Space and Propulsion

Output

Sample Return

Satellite Constel.

All-Electric Satellite

Space Debris Removal

Low-Cost Mass Trans.

High power Hall thruster, Helicon thruster, Nuclear fusion propulsion, MPD thruster (Newton to 100 Newton class)

R&D

Hall thruster, ion engine, helicon thruster (millinewton to newton class)

Small ion engine, electrospray, PPT
Micronewton to millinewton class thrusters

Biotechnology

Output

Agri. (cultivat. & breed. and their stimulation)

Improvement of fisheries and soil environ.

Food/Fertil. /Animal Feed

Disinfect./Steril./Insect.

Maintaining freshness and reducing food waste

Health/Reg. Medicine

Activate Cell Func.

Drug Discovery and Pharmaceuticals

Med. Care (Cancer/Immun./Infect. Dis.)

Preclinical → Clinical → Safety Verification PMDA

R&D

Micromolecules into Cells

Macromolecules (gene) into Cells

Single Cell Treatment

Monitoring and control of the spatial and temporal distribution of dose and amount of introduced chemicals in living organisms

Resource-Saving and Low-Carbon

Output

All-Solid-State Li-Ion Bat. (S-C)

All-Solid-State Li-Ion Bat. (S-Si)

Innovative Bat. (F, Zn)

Li-Air Bat.

CO2 to CH4, and CH4 pyrolysis

CH4 pyrolysis implement.

Liquid Fuel Synthesis

Sustainable Aviation Fuel

Functional Carbon Mater.

Precious metal-free catal.

Beyond Haber-Bosch (Nitrate, ammonia, amino acids)

R&D

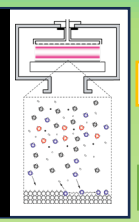
Scale-up of distributed non-thermal plasma reactors

Process electrification / Recycling and reuse technology

Energy-saving and green mass production technology

Room Temp. Catal.

Film Formation and Material Synthesis



Output

Silicon

Low-Dim. Semiconductors (Nanosheets/Nanowires)
3D Nano Devices

Quick production of semiconductors for Quantum Computers
LSI Devices with Photonics + Electronics

Carbon

Large Area Single Crystal Diamond Wafer
Carbon Nano Dev. Low-Dim. Semicond.

Ultra-High Eff. Power Devices
Org./Inorg. Hybrids

Quantum Devices
Q-Carbon Artificial Organs

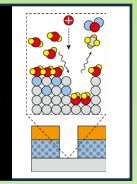
Inorganic

Oxides (Functional Dev. & Next-Gen. Power Semicond.) Nanomater. Mass Prod. for 2nd Bat. High-Power/Extreme-Life 2nd. Bat.
Rare-Earth-Free Ferromagn. Binary Alloy Nanomater. Innovative Solar Cell Mater. Environ.-Friendly Devices

R&D

Diamond (Precision/Speed/Large-Area/Single Cryst./Spin-Conductivity Cont.) Film Formation (Low-Damage/Low-Temp./Hi-Speed)
CNT (Chiral. Cont.) Si (Sel. Transfer/Growth) 2D Mater. (Stack. Angle Cont.) Single-Molecule Scale Struct. Orient. Cont. Integration
Multi-element Nano. Wafer bonding Hi-temp. Sup. Cond. Nano. Quantum Prop.Cont.Synth. Self-Org. Nano. Low-Environ.-Impact Processes

Micro/Nano Manufacturing



Output

Higher Integ. & Performance of Conv. Devices

Quantum Computing, Neuromorphic (New Materials, New Structure Devices)

Fin/GAA FET

3D stacking (CFET)

New Channel Materials (Ge, 2D Materials, CNTs, Oxides)

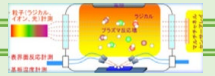
Backside wiring (new mater./struct.)

3D Stacked Heterojunction Devices

R&D

Low Environmental Impact (Low GWP Gas, Energy Circulation, etc.)

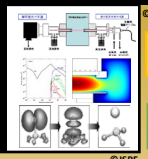
Autonomous Control (Hi-Precision Monitor, Feedback Cont., AI-Assisted Feedforward Cont.)



Hi-Precision (High AR, Hi-Lateral Precision, Damage Suppress./Recover., Atomic/Molecular Rearrange., ...)

Basic Science

Generation / Measurements / Control / Modeling / Simulation



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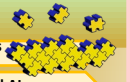
Output

Particle Density Distrib. Cont.

Particle Energy Cont.

Atomic/Molecular Scale Control of Elementary Reactions and Self-Organization



Time-Space Resolved Hi-Speed Meas. of Multiple Parameters

Elementary Processes as "White-Box" using Machine Learning and AI

Multi-scale and multi-phase simulation

Virtual Reality of Plasma Processing

R&D

Advanced Ab Initio Calc. (Elec/Vib/Rot Excitation, Radiatoin, ...)

Quantum Dynamics Calc. of Excited States

Reliable Basic Data Accumulation

Data Complementation Using Info. & Comput. Sci.

Short-Term Update of Reliable Database

Plasma propulsion will provide low-cost mass transport for large-scale space infrastructure

Plasma agriculture, forestry and fisheries are also used in space

Extreme Env. Agri., Forestry and Fisheries (Space & Deep sea)

Designer Cells

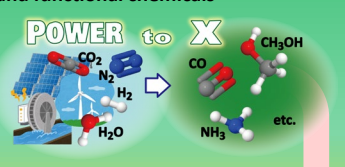
Plasma medicine can also be used in space life

Functional crops
- Fertilizer
- Fuel
(resource return)

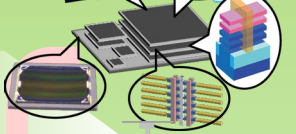
Plasma Chem. Industry supports Plasma Agri., Forestry and Fisheries

Tailor-made medical

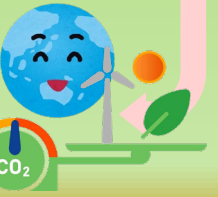
Carbon-neutral Plasma Chemical Industry synthesizes and recycles functional catalysts and functional chemicals



Carbon-neutral autonomously controlled high-precision plasma equipment synthesizes fundamental materials for Well-Being & Society 5.0 and turns them into devices



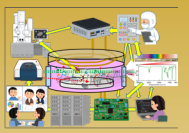
CO2 circulation technol. supports low-carbon mater. processes



Adv. info. process. devices accelerate plasma comput. sci.

Interactive VR plasma process design and analysis tool

Process navigation system using in-situ measurement and digital twin



2020 2030 2040 2050 **Carbon-Neutral / Well-Being / Society 5.0**

Image Sources: JAXA, Akihiro Ikeshita, ITER, Pale Blue Inc., NU-Rei, Medgadget, The Japan Society of Plasma Science and Nuclear Fusion Research, Irasutoya