4 Quantum Beam Science Research

Development of Quantum Beam Technology

Characteristics of quantum beams

Quantum beams such as neutrons, ions, electrons, high intensity lasers, and synchrotron X-rays have a creative function, allowing us to process materials on a nanometer level (atomic or molecular level) as they interact with constituent atoms of a material to change their configuration, composition, and electronic state. Such quantum beam interactions also cause changes in the beams themselves, such as the beam direction and energy, and sometimes generate different types of quantum beams. Thus quantum beams have a probe function as well, whereby we can obtain atomic or molecular level information by observing alteration of the beam parameters.

Application of quantum beams

At JAEA, we are performing advanced beam technology R&D using our beam facility complex, which includes research reactors, accelerators, and so on (Quantum Beam Platform), as shown in Fig.4-1. By utilizing the creative and probe functions of quantum beams, we are promoting fundamental and applied research in a wide range of fields, such as (1) materials science, (2) environment and energy, and (3) life science, advanced medicine and biotechnology, which are listed as the priority fields to be promoted in the Science and Technology Basic Plan of Japan. We are intensively performing these R&D activities to contribute to progress in science and technology as well as the promotion of industry.

Recent achievements

In the materials science field, we clarified the structure and kinetics of water molecules under extremely high temperature and pressure conditions, newly observed the orbital structure of molecules using tunnel ionization, and found Fermi surfaces formed by heavy electrons in metal. We also developed a soft X-ray laser interferometer and first observed the behavior of metal fine particles in a catalyst using time-resolved X-ray absorption spectroscopy. These activities are introduced in Topics 4-1 to 4-5. In Topics 4-6 and 4-7, we describe the origin of the rarest isotope in the solar system, Ta-180, and the identification of noble gas components in meteorites.

In the environment and energy field, we successfully synthesized high performance polymer electrolyte membranes to be applied in fuel cells, fabricated radiation resistant transistors based on SiC semiconductors, and developed a new welding system for inspection and repair of the inner walls of nuclear plant tubes using lasers. These results are shown in Topics 4-8 to 4-10.

In the life science, advanced medicine, and biotechnology field, we succeeded in elucidating the catalytic mechanism of protease using neutron diffraction, and developed a new technique to obtain global conformational changes of ribosome based on electron microscopy data. We also developed a novel radiopharmaceutical that enables us to find very small tumors a few millimeters in size. These achievements are described in Topics 4-11 to 4-13.

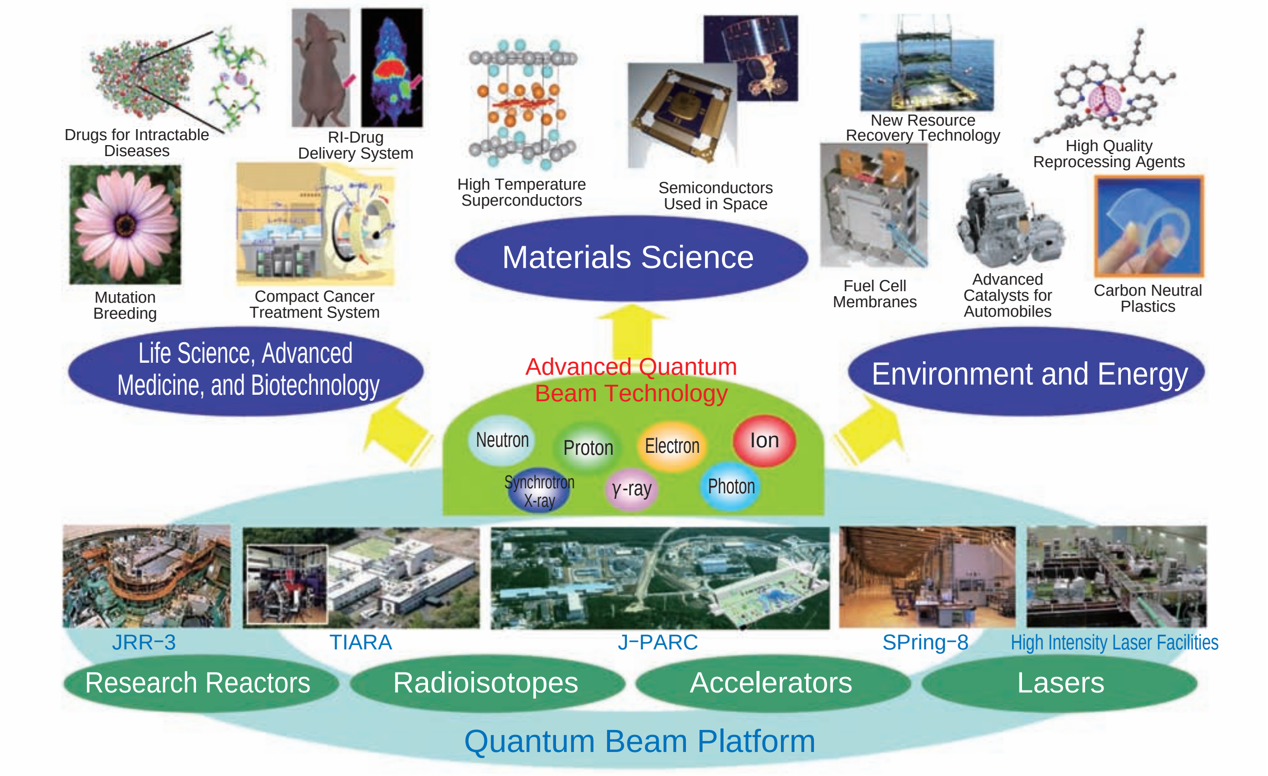

Fig.4-1 JAEA quantum beam facilities and the R&D done there