HORIBA

HORIBA Solutions for Nuclear Energy

Energy
Innovation
with HORIBA

HORIBA is your partner to transform nuclear energy, from fuel to next gen reactors

Nuclear energy encompasses a range of complex issues and concerns. HORIBA, a company focused on metrology and characterization techniques, can support the nuclear energy industry throughout the life of the process:

- **Mining** by the characterization of the nuclear fuel.
- Characterization of nuclear **materials** such as nuclear fuel and reactors coatings, including corrosion studies.
- Nuclear **waste treatment** of MOx.
- **Monitoring and surveillance** by checking stack gas.
- **Energy generation** by fusion technique using high power diffraction gratings.
- Nuclear **dismantling** for the characterization of polluted materials.

HORIBA solutions support all generations of nuclear reactors, from LWRs and SMRs to the advanced modular reactors of the future, to help you with your specific problems. All our analyzers and spectrometers are available as non-nuclearized and many can be adapted for a nuclearized environment.

Nuclear fuel

Nuclear fuel characterization refers to the process of analyzing and understanding the properties and behavior of materials used in nuclear reactors. This is a critical aspect of nuclear technology and reactor safety. One of the first steps in nuclear fuel characterization is to determine the composition of the fuel. This involves identifying the isotopic composition and the presence of impurities.

HORIBA can help you with

- Isotope ratio measurements (Pu, U, etc.) **(Elemental analysis, ICP-OES, Ultima Expert)**
- Elemental analyzer for Zr or U matrix **(C/S analysis, O/N/H analysis, EMIA Expert, EMGA Expert)**
- Size and shape of particles for raw materials **(Particle size, LA960V2, SZ100)**
- Molecular characterization of nuclear fuel **(Raman, LabRAM Odyssey)**

Light Water Reactor (LWR)

Light Water Reactors (LWRs) are the most common type of nuclear reactors in use today, and they come with their set of challenges and problems.

The greatest challenge in the 2020s is the ageing of the equipment, that's why material and corrosion studies are of great importance in extending the life of power plants.

HORIBA can help you with

- Corrosion studies of materials used in the nuclear plant **(ICP-OES, Ultima Expert; GDOES, GD-Profiler 2)**
- Coatings of multilayered materials via depth profile elemental analyzer **(GDOES, GD-Profiler 2)**
- Study of embrittlement (**C/S analysis, O/N/H analysis, EMIA, EMGA)**
- Scaling, particles charges and interactions in different media **(Particle size, LA960V2, SZ100ZV2)**

Small Modular Reactors (SMR)

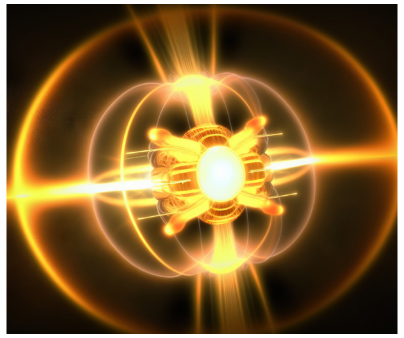
Small Modular Reactors (SMRs) are a promising and innovative development in the field of nuclear energy. They offer several advantages and have garnered significant interest in recent years.

Material characterization is a critical aspect of designing, licensing, and operating Small Modular Reactors (SMRs). SMRs come with their unique set of challenges in this regard for new and innovative materials.

These new materials will work in harsh operating conditions and reduced space. The longevity and durability of materials are points to evaluate. Characterizing materials' interactions with specific coolants, such as molten salts or gases, is essential. So materials should be choosen and characterized with all these constraints.

HORIBA can help you with

- Study of embrittlement (**C/S analysis, O/N/H analysis, EMIA, EMGA)**
- Developing in-situ, online monitoring tools for radioactive materials **(Fluorescence spectroscopy, Fluorolog-QM)**
- Corrosion studies of materials used in the nuclear plant **(ICP-OES, Ultima Expert; GDOES, GD-Profiler 2)**
- Coatings of multilayered materials via depth profile elemental analyzer **(GDOES, GD-Profiler 2)**



Advanced Modular Reactors (AMR)

Advanced Modular Reactors (AMRs) represent a promising evolution in nuclear reactor technology. These reactors offer advantages in terms of safety, efficiency, and flexibility, but they also come with their own set of challenges and can be seen as the future of nuclear energy.

Like SMRs, AMRs may use advanced materials and coolants. Characterizing these materials for durability, radiation resistance, and compatibility with the reactor's operating environment can be a complex task.

The HORIBA Group offers one of the key components of inertial confinement fusion reactors: **the laser-pulsed compression gratings.**

HORIBA can help you with

- Development of new materials for nuclear plants **(ICP-OES, Ultima Expert; GDOES, GD-Profiler 2, Raman, LabRAM)**
- Energy generation via fusion **(laser-pulsed compression gratings)**

Waste and environment

Waste and environmental considerations are essential aspects of nuclear energy. Nuclear power has several waste-related and environmental impacts, and managing these aspects responsibly is critical to the safe and sustainable use of nuclear energy.

Measurement technologies can bring support for monitoring radioactive waste, environmental impact, waste recycling, dismantling too old plant.

HORIBA can help you with

Environmental impact
- Measurement of stack gases CO, CO_2, NO_x, O_2, SO_2, N_2O, CH_4 **(ENDA-5000)**
- Portable solution for gas measurement CO, CO_2, NO_x, O_2, SO_2, N_2O, CH_4 **(PG-350)**
- Multi-component measurement CO, CO_2, CH_4, NO, SO_2, N_2O, NH_3, O_2 **(VA-5000)**

Waste control
- Elemental characterization of waste **(ICP-OES, Ultima Expert)**
- Molecular characterization of waste **(Raman, SuperHead, LabRAM)**
- Flocculation of waste, filtration and purification process **(Particle size, LA960V2, SZ100ZV2)**

Dismantling
- Quantitative and qualitative elemental determination **(ICP-OES, Ultima Expert)**
- Molecular characterization of materials **(Raman, LabRAM Odyssey)**

Safety monitoring

Safety monitoring in the nuclear energy industry is essential to prevent accidents, mitigate risks, and ensure the safe operation of nuclear facilities. It is a multi-faceted process that involves technological, human, and regulatory elements to maintain the highest standards of safety.

HORIBA can help you with

- Environmental Radiation Monitor **(Radi)**

A look at useful HORIBA techniques for nuclear energy

ULTIMA Expert

ICP-OES, elemental analysis

ICP-OES is an analytical technique used for the detection of trace elements. The sample is nebulized then transferred to an argon plasma. It is decomposed, atomized and ionized whereby the atoms and ions are excited. The intensity of the light emitted when the atoms or ions return to lower levels of energy is measured. Each element emits light at characteristic wavelengths and these lines can be used for quantitative or qualitative analysis.

- Enlarged dynamic range for major elements and exceptional sensitivity for trace elements, even in highly dissolved solids matrices
- Elimination of spectral interferences, even for trace element analysis in line-rich matrices
- Optimised HORIBA design for easy integration with glove boxes
- More than 30 years' experience in glove box systems for nuclear decommissioning

GD-Profiler 2

GDOES, elemental analysis and depth profile analysis

GDOES offers elemental depth profiles and is a powerful tool to analyze coated and treated material surfaces and interfaces. GDOES combines a glow discharge powered by a pulsed radio frequency (pulsed RF) source with an optical emission spectrometer. The GD plasma sputters a representative area of the sample, layer by layer, and simultaneously excites the extracted atoms. The obtained emitted light is detected by high resolution optics, giving the elemental composition, while the erosion rate, layer thickness and depth are measured with a built-in patented differential interferometer (DIP). Full automation of the GDOES operations can be done with the Sample Mapping Unit (retrofittable).

- For thin & thick films – from nanometer to hundreds of microns with nanometer depth resolution
- Determination of all elements including deuterium and hydrogen

EMIA-Expert

EMIA, EMGA, C/S and O/N/H Elemental analyzers

The EMIA analyzers measure carbon and sulfur in materials. The technique combines heating combustion in an oxygen stream and Infrared (IR) detection. Carbon is measured as carbon dioxide (CO_2) and partly carbon monoxide (CO), and sulfur is measured as sulfur dioxide (SO_2) simultaneously by the non-dispersive infrared detectors without additional oxidizing or SO_3 scrubbing reagents.

The EMGA analyzers measure oxygen, nitrogen and hydrogen with high accuracy and repeatability suited to cutting-edge technological materials. Oxygen is measured as carbon monoxide (CO) and carbon dioxide (CO_2) by two non-dispersive infrared (NDIR) detectors; nitrogen is measured by a thermal conductivity detector; and hydrogen is measured by a non-dispersive infrared detector as H_2O. A dedicated hydrogen analyzer with thermal conductivity detector is also available for more in-depth measurements.

- Very sensitive
- Optimised HORIBA design for easy integration with glove boxes

A look at useful HORIBA techniques for nuclear energy

Particle characterization

Static Light Scattering (SLS - Laser diffraction)

Static Light Scattering technology measures light scattered at different angles from particles illuminated by laser sources. Different size distributions are calculated based on Mie theory from scattered signals collected thanks to detectors positioned at different angles.

Dynamic Light Scattering (DLS - Photon correlation spectroscopy)

Dynamic Light Scattering technology measures fluctuations in scattered light intensity with time. These fluctuations in intensity are due to random Brownian motion of nanoparticles. Since larger particles move more slowly than small particles, particle size can be determined from these light scattering intensity fluctuations.

Fluorolog-QM

Fluorescence

Fluorescence is an emission of light (luminescence) which appears when a molecule previously excited by the absorption of photons, returns to its original state of energy by emitting light radiation.

HORIBA Scientific, the global leader in fluorescence spectroscopy instrumentation, offers the most extensive product line in steady state and lifetime fluorimetry, including microscope-based solutions.

LabRAM Odyssey

Raman spectroscopy, molecular characterization

Raman spectroscopy is a light-scattering technique. Interaction of laser light with a sample's molecules results in a Raman spectrum which is extremely information rich, providing:

- Chemical composition and distribution
- Molecular structures and functional group characterization
- Crystal forms, chirality, stress, doping, defect/disorder, etc.
- Phase transformation/reaction monitoring
- Spectral imaging/multilayer analysis

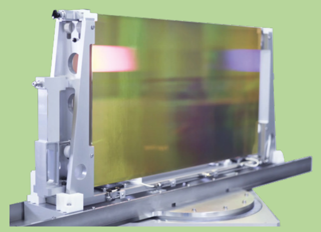
Optimised HORIBA design for easy integration with glove boxes.

PA-100

Radi, environmental radiation monitor

Most environmental radiation consists of three types: Alpha rays (α), beta rays (β) and gamma rays (γ). HORIBA's PA-1000 "Radi" environmental radiation monitor makes it easy for non-specialists to measure even minute levels of gamma.

- Simple radioactivity measurement using environmental radiation monitor
- For Improvement of the safety and security for the local residents and local communities nearby the nuclear power plants



Laser pulsed compression grating

Gratings for high energy or high intensity lasers

HORIBA Scientific is a pioneer in holographic gratings manufacturing and offers a broad range of gratings for laser applications. Notably, HORIBA manufactures the world largest gold-coated gratings for pulse compression of high intensity lasers. HORIBA manufactures transmission gratings for high energy nanosecond pulse lasers for 2w/3w beam splitting and focusing.

- Type: Gold-coated, multi-layer dielectric or transmission gratings
- Dimensions: Up to 1500 mm (world's largest gratings)
- Groove density: typ. 1200/1480/1740 gr/mm or custom design upon request
- Wavelength: 800 / 910 / 1053 nm and corresponding 2w/3w, or custom design upon request
- Efficiency: > 90% (typ. 92%) depending on grating design
- Compatible with ultra-vacuum environment

One of the main components for inertial confinement fusion reactors.

ENDA 7000

PG-350

Stack Gas Analyzer ENDA 7000 or PG-300

The ENDA-7000 is designed to continuously measure the concentrations of NOX, SO_2, CO, CO_2, O_2, and NH_3 in stack flue gas streams. The model is offered in dozens of combinations based on measurement requirements. The ENDA-7000 uses an extractive method which measures undiluted sample gases, and is very suitable to stack gas measurements such as shale gas, LNG, or biogas and other combustion applications.

The PG-300 series is a compact and lightweight gas analyzer designed to measure up to five different gas components simultaneously (CO, CO_2, NO_X, O_2, SO_2, N_2O, CH_4, CO_2, O_2). Its ability to provide precise measurements has been proven in both field and laboratory applications.

VA-5000

Multi-component Gas Analyzer, VA-5000

The Multi-component Gas Analyzer VA-5000 Series is an all-round analyzer that satisfies measurement needs as required for environmental monitoring, energy development support, quality controls, and as a continuous emission monitoring system (CEMS). The VA-5000 Series Gas Analyzer can be configured with up to 4 detector modules within a single case. Many combinations of sensor modules with a wide selection of ranges allows this series of analyzers to be used for a variety of applications. Simultaneous measurement of up to four gas components: CO, CO_2, CH_4, NO, SO_2, N_2O, NH_3, O_2.

More about HORIBA?

The HORIBA Group, made up of 49 companies in 27 countries is a leading company that provides analytical and measurement systems throughout the world.

HORIBA business is evolving in the markets of automotive, process and environmental instruments, medical diagnostics, semiconductor instruments and scientific instruments. We have displayed our strength in the global market, especially in the fields of automotive emissions and stack-gas measurement, air pollution, water pollution monitoring, quality control in various industries, and clinical diagnosis, achieving dramatic growth over the past few years. It is our continual source of joy and pride that our analytical and measurement business can contribute to global environmental conservation, safety and health, and moreover to improving energy problems.

The identity and culture of HORIBA can be defined as follows:

Long-Term Vision: HORIBA demonstrates a commitment to long-term sustainability and growth. A long-term vision entails a focus on innovation and adapting to changing market dynamics.

Technological Excellence: HORIBA places a strong emphasis on technological innovation and excellence, continuously developing and applying advanced technologies to create superior products and solutions.

Innovative: HORIBA actively seeks creative and novel approaches to solving complex problems. It may involve pushing the boundaries of what is possible and embracing new ideas to drive progress and differentiation.

Unique Portfolio and Services: HORIBA offers a portfolio of products and services that are distinct and stand out in the market. This uniqueness implies that the company's offerings cater to specialized or niche markets, providing value that is not readily available elsewhere.

Quality and Demanding Fit to Purpose first: HORIBA offers premium products and services. Quality and uniqueness are valued. This approach supports the company's commitment to long-term growth and technological excellence.

Aimed at Delighting Customers: A customer-centric approach is central to the company's culture. HORIBA is dedicated to exceeding customer expectations and creating a "wow-effect."

Omoshiro-okashiku
Joy and Fun

Corporate motto: Omoshiro Okashiku–Joy and Fun

Our philosophy around work, which occupies a considerable part of our everyday lives, is that we should enjoy what we do, be interested in and proud of it. By enjoying our work, we are living a happier and more fulfilling life. This belief is widely shared by all HORIBARIANs* around the world and reflects the meaning behind our corporate motto, "Joy and Fun," which was established by our late founder, Dr. Masao Horiba in 1978.

There is something special about our technology and how we develop it. Since our foundation, our technology is characterized by "HONMAMON," a word used in Kyoto to describe "authentic excellence" in technology; something we take great pride in.

HORIBA Energy Website
https://horiba.link/energy

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