4 Quantum Beam Science Research

Development of Quantum Beam Technology

Characteristics of quantum beams

Quantum beams, which include electromagnetic waves (lasers, X-rays, γ-rays, etc.) and energetic particles (electrons, protons, neutrons, ions, etc.), possess both wave and particle characteristics. Quantum beams have a creative function, allowing us to process materials on a nanometer level (atomic or molecular level) because 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, e.g., the beam direction and energy, and sometimes generate different types of quantum beams. Thus we can get the atomic or molecular level information by observing alteration of the beam parameters, giving quantum beams a probe function as well.

Application of quantum beams

At JAEA, we are performing R&D of advanced beam technology using neutrons, ions, electrons, γ-rays, lasers and synchrotron X-rays produced in our quantum beam facility complex by research reactors, accelerators, and so on (Quantum Beam Platform) shown in Fig.4-1. By utilizing the creative and probe functions of quantum beams, we do fundamental and applied research in a wide range of fields, e.g. (1) materials science field, (2) environment and energy field, and (3) life science, advanced medicine and biotechnology field, which are listed as the 'Priority Fields to be Promoted' in the 'Science and Technology Basic Plan' of Japan. We are intensively promoting this R&D to contribute to progress in science and technology as well as for the promotion of industry.

Recent achievements

In the materials science field, we have found the collective excitation of electrons in high temperature superconductors, the Mn site dependence of the spin moment of a dilute magnetic semiconductor $Ga_{1-X}Mn_XAs$, the hydrogenation of aluminum with hydrogen fluid, and the degradation modeling of multi-junction space solar cells, which are introduced in Topics 4-1 to 4-4. In the environment and energy field, we have demonstrated breakdown of toxic organic compounds using electron-beam irradiating alumina, isotope separation by excitation of molecular vibration due to ultrashort-pulsed lasers, and isotope mapping of heavily shielded objects using laser Compton γ-rays, Topics 4-5 to 4-7. In the life science, advanced medicine and biotechnology field, we have succeeded in determining the whole atomic structure of HIV-1 protease, which is effective for developing anti-HIV drugs, Topic 4-8. We have also investigated protein dynamics using neutron inelastic scattering, found symbiotic nitrogen fixation with a positron-emitting tracer imaging system, clarified the bystander effect using heavy-ion microbeams, and developed nano-capsules opened by radiation for cancer therapy, Topics 4-9 to 4-12.

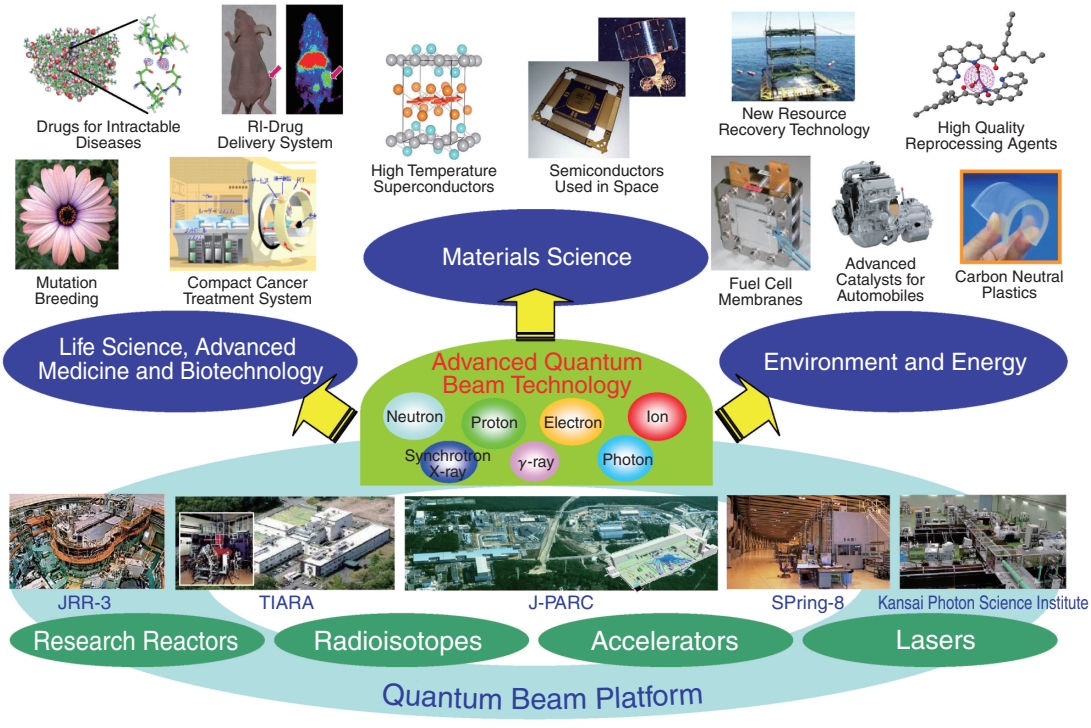

Fig.4-1 JAEA quantum beam facilities and R&D done there