# Utilization of Quantum Beams for Developments and Prospects for the Future

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Quantum beam analysis brings provides various information of materials that cannot be obtained with laboratory equipment. We have conducted such analysis using synchrotron radiation, muon beams and neutron beams since around 2000. The analysis targets are all kinds of materials used in automobiles such as metals, resin, semiconductors including exhaust gas purification catalysts and secondary batteries. The features of quantum beam analysis that we are particularly interested are the ability to investigate electronic and chemical information of specific elements in a material and to measure from crystal structure to internal structure of components. As examples, the former are *operando* analysis of exhaust catalysts and secondary batteries, the latter are strain distribution measurements and observation of destruction process in power electronics devices. By recognition of benefit of synchrotron radiation, we built contract beamline (BL33XU; Toyota Beamline) at SPring-8 in 2009.

From the viewpoint of manufacturing one of the most effective applications was development of new generation exhaust catalysts. In the conventional development or improvement method for the catalysts, we had examined many materials and procedures with trial and error. So even if we could produce good performance item, we could not succeed to development and improvement of the next generation. By introducing *operando* analysis method of synchrotron radiation, it became possible to clarify the relationship between the chemical state of precious metals in catalyst and catalytic activity, and it became possible to take over knowledge of development and improvement to next generation catalysts. As a result, the method of development and improvement of the catalyst itself could be improved by scientific basis without relying on intuition and experience.

As we began to use quantum beams for industrial applications relatively earlier, we often had to develop devices and analytical methods. For example they were high-speed XAFS measurement system, scanning three-dimensional XRD microscopy, various sample cells for *operando* measurements, application of $\mu$-SR technique to ion diffusion coefficient measurement and XAFS analysis program for large amount of spectra obtained from high-speed XAFS measurements. In recent years, various *operando* measurements technique has become so common that they can be easily carried out with many beam lines, and many users use it. Because it is supposed increase of the need for more advanced measurement and measurement of practical products, the facilities will be expected further support to such need. As an example, the use of two-dimensional detectors has become common and terabytes data may be obtained in one experiment. Developments of software for handling such large amount of data would become much important. Establishment of handling and analysis method of large data is desired.