Contribution on Carbone Neutrality by HORIBA Measurement Technology

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Agenda

1. Corporate Profile
2. Carbone Neutral Trend
3. Analyzer Technology for Carbon Neutral
4. Appendix

Corporate Profile

- Head Office — Kyoto, Japan
- Founded — October 17, 1945
- Incorporated — January 26, 1953
- Net Sales — 187.1 BJPY (FY2020)
- Employees — 8,269 (FY2020)
- Business — Manufacturing, sales, services of analysis and measurement equipment

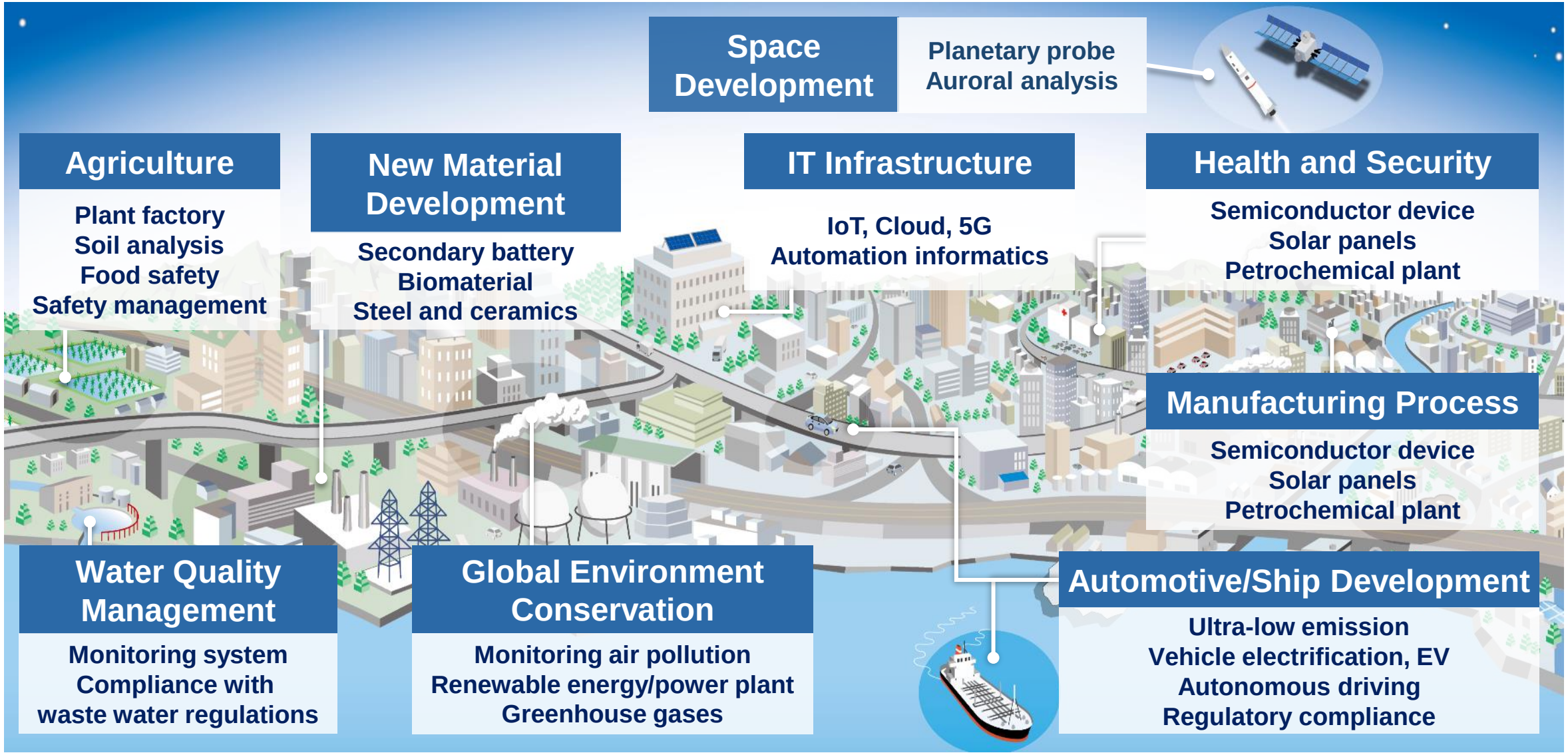
Founder
Dr. Masao Horiba

Chairman & Group CEO
Atsushi Horiba

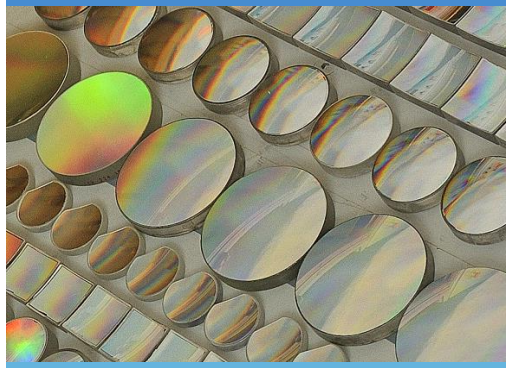
Motto “Joy and Fun”

Work that occupies most of the time in our lives should be more fulfilling to be able to enjoy our lives even more. Taking on new challenges and having pride in our work leads us to “Joy and Fun.”

HORIBA's Business Domain



Application of Basic Technologies

Gas Flow Control	Infrared Measurement	Spectroscopic Analysis	Particle-size Distribution Analysis	Electrochemistry
				
Automotive	Automotive	Scientific	Automotive	Process & Environmental
Process & Environmental	Process & Environmental	Semiconductor	Medical	Semiconductor
Semiconductor			Scientific	Medical
				Scientific

HORIBA allocates its development resources by focusing on specific analytical and measurement technologies, through the applied development of these technologies, efficiently conducts product development in 5 business segments with different markets.

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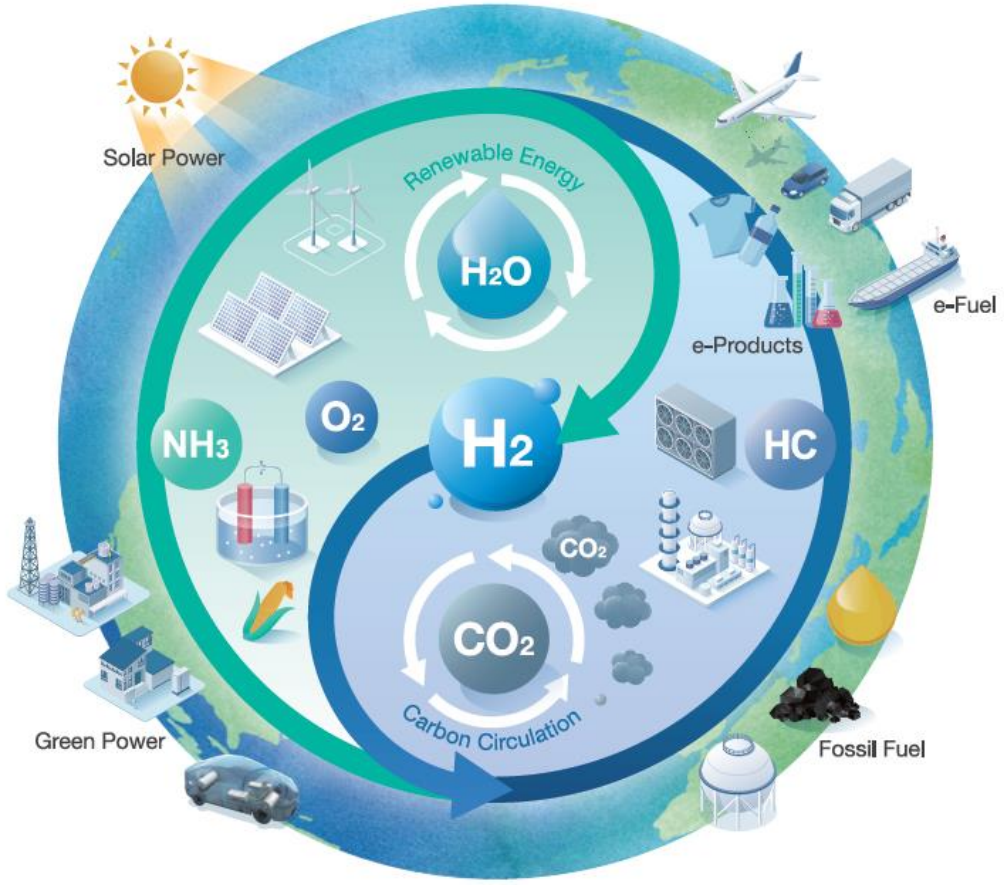
HORIBA SOLUTIONS for Energy Innovation

- $H_2 \cdot CO_2 \cdot H_2O$ NETWORK for carbon neutrality
- Utilization of H_2, Capturing CO_2, Not emitting CO_2



Analysis of Materials & Physical Properties

- Structural analysis
- Elemental analysis / quantitative elemental analysis
- Particle characterization and particle size analysis
- Thin film characterization
- Optical property characterization
- Hydrogen embrittlement evaluation
- In-line and on-line analysis

Evaluation of Performance

- Fuel cell and water electrolysis performance evaluation
- Hydrogen and ammonia combustion evaluation
- Battery charge/discharge characteristics evaluation
- Initial shipping performance inspection (Fuel cells, water electrolysis, batteries)
- Catalyst performance evaluation
- Battery material degradation analysis

Monitoring of Industrial Process

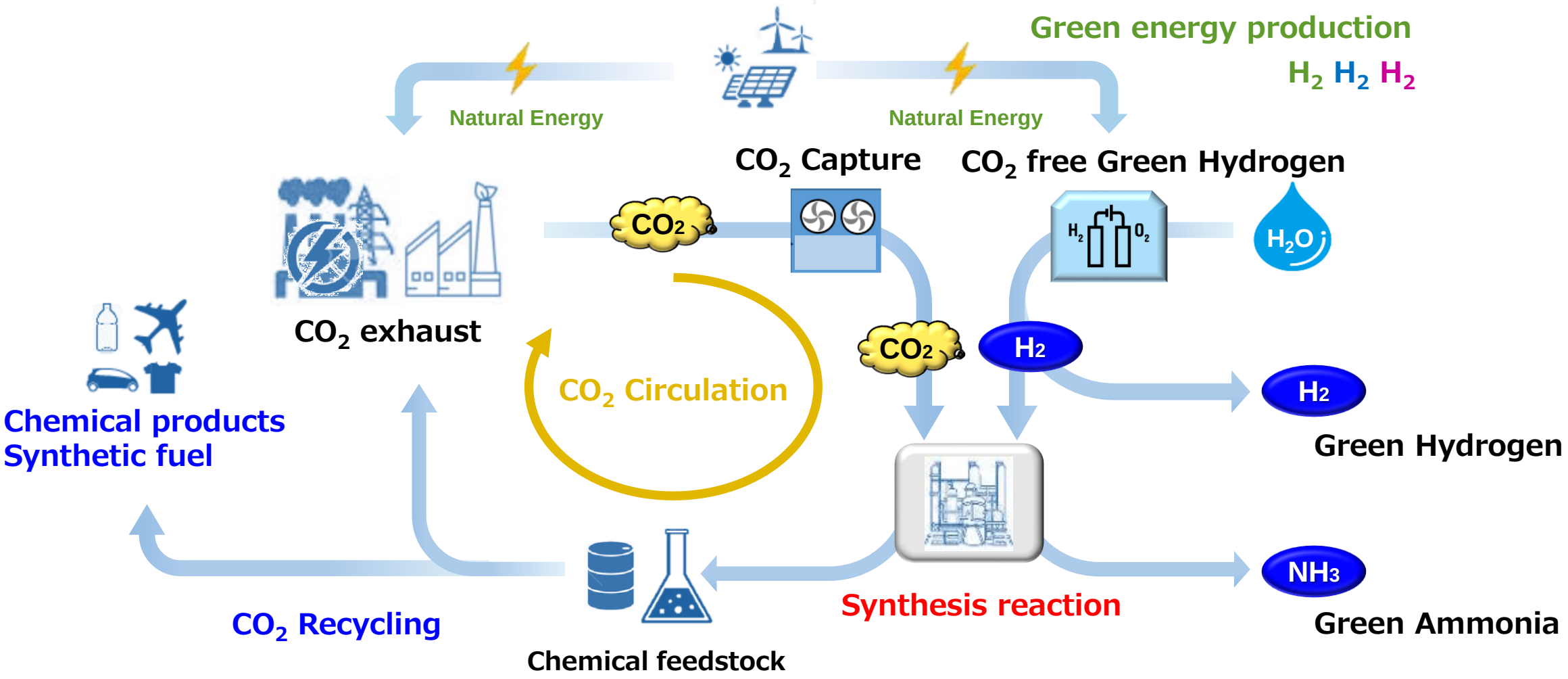
- Real-time gas monitoring
- Air quality (CO_2) monitoring
- Process monitoring for thermal power generation
- Synthesis process monitoring
- Temperature monitoring
- Semiconductor manufacturing process monitoring
- Water quality analysis
- Water, sewage, and wastewater monitoring

Optimization of System

- Powertrain evaluation
- Conformity and certification testing
- Vehicle evaluation and testing
- On-road real driving evaluation
- Factory energy management system
- Thermal management
- Safe operation of labs

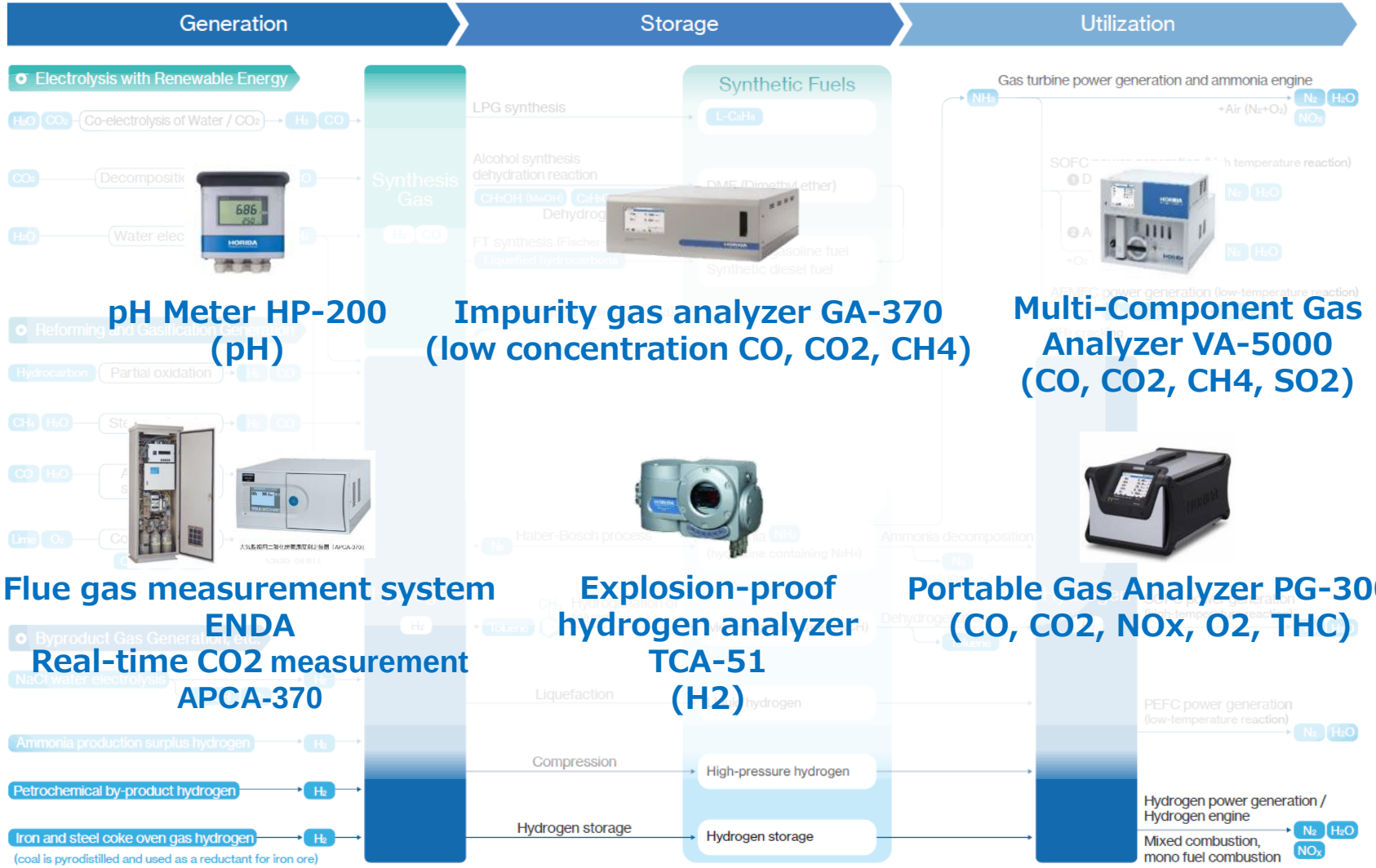
Power to chemicals & Energy transformation

- Realization of a decarbonized society



Why H_2 makes a great contribution for CN?

- H_2 is a common medium for “generating,” “storing” and “utilizing” energy, and can be converted into the wide variety of hydrocarbon fuels and bulk materials



pH Meter HP-200 (pH)

Impurity gas analyzer GA-370 (low concentration CO, CO2, CH4)

Multi-Component Gas Analyzer VA-5000 (CO, CO2, CH4, SO2)

Flue gas measurement system ENDA Real-time CO2 measurement APCA-370

Explosion-proof hydrogen analyzer TCA-51 (H2)

Portable Gas Analyzer PG-300 (CO, CO2, NOx, O2, THC)

Realize a Smart Hydrogen Society by

HORIBA Contributes to a Sustainable Hydrogen Energy Society with Analysis and Measurement Technology

SUSTAINABLE DEVELOPMENT GOALS

Generation | Storage | Utilization

Practical Use

By-Product Hydrogen (From steel factories, chemical factories, etc.)

Natural Gas

Coal

Gasification Furnace

Hydrogen Production (Reforms)

Biomass

Sewage Treatment Facility

Methane Fermentation System

Impurity Monitoring
Measures impurities such as CO_2 and CO accurately during H_2 purification, which can lead to deterioration of the fuel cell
Trace Gas Monitor
GA-370

Hydrogen Concentration Monitoring
Monitors the purity of H_2 in real time, with safe explosion-proof specifications
Thermal Conductivity Analyzer
TCA-51 Series

Generated Gas Monitoring
Measures CH_4 and CO_2 in CH_4 refining system for optimizing fermentation conditions
Multi-Component Gas Analyzer
VA-5000

Greenhouse Gas Monitoring
Monitors the concentration of N_2O generated by nitrification/nitrogen reactions during sewage treatment
Multi-Component Gas Analyzer
VA-5000

Hydrogen Tank

Hydrogen Station

Compressed Hydrogen Trailer

Liquefied Hydrogen Commercial Vehicle

Liquefied Ammonia

Residential Fuel Cell

Evaluation of Residential Fuel Cell Catalysts
Quantitatively analyzes S and C that are catalyst poisons for fuel cells from the ppm order
Carbon/Sulfur Analyzer
EMIA Series

SOFC Evaluation
Performance evaluation from single cell to full stack
SOFC Evaluation System
Evaluator HT Series

Industrial Use

Impurity Monitoring
Accurately measures impurities such as CO_2 and CO, which can lead to deterioration of the fuel cell
Trace Gas Monitor
GA-370

Hydrogen Concentration Monitoring
Monitors the purity of H_2 in real time, with safe explosion-proof specifications
Thermal Conductivity Analyzer
TCA-51 Series

Fuel Cell Bus

Fuel Cell Truck

Fuel Cell Vehicle

Air

Battery

Power Control Unit

Motor

Stack

Hydrogen Tank

Hydrogen Embrittlement Evaluation
Depth profiling of H_2 distribution in a trace amount, which causes embrittlement
Glow Discharge Optical Emission Spectrometer
GD-Profiler2
Quantitatively analyzes trace amounts of H_2 in metals that cause embrittlement
Hydrogen Analyzer
EMGA-921

Battery Evaluation
Meets stringent battery test requirements and enables highly accurate performance and cycle evaluation
Battery Charge/Discharge Evaluation System
Evaluator B

PEFC Evaluation
Performance evaluation from single cell to full stack
PEFC Evaluation System
Evaluator LT Series

Solar Cell Evaluation
Evaluates film thickness, refractive index, degradation characteristics, impurities, crystallinity, etc.
Raman Microscope
XploRA PLUS
Spectroscopic Ellipsometer
UVISEL 2

Solar Cell Manufacturing Process
Measures and controls the concentration of cleaning water and film forming gas to manage optimum conditions, in panel manufacturing processes such as crystal systems
Chemical Concentration Monitor
CS-700
Mass Flow Controller
SEC-Z500

Solar Power

Wind-Power Generation

Oxygen

Hydrogen

Water

Electrolyze water and generate H_2 by SOEC, etc.

Water Electrolysis Cell Evaluation
Optimizes water temperature, flow rate and evaluates performance/efficiency of water electrolysis cell
Water Electrolysis Cell Evaluator
Evaluator EC/ES

Electrolyte Evaluation
Mapping analysis of metal contamination that leads to electrolyte degradation
X-ray Analytical Microscope
XGT-9000

Catalyst/Electrolyte Evaluation
Nondestructive analysis of catalyst crystallinity correlated with catalyst degradation
Raman Microscope
XploRA PLUS

Single Cell

Anode

Gas Diffusion Layer

Catalyst Layer

Electrolyte

Catalyst Layer

Gas Diffusion Layer

Cathode

Fuel Cell

Catalyst Performance Evaluation
Analyzes gas concentration before and after catalyst, which is essential for evaluating catalyst performance
Multi-Component Gas Analyzer
VA-5000
Rapid analysis of catalyst particle size distribution that affects catalyst performance, from nm to mm order
Laser Diffraction/Scattering Particle Size Distribution Analyzer
Partica LA-960V2
Nanoparticle Analyzer
nanoPartica SZ-100V2

Demonstration R&D

Artificial Photosynthetic Catalyst Evaluation
Evaluates the conditions under which the catalyst functions effectively
Fluorescence and Absorbance Spectrometer
Duetta

Photocatalyst

Water

Photocatalyst

Electrolyze water and generate H_2 by photocatalyst (Artificial photosynthesis etc.)

Gas Flow Control
Measures H_2 and O_2 gas used for fuel cell power generation and enables optimum conditions
Mass Flow Controller
SEC-N100

Off-Gas Measurement in Fuel Cell Power Generation
Measures CO, CO_2 and O_2 in off-gas after city gas reforming
Portable Gas Analyzer
PG-300 Series

Hydrogen Power Generation (Fuel cell power generation)

SOEC: Solid Oxide Electrolysis Cell
SOFC: Solid Oxide Fuel Cell
PEFC: Polymer Electrolyte Fuel Cell

HORIBA, Ltd. http://www.horiba.com

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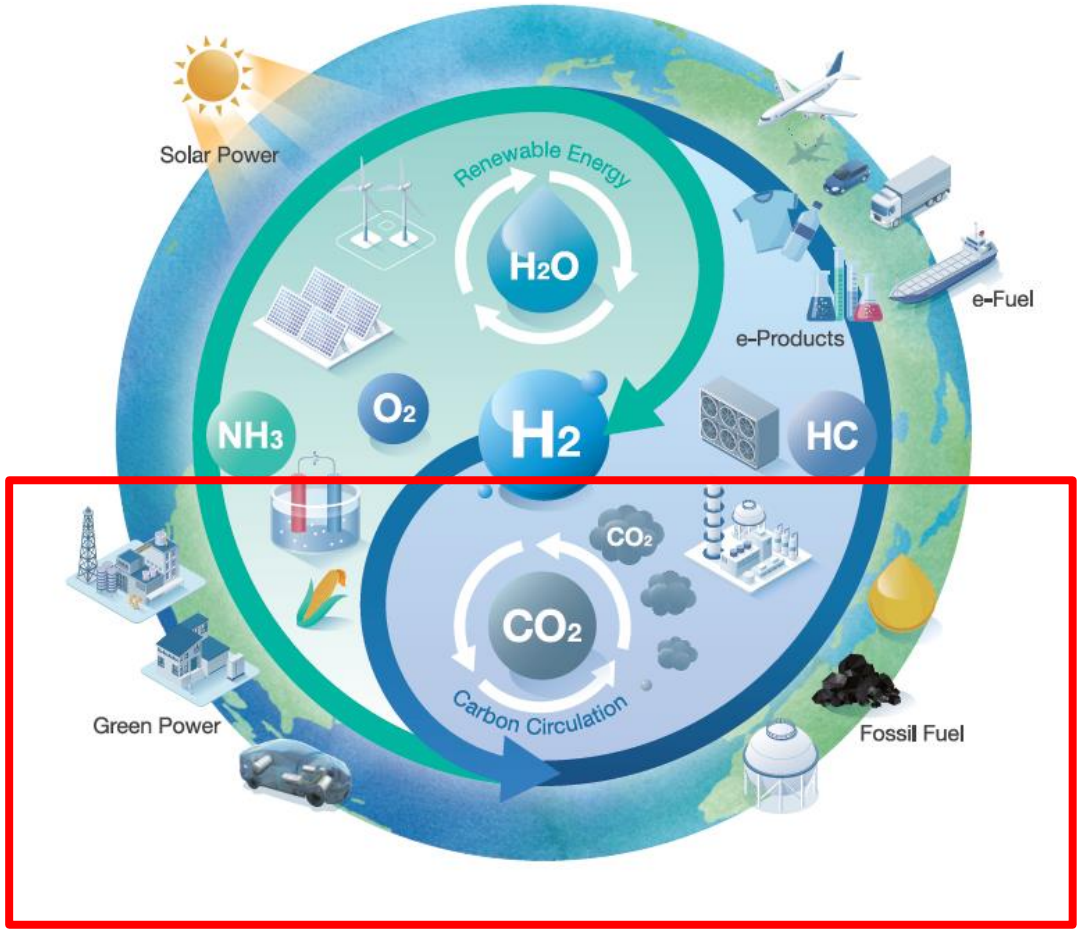
Towards the carbon neutral society

- HORIBA will contribute to realize the carbon neutrality through “measurement” technologies toward 2050



Maximize Total Energy Efficiency

Utilize Sustainable Green Energy

Realize Carbon Capture & Circulation

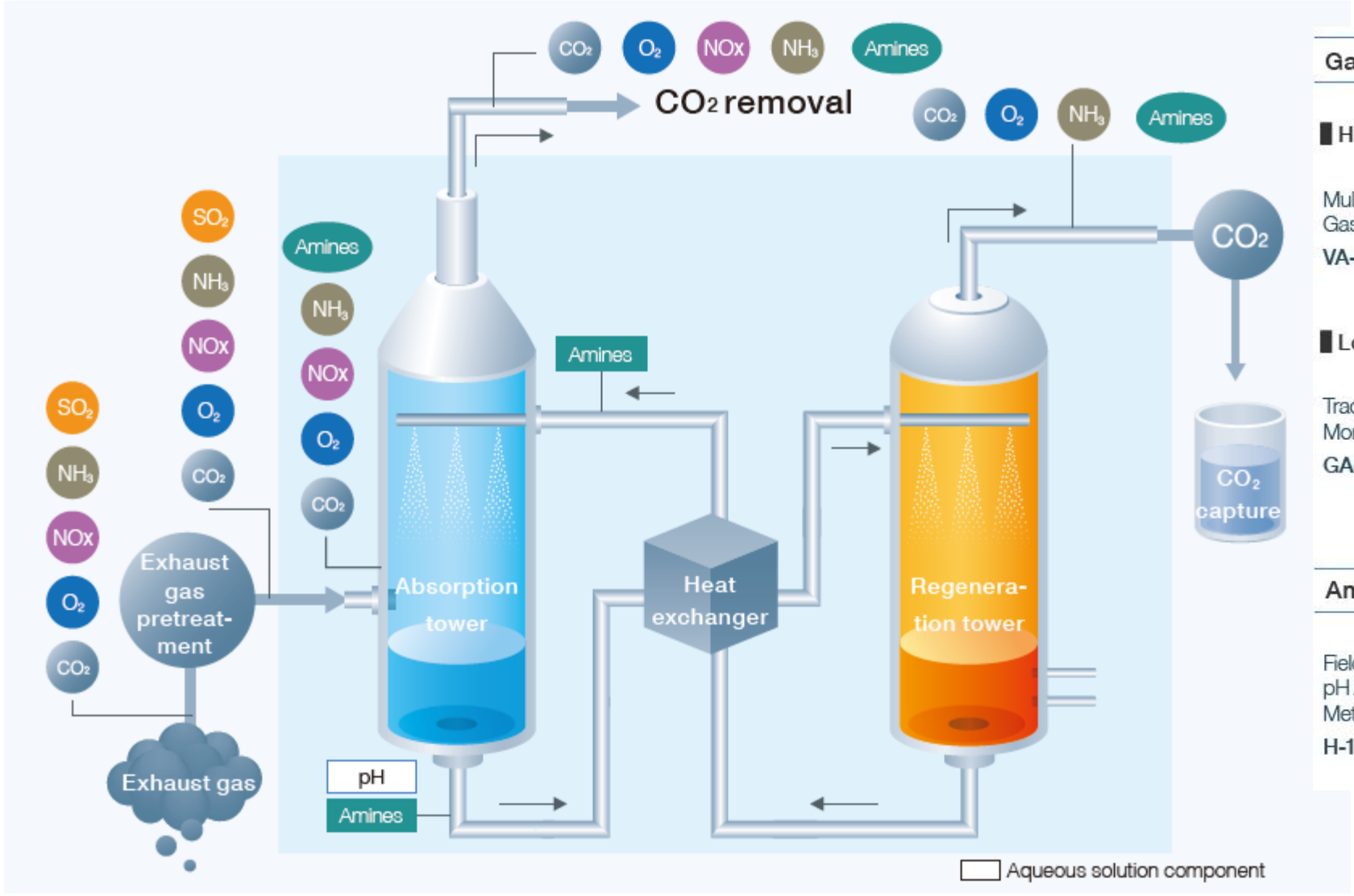
Measurement request to CCS in US

Current requirements

- CO2 monitoring during storage, and pipeline
  - From the relationship with Tax credit amount, will the measurement method be stipulated in reference method
- Amine Absorber/Solvent Monitoring
  - Liquid measurement, Color change and bubble generation
  - Issue; Optimal measurement principle and system establishment
- Impurities measurement in rich CO2
  - Requirements differ depending on CO2 usage after recovery

CCS Plant Inquiry

Chemical Absorption (Amine)



Gas Measurement Solutions

High concentration gas measurement

Multi-component Gas Analyzer
VA-5000 Series

Stack Gas Analysis System
ENDA Series

Low concentration gas measurement

Trace Gas Monitor
GA-370

Ambient NOx Monitor
APNA-370

*Contact us for the combination of gas components to be measured and equipment.

Amine Solution Measurement Solution

Field-installation Type pH / Conductivity Meter
H-1 Series

Process Raman Systems

Raman analysis for Amine Solvent

ELSEVIER
CrossMark
Available online at www.sciencedirect.com
ScienceDirect
Energy Procedia 114 (2017) 1179 – 1194
Energy Procedia

13th International Conference on Greenhouse Gas Control Technologies, GHGT-13, 14-18 November 2016, Lausanne, Switzerland

Raman Spectroscopy as an Online Monitoring Tool for CO2 Capture Process: Demonstration Using a Laboratory Rig

M.H. Wathsala N. Jinadasa, Klaus-J. Jens, Lars Erik Øi, Maths Halstensen*

Faculty of Technology, University College of Southeast Norway, 3918, Porsgrunn, Norway

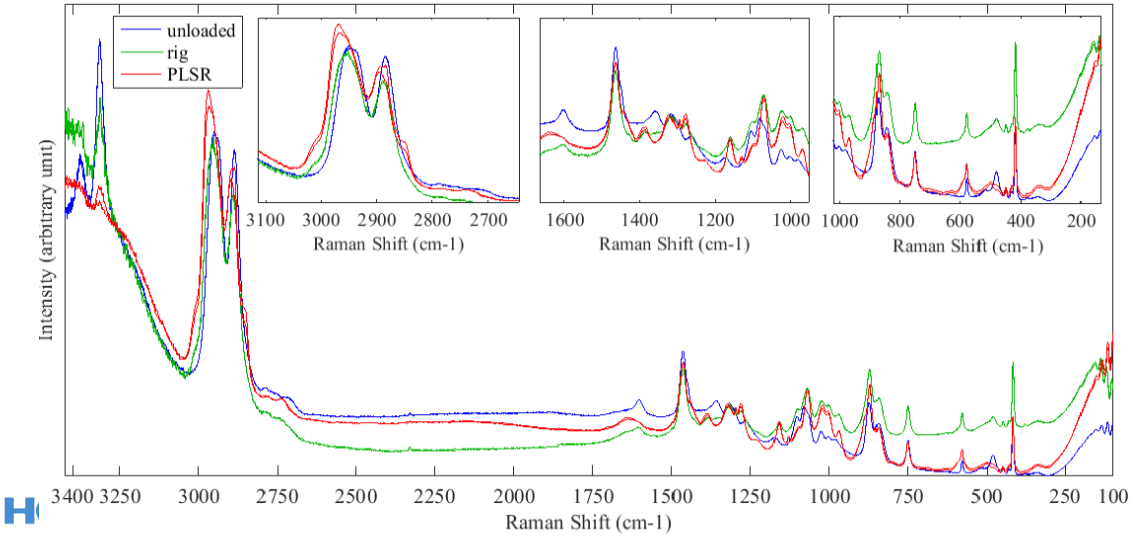
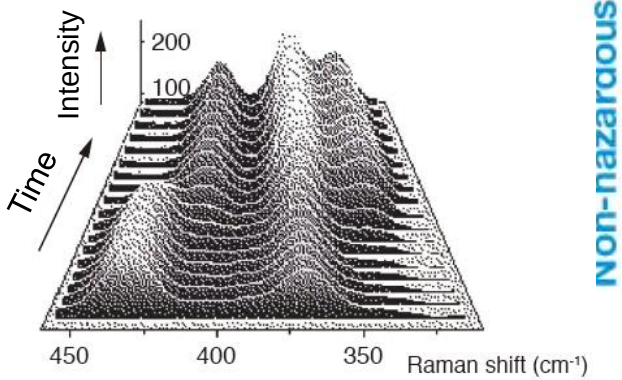
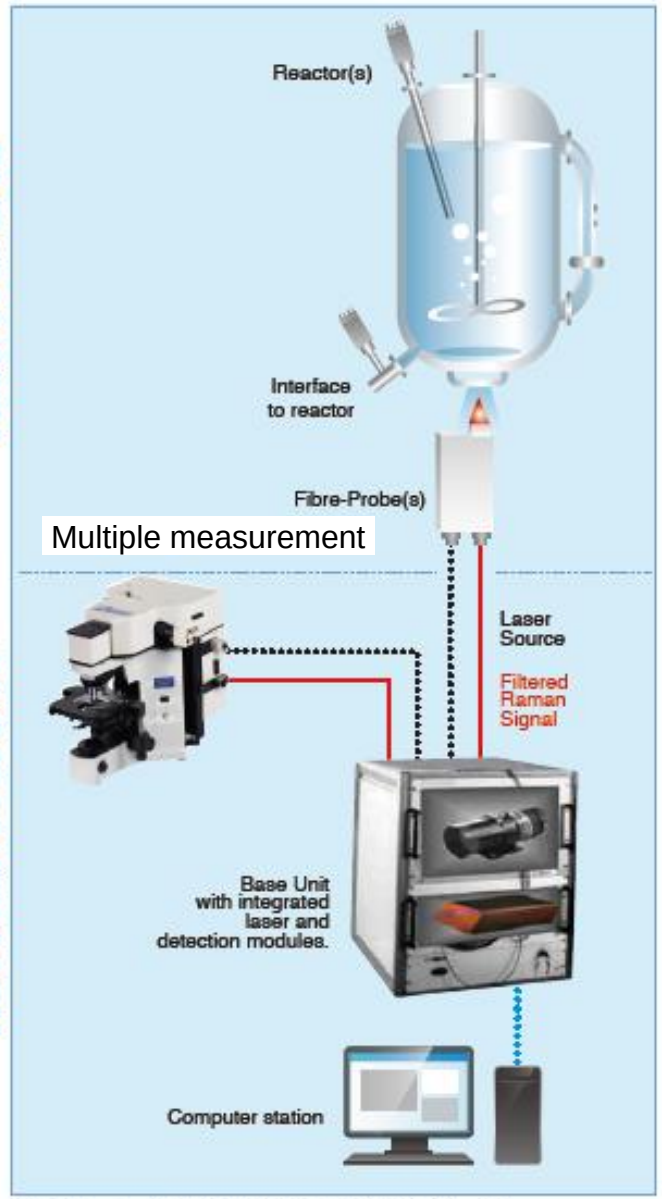


Fig. 2 : Comparison of Raman signals for CO2 loaded and unloaded MEA



Monitoring from non-hydrate to hydrate



- Process Raman system

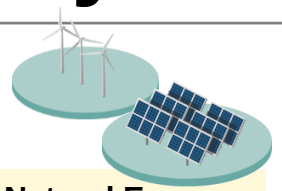
CO_2中の不純物計測向けIRLAM製品（参考）

測定原理	量子カスケードレーザ 赤外分光法（QCL-IR）
測定成分	NO, NO_2, SO_2, CO_2
測定レンジ （据え置き型 / 可搬型）	NO: 0-200 / 400 ppm
	NO_2: 0-100 / 200 ppm
	SO_2: 0-200 / 400 ppm
	CO_2: 0-100% / 100%
ゼロノイズ（2σ） （据え置き型 / 可搬型）	NO: 0.02 / 0.04 ppm
	NO_2: 0.005 / 0.01 ppm
	SO_2: 0.15 / 0.3 ppm
	CO_2: 0.01 / 0.02%
サンプルライン温度	113℃
外形寸法 / 重量	W440xD660xH877mm / 120kg （据え置き型） W350xD470xH255mm / 30kg （可搬型）

据え置き型

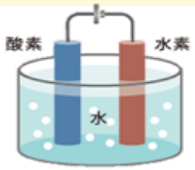
可搬型

Keywords for Carbon Neutral Realization



Natural Energy

Elec-Chem Reaction

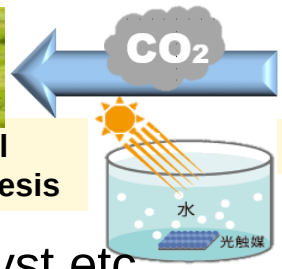


Water

Hydrogen Production

Renewable Energy

Artificial Photosynthesis



Water

Catalyst etc.

R&D for New Material

Future Strengthening Area

Fischer-Tropsch Process

$C_{5\text{-}19}$ / $C_{2\text{-}4}$ Hydrocarbons

Synthetic Fuel

Methanation

HORIBA's Contribution to Carbon Neutral Cycle

Natural Gas

Industrial Plants

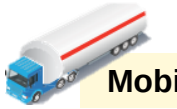
CCUS

Coal

Separation & Capture

Combustion Optimization

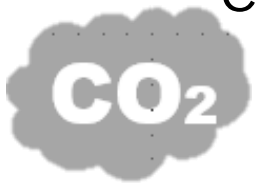
Effective Reduction & Utilization



Mobility

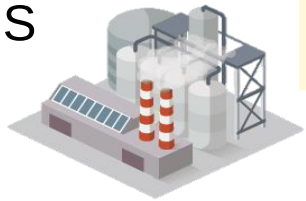
Atmosphere Emission

Direct Air Capture

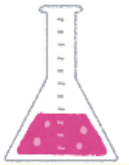


Separation & Capture

CCUS



Industrial Plants



Chemical Raw Materials

Energy Innovation with HORIBA

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