

Contents

Part I

1. Materials Science	1
P1-1 Functional Polymer Research Project	2
Leader : Yasunari Maekawa	
P1-2 Advanced Catalyst Research Project	3
Leader : Tetsuya Yamaki	
P1-3 Positron Nano-Science Research Project	4
Leader : Atsuo Kawasuso	
P1-4 Two-dimensional Material Spintronics Research Project	5
Leader : Seiji Sakai	
P1-5 Semiconductor Radiation Effects Research Project	6
Leader : Takeshi Ohshima	
P1-6 Biocompatible Materials Research Project	7
Leader : Mitsumasa Taguchi	
P1-7 Environmental Polymer Research Project	8
Leader : Noriaki Seko	
P1-8 Element Separation and Analysis Research Project	9
Leader : Hironori Ohba	
P1-9 Advanced Functional Polymer Materials Research Group	10
Leader : Yasunari Maekawa	
2. Life Science	11
P2-1 Ion Beam Mutagenesis Research Project	12
Leader : Yutaka Oono	
P2-2 Microbeam Radiation Biology Research Project	13
Leader : Tomoo Funayama	
P2-3 Medical Radioisotope Application Research Project	14
Leader : Noriko S. Ishioka	
P2-4 Generation of Radioisotopes with Accelerator Neutrons Research Project	15
Leader : Kazuyuki Hashimoto	
P2-5 Radiotracer Imaging Research Project	16
Leader : Naoki Kawachi	
P2-6 Radiation and Biomolecular Science Research Project	17
Leader : Akinari Yokoya	
P2-7 Biomolecular Function Research Project	18
Leader : Motoyasu Adachi	
P2-8 Biomolecular Structure and Dynamics Research Project	19
Leader : Taro Tamada	
3. Advanced Quantum-Beam Technology	21
P3-1 Laser Compton Scattering Gamma-ray Research Project	22
Leader : Ryoichi Hajima	
P3-2 Beam Engineering Section	24
Section Manager : Yasuyuki Ishii	

Part II

1. Materials Science	25
1-01 Single Event Effect Evaluation Results of Cu-based Atom Switch ROM and FPGA	28
1-02 Recovery of Radiation Degradation in InGaP Solar Cells by Light Soaking	29
1-03 Effects of Cosmic Radiation on Time-measuring Analog-digital Mixed ASICs	30
1-04 Radiation Response of Silicon Carbide Junction Field Effect Transistors	31
1-05 Evaluation of Radiation Hardness on Carbon Nanotube Field Effect Transistor	32
1-06 Radiation Damage Tests of Semi-Conductors	33
1-07 Research of the Radiation Tolerance in Space Environment of General Electronic Devices	34
1-08 Preparation of Nano-Structure Controlled Ion-Exchange Membranes by Ion Beams for Application to Seawater Concentration	35
1-09 Preparation of Titanium Dioxide Nanocones Using Ion Track-etched Membranes as Template	36
1-10 Electron Beam Induced Formation of Pt Particles on Ceria Films	37
1-11 Microscopic Observations of Nanostructure in Oxide Ceramics Irradiated with Swift Heavy Ions at Grazing Incidence	38
1-12 Utilization of Ion Implantation for Synthesis of Nitrogen-doped Carbon Material with Catalytic Activity (3)	39
1-13 Control of Pore Shapes in Track-etched Membranes by Using Depth Distribution of LET	40
1-14 DFT Study of the Pt Nanoparticles on the Ar-ion Irradiated Glassy Carbon Substrate	41
1-15 Prediction of Scintillation Light Yield by Heavy Ions Based on Sub-micron Radiation Transport Calculation and Förster Effect	42
1-16 Study on Planar Perfect Blackbody from Etched Ion Tracks	43
1-17 Preparation of Nitrogen-doped Carbon-based Catalysts by Electron-Beam Irradiation During High Temperature Pyrolysis	44
1-18 Electron-Beam Irradiated Electrode of a Redox Flow Battery for Low Internal Resistances	45
1-19 Overvoltage Reduction of Membrane Bunsen Reaction by Using Radiation-grafted Cation Exchange Membranes	46
1-20 Proton Selectivity and Permeability of Cross-linked Radiation-grafted Cation-Exchange Membranes for Efficient HI Concentration	47
1-21 Characterization of (111)-oriented $Ti_{1-x}Al_xN$ Thin Films on Monocrystalline AlN by Reactive CVD	48

1-22	Ion Irradiation-Induced Novel Crystal Lattice Plane Spacing Change in Silicon Carbide Nanotubes	49
1-23	Fabrication and Evaluation of Nanoparticles Bi-Ti-O Ferroelectric Materials by Ion Irradiation	50
1-24	Development of Hydrogen Permselective Membranes by Radiation-Induced Graft Polymerization into Ion-Beam Irradiated Poly Vinylidene Chloride Films	51
1-25	Development of Radiation-grafted Cation and Anion Exchange Membranes for Reverse Electrodialysis Process	52
1-26	The Relationship Between Membrane Properties and Hierarchical Structure of Radiation Grafted Anion Conducting Polymer Electrolyte Membranes	53
1-27	Effect of γ -Ray Irradiation on Friction Property of Poly(vinyl alcohol) Cast-drying on Freeze-thawed Hybrid Gel	54
1-28	Changes in Mechanical Properties of Polyethylene by Gamma-ray Irradiation in Water ..	55
1-29	Synthesis of Fibrous Grafted Adsorbent Having Sulfur-based Functional Group	56
1-30	Development of Boron Removal Technique Combined Grafted Powder Adsorbent with Spring Type Filter	57
1-31	Amidoxime and Ammonium Fabric Adsorbents Prepared by Radiation Grafting for Chromium Removal	58
1-32	Surface Crosslinking of Silicone Rubber by Electron Beam Irradiation	59
1-33	Study on Hydrogen Generation from Cement Solidified Products Loading Low-level Radioactive Liquid Wastes at Tokai Reprocessing Plant	60
1-34	Effects of Displacement Damage, Helium and Hydrogen on Electrical Properties of Silicon Carbide	61
1-35	Effects of Self-Ion Irradiation on Rhenium Distribution and Microstructure in Tungsten-Rhenium Alloy	62
1-36	Hydrogen Gas Measurements of Phosphate Cement Irradiated During Heat Treatment ..	63
1-37	Effect of Damage Depth Profile on Hydrogen Isotopes Dynamics in W	64
1-38	Experimantal Results of Swelling Behavior of FMS Steels Under ADS Irradiation Conditions	65
1-39	Irradiation Tests of Radiation Hard Components and Materials for ITER Blanket Remote Handling System	66
1-40	Development of Radiation Resistant Monitoring System in Light Water Reactor	67
1-41	Development of the Predicting Method for the Long Term Corrosion Under Irradiation	68
1-42	Synergetic Effect of He, H and Displacement Damages on the Void Swelling Behavior of F82H	69
1-43	Change in Hardness of FeCuMn Alloy by Energetic Ion Irradiation	70

1-44	Study on Synthesis of Pd Catalyst from Eluent After Separation Process for High-level Liquid Waste Based on Radiation-induced Reaction	71
1-45	Characterization of Adsorbent for U and Pu Recovery from Degraded PUREX Solvent	72
1-46	Gamma ray Irradiation Durability of CMPO Adsorbent for MA(III) Recovery	73
1-47	Synthetic Reference Sample by Electron Irradiation for IR Measurement of Carbon Concentration in Silicon Crystal	74
2.	Life Science	75
2-01	Validation of Ion Species and Beam Size Availability in Collimating Ion Microbeam System of TIARA	78
2-02	Reduction of Clonogenicity and Inhibition of 5-bromo-2'-deoxyuridine Incorporation in Glioblastoma Cells After Gamma-ray and Carbon-ion Irradiation	79
2-03	Bystander Cellular Effects Induced in Normal Human Fibroblasts by 190 MeV $^{12}\text{C}^{6+}$ and 220 MeV $^{20}\text{Ne}^{8+}$ Ions	80
2-04	LET and Ion Species Dependence of Oxidative Damage in DNA Sheet Generated Along Ion Beam Track	81
2-05	Cell Cycle Arrest and Reentry in <i>Bombyx</i> Embryo at Cleavage Stage After Heavy Ion Irradiation	82
2-06	Carbon-ion Microbeam Revealed Abscopal Activation of Microglia After Lesions by Irradiation in Medaka Embryonic Brain	83
2-07	Development of Wettable Ultra-thin Microfluidic Chip for Immobilization of <i>C. elegans</i> During Microbeam Irradiation	84
2-08	Effects of Carbon Ion Irradiation on Swimming in the Nematode <i>C. elegans</i>	85
2-09	Apparent Distance Between Lesions in DNA Irradiated with $^{4}\text{He}^{2+}$ Beam in a Cell-Mimetic Aqueous Solution	86
2-10	Genome Wide Analysis of Rice Mutants Isolated from Ion-Beam-Mutagenized Population	87
2-11	Mutation Frequency in Flavonoid Genes Under Different Flavonoid Phenotypic Conditions	88
2-12	Mutagenesis of the Oil-producing Algae by Ion Beam Irradiation	89
2-13	Screening of Root Nodule Bacteria for Salinity Tolerance Using Ion Beams Irradiation	90
2-14	Ion Beam Breeding of Rice for the Mutation Breeding Project of the Forum for Nuclear Cooperation in Asia (FNCA)	91
2-15	The Moss <i>Physcomitrella patens</i> Is Hyperresistant to DNA Double-strand Breaks Induced by Ionizing Radiation	92
2-16	Evaluation of Particle Fluence of Cluster and Monomer Ion Beams Using a Solid-state Track Detector	93

2-17	Induction of Chromosomal Aberrations in <i>Albuca virens</i> ($2n=6$, Hyacinthaceae) via Ion Beam Irradiation	94
2-18	Improvement of Cut Flower Weight of Autumn-flowering Spray Chrysanthemum 'Kyura Syusa'	95
2-19	Development of New Strains with Sporeless Mutation in Mushrooms Using Ion Beam Irradiation	96
2-20	Breeding of Non-Urea Producing Gunma KAZE Yeasts Which Are Suitable for Export	97
2-21	Effect of Ion-Beam Irradiation on the Sensitivity of Oleaginous Yeast <i>Lipomyces starkeyi</i> Against Fatty Acid Synthesis-Inhibitor Cerulenin	98
2-22	Mutation Breeding of <i>Tweedia caerulea</i> 'Pure Blue' by Ion Beam Irradiation	99
2-23	Genome Analysis of the Radioresistant Bacterium <i>Deinococcus aerius</i> TR0125	100
2-24	Effect of Ion Beams and Gamma Rays Irradiation on Mutation Induction in <i>Bacillus subtilis</i> Spores	101
2-25	Study of the Lethal Effect Caused by the Various LET Particle Ion Beam in Budding Yeast <i>S. cerevisiae</i>	102
2-26	Microflora Analysis of Black Pepper Using MALDI-TOF Mass Spectrometry and Decontamination by Gamma-ray Irradiation	103
2-27	Breeding of New Potted Flower Varieties Using Ion Beam	104
2-28	Creation of Mutant Cultivars by Ion Beam Irradiation to Diploid and Tetraploid <i>Tweedia caerulea</i>	105
2-29	Analysis of Response Deficient Mutants of <i>Streptomyces coelicolor</i> to Contact-dependent Stimuli	106
2-30	Knockout and Plasmid Complementation of the <i>pprA</i> Gene in the Radioresistant Bacterium <i>Deinococcus radiodurans</i>	107
2-31	Effects of Growth Stages on Cadmium Accumulation in Shoot of Oilseed Rape Plants	108
2-32	A Simulation Study on Imaging of Carbon-Ion Beams Using a Pinhole Camera Measuring Secondary Electron Bremsstrahlung	109
2-33	Development of a Cost-Effective Compton Camera for Targeted Alpha-Particle Radiotherapy	110
2-34	Comparison of Iron Localization in <i>Lotus japonicus</i> Root Using Micro-PIXE	111
2-35	Analysis of Trace Elements in Acute Myelogenous Leukemia Cell Line Using In-Air Micro-PIXE	112
2-36	Elemental Analysis of the Lungs in Patients with Idiopathic Pulmonary Fibrosis	113
2-37	Long-term Fluorine Penetration from Fluoride-containing Luting Materials to Dentin	114
2-38	Boron Analysis and Imaging of U251 Cells by Using Micro-Particle Induced X/Gamma Ray Emission	115

2-39	Search Trace Elements in Brain Microvascular Endothelial Cells (BMECs) and Effects of Nicotine on Trace Element in BMECs	116
2-40	Kinetics of Encapsulated Hyaluronic Acid-Protamine Particle After Intravenous Injection	117
2-41	Astatediated Antibody Fragment for Reducing Renal Radioactivity Levels	118
3.	Advanced Quantum-Beam Technology	119
3-01	Fabrication of Mach-Zehnder Waveguide Embedded in Biocompatible Thin Film by Proton Beam Writing	121
3-02	Refractive Index Change and Thermo-Optic Effect in Polydimethylsiloxane Nanocomposites with Oxide Nanoparticles Induced by Proton Beam Writing	122
3-03	Quantification of Damage to a Biomolecular Sample in Transmission SIMS Using MeV C ₆₀ Primary Ions	123
3-04	Lithium Distribution Analysis in All-solid-state Lithium Battery Using Maxicrobeam PIXE and PIGE Techniques	124
3-05	Vacancy-induced Magnetism in GaN Film Probed by Spin-polarized Positron Beam	125
3-06	Dopant Dependence on Vacancy Defects in Ion-Beam Synthesized β-FeSi ₂ Films	126
3-07	Properties of Scintillation Emission Signal from Nd:YAG/Cr:YAG Composite by Gamma Ray Irradiation	127
3-08	Status Report on Technical Developments of the TIARA AVF Cyclotron	128
3-09	Dynamic Behavior of Elements with Low Atomic Numbers in Lithium Oxide Ceramics Under Irradiation	129
3-10	Analysis of Linear Energy Transfer Effects on the Scintillation Properties of Ce:Gd ₃ Al ₂ Ga ₃ O ₁₂ (GAGG)	130
3-11	Measurements of Relative Angular Distribution of the n-p Elastic Scattering Reaction for 45-MeV Neutrons	131
3-12	Photo-stimulated Luminescence of G2000 and Recovery by Annealing	132
3-13	Technical Development of Continuous Uniform Ion Irradiation for Production of Track-etched Membranes	133
3-14	Flux Enhancement of Carbon Ion Beams Guided by Cylindrical Glass Channel	134
3-15	The Number Distribution of Emitted Negative Secondary Ions for Sub MeV C ₆₀ Impacts ..	135
3-16	Shape Elongation of Embedded Metal Nanoparticles Induced by C ₆₀ Cluster Ion Irradiation	136
3-17	Observation of Magnetic Depth Profiles for C Cluster Ion Irradiated FeRh Thin Films with Depth-resolved X-ray Magnetic Circular Dichroism	137
3-18	Porous Structure on Ge Surface Formed by C ₆₀ Ion Beam Irradiation	138

3-19	Ion Energy Dependence of Optical Absorption Spectra for Silica Glass Implanted with Ag Ions	139
3-20	Micro-PIXE Analysis Study of Ferrite Products Synthesized from Simulated Radioactive Liquid Waste Containing Chemical Hazardous Elements	140
3-21	Ion Beam Induced Luminescence of Eu ³⁺ extracted by HDEHP	141
3-22	Dating of the Yamada Fault Distributed on Tango Peninsula Using Radiation Defect Radical Centers	142
3-23	Preliminary Test of a Penning Ionization Gauge Ion Source with Electromagnets for a Compact Ion Microbeam System	143
3-24	Reduction of Beam Diameter by Optimization of an Extraction Condition in a Compact Ion Microbeam System	144
3-25	Status Report on Technical Developments at Electrostatic Accelerators	145
4.	Status of Quantum-Beam Facilities	147
4-01	Utilization Status at TIARA Facility	148
4-02	Operation of the AVF Cyclotron	149
4-03	Operation of Electrostatics Accelerators in TIARA	150
4-04	Operation of the Electron Accelerator and the Gamma-ray Irradiation Facilities	151
4-05	Utilization Status of the Electron Accelerator and the Gamma-ray Irradiation Facilities	152
4-06	Radiation Monitoring in TIARA	153
4-07	Radioactive Waste Management in TIARA	154
4-08	Facility Use Program in Takasaki Advanced Radiation Research Institute (TARRI)	155
Appendices	157	
Appendix 1	Publication list	158
Appendix 2	Type of Research Collaboration and Facilities Used for Research	179
Appendix 3	Examples of Typical Abbreviation Name for Organizations in National Institutes for Quantum and Radiological Science and Technology, and Japan Atomic Energy Agency	181