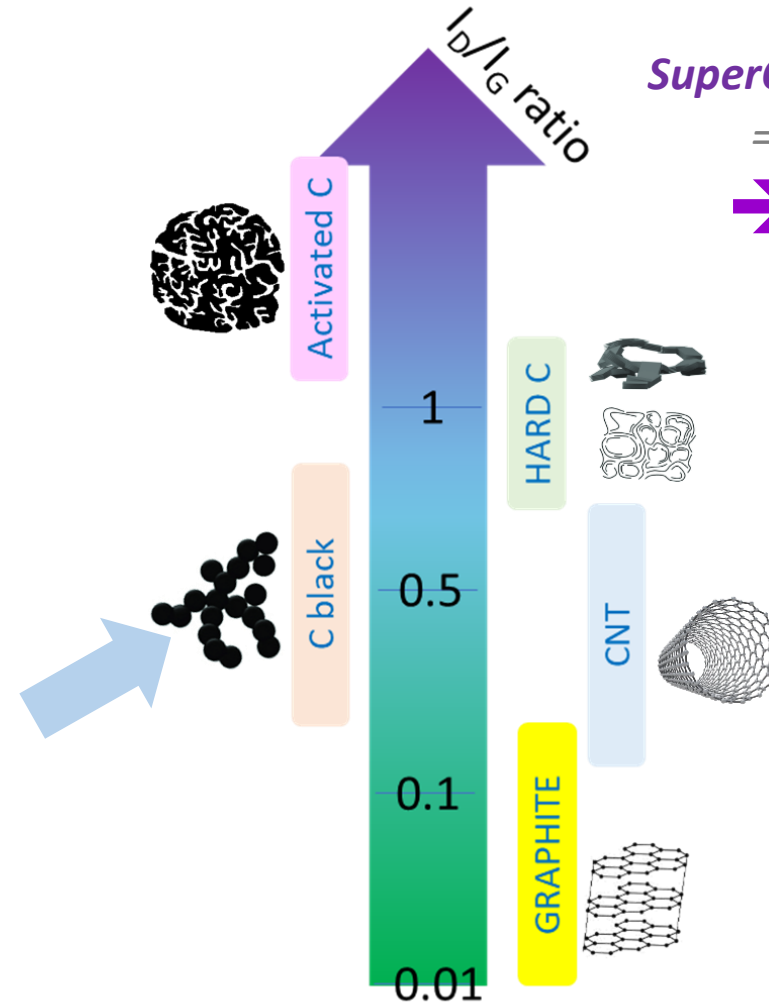
I_D/I_G ratio \rightarrow carbon crystallinity \rightarrow cell energy & power density

Carbon Raman spectrum



D band: $\sim 1350 \text{ cm}^{-1} \rightarrow$ degree of disorder / structural defect

G band: $\sim 1580 \text{ cm}^{-1} \rightarrow$ degree of level of **structural order** (graphitic content)



SuperCaps & capacitors \rightarrow High Ratio
= more active area & active site
 \rightarrow **High power density**



Sodium-Ion Battery \rightarrow Medium ratio

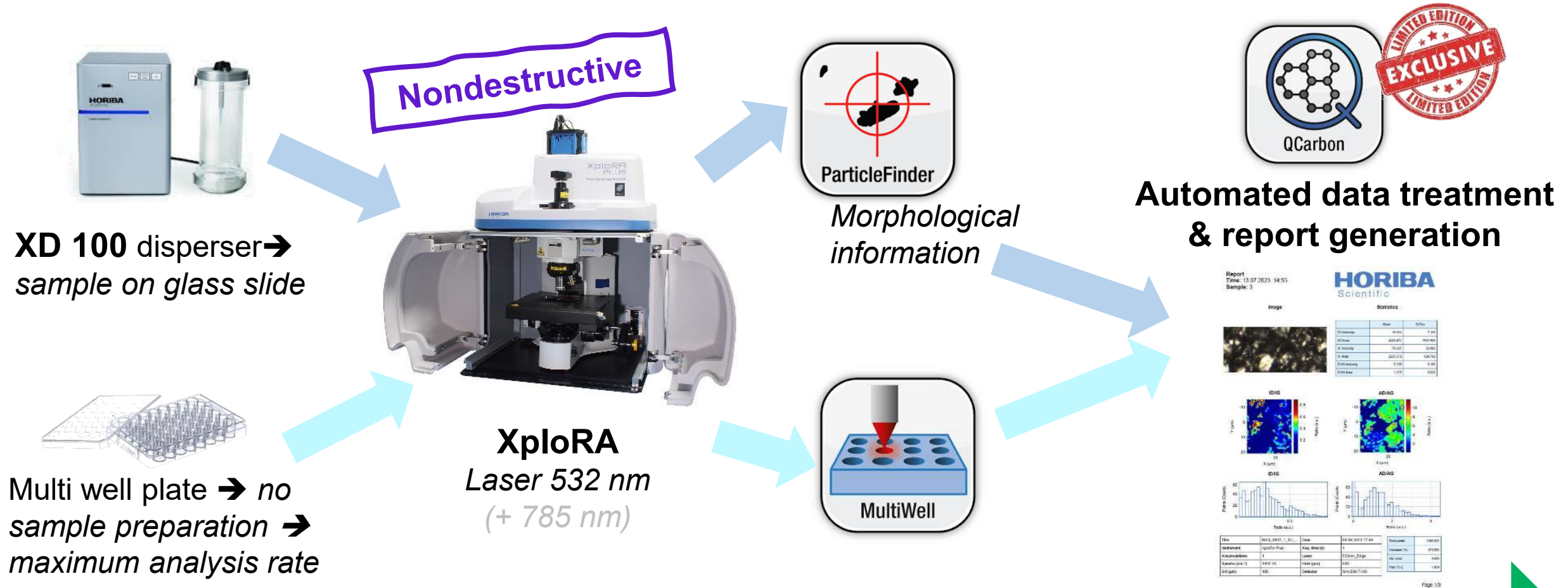
\rightarrow Combine good power & energy density
Also use for specific LiB (space...)



Lithium-Ion Battery \rightarrow Low Ratio
= high electrical & thermal conductivity, high mechanical strength, high chemical stability
 \rightarrow **High energy density**



A full solution from sample preparation to automated data analysis

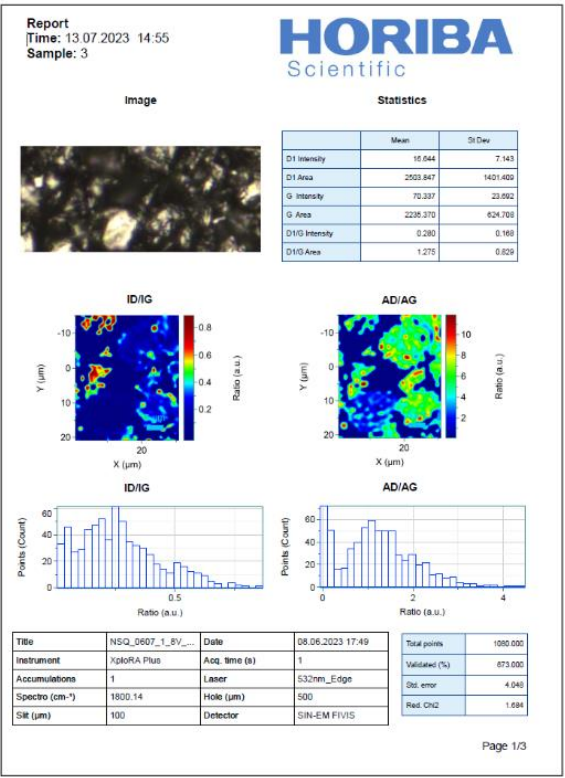
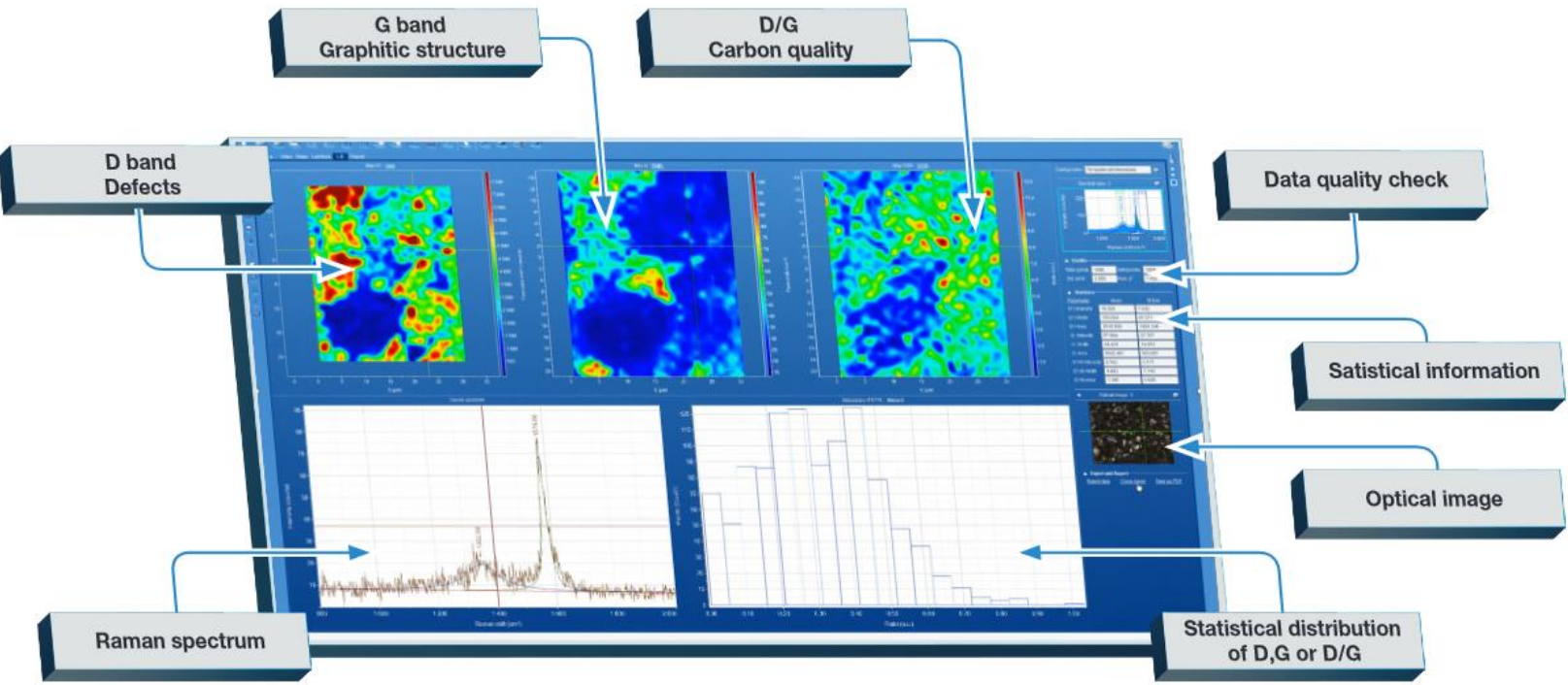


Fully automated data treatment built for battery application

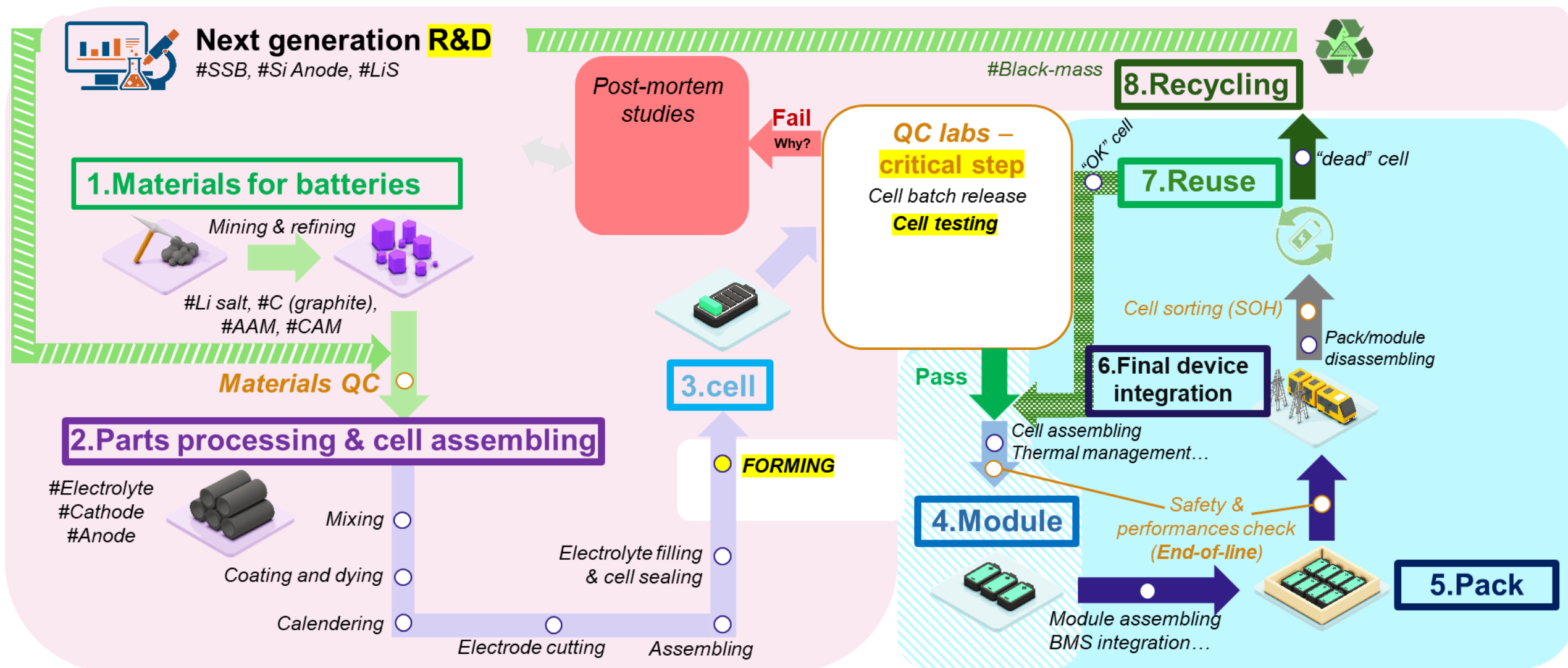
One-click data analysis
On multiple parameters: **peak fitting**,
QC check, **D**, **G**, **D/G ratios** and
statistics...

Fully customizable for each
customer
*Can be adapted and modified
to fit customers' specific needs*

Automated & customizable
PDF report generation

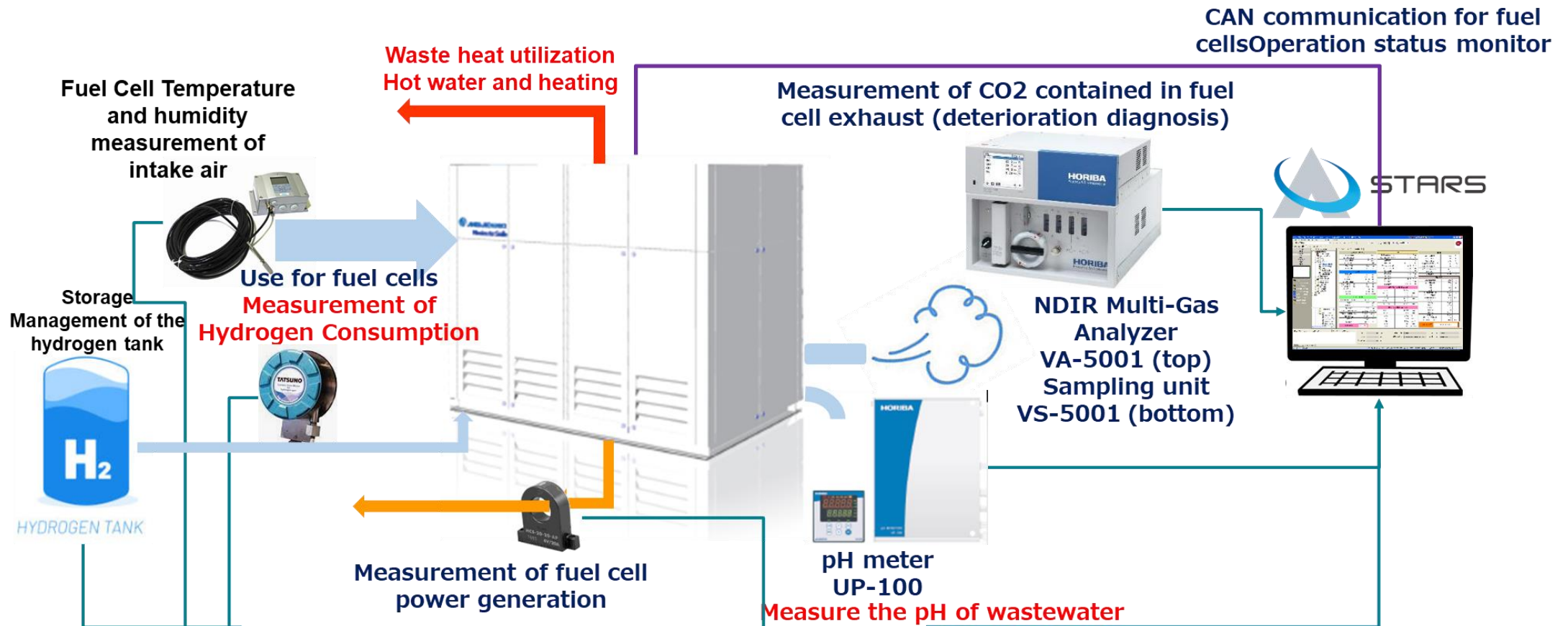


To go further: full solutions for all the battery value chain



To go further: design full integrated solution for Hydrogen testing

Various **analyzers and sensors** are connected to the installed equipment to perform data measurement. In addition to improving the efficiency of power generation, we also **diagnose the deterioration of fuel cells**.



Horiba your partner for materials characterization ... and more

- ❑ **Horiba: a full range of knowledge to provide advanced, easy-to-use and automated solutions for carbon materials characterization**
 - ❑ *Characterize your materials → define final device performances*
 - ❑ *μRaman, AFM, PCA, Elemental analysis, gas analysis...*
- ❑ **From laboratories to full integrated process control**
 - ❑ *With advanced software integration (Stars)*
- ❑ **For battery and hydrogen markets... but not only**

Omoshiro-okashiku
Joy and Fun

おもしろ可笑

THANK YOU

Terima kasih 谢谢
Gracias
Tack ska du ha
Danke
Grazie
Σας ευχαριστώ πάρα πολύ
धन्यवाद
شُكْرًا
ขอบคุณครับ
Большое спасибо
Cảm ơn
감사합니다
Dziękuję
Obbrigado
Merci