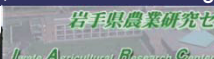




High-voltage and plasma applications for agriculture and food safety



K.TAKAKI (Iwate University); **Collaborations:** Fukuoka Agricultural Research Center, Kyushu Univ., National Institute Advance Industrial Science & Technology, Iwate Agricultural Research Center, Iwate biotechnology research center.



Coaxial cable

Lightning Makes Mushrooms Multiply

High voltage electricity stimulates multiplication of mushrooms (Top: No voltage applied. Bottom: 50,000 volts applied)

Normal +5°C **"HYOKAN Feel Technology" +9°C**

Maintains freshness of agricultural and fishery products with high voltage (Left: w/o electrostatics. Right: w/ electrostatics).

Easy to handle high voltage power supply

Discharge inside cable Liquid region

Streamer discharges Gas region

Plasma generation by a high voltage power supply

Electrolytic extraction of useful components (polyphenol) from crops (Left: w/o pulse electric field applied. Right: w/ pulse electric field applied.)

Enhancement of the komatsuna growth with plasma irradiation to cultivation water (Left: No plasma irradiation, Middle: 10 mins. plasma, Right: 20 mins. plasma)

Inactivation of ralstonia solanacearum in culture for tomato seedlings with plasma (Left: Culture without bacteria. Middle: Culture with bacteria. Right: Culture treated with plasma after the bacteria is mixed in.)

What kind of research?

<Increases agricultural/fishery productivity using high voltage plasma>

Thunder (lightning) is called "Inazuma" (稲妻), which means the good partner of rice plant growth. Thunder has long been considered essential for the vegetation of rice and other plants. Thunder is actually high voltage plasma. We developed a compact high-voltage plasma generation system that is easy to use in order to elucidate the mechanism of the high-voltage plasma contribution on vegetation and control of an environment suitable for the plant growth. With this system, high voltage plasma can be utilized to control cultivation and fruition, maintaining the freshness of agricultural and fishery products, and extracting functional components in food even without the professional knowledge of high voltage electricity or plasma.

● Nitrogen fixation and biostimulation with high voltage plasma ● Capturing and deactivating bacteria using the static electricity in the storage

Nitrogen fixation in the cultivation water and nitrate ions taken in by plants controlled by plasma

Applying electric field to cut shiitake mushroom hyphae and followed activation of enzymes

Changes in the viable bacteria and basidiomycetes numbers by applying high voltage to wire electrodes (log-scale)

What is it useful for?

<Stable harvest, shorter cultivation, maintenance of the freshness of the harvested products>

● Nitrogen fixation and biostimulation with high voltage plasma ● Eliminating and inactivating bacteria using electrostatic effect in the food storage

Growth rate increases with discharge time 2.5 times

2.1 times

Growth enhancement of Komatsuna plant and increment of sugar content of strawberry by plasma irradiation

Enhancement in shiitake harvest by applying high voltage to bed logs

Maintains the freshness of peaches and reduces drop loss in sea urchin by applying an electric field in food storage

How is "Plasma" used in our research

Techs for High voltage pulsed

Plasma generation

Air ions NO₃⁻, H₂O⁺

Electrostatic eliminator

Water purification

Active species O₃, ·OH, ·O...

Sterilization

for Hydroponics

Preservation of vegetables

Ethylene (C₂H₄)

Agricultural Applications of High Voltage

High Voltage / Pulsed Power Technologies

10 kV ~ 100 kV, 10 ns ~ 100 μs

Pulsed Electric Field

Generated by high voltage pulses (E = -grad V)

Mechanical action and stress are applied on cell, membrane and protein

Plasma: One of the states of matter, consisted of electrons and ions produced by ionization of neutral molecules in gas.

Production of Reactive Species which has high oxidation potential

H₂O + e⁻ → ·OH + ·H + e⁻

e⁻ + O₂ → ·O(·D) + ·O(·P) + e⁻

·O(·P) + O₂ + M → O₃ + M

·O(·D) + H₂O → ·OH + ·OH

Waveforms of VI

Agricultural Applications of High Voltage

Pulsed Electric Field

Generated by high voltage pulses (E = -grad V)

Mechanical action and stress are applied on cell, membrane and protein

Use in Brewing and Fermentation: Inactivation of enzymes and bacteria without heating- Reduction of losses of flavor components

Use in Food Processing Extraction of Useful component from grape skin by destruction of cell membrane:

After pulsed electric field

Anthocyanoplasts: Contains polyphenol inside of membrane

Use in Mushroom Production: Improvement of Production by applying stress on hypha

Lightning Makes Mushrooms Multiply

w/o E.F. w/ E.F.

Hypha after pulse application

Agricultural Application of High Voltage

Plasma: Production of **reactive species** which has high oxidation potential such as O₃, ·OH, ·O

Waste water treatment: decomposition of toxic organic compounds

Use in hydroponics: Improvement of production/ Reduction of infection risk(Inactivation of Bacteria)

Use in Fruits /Vegetable Storage: Keeping freshness by decomposition of Ethylene(C₂H₄)

Ethylene(C₂H₄) release

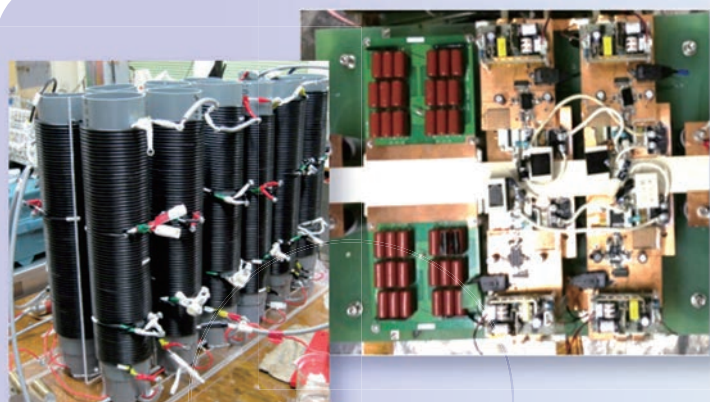
Ripening Damage on fruit Quality loss

C₂H₄ + O₃ → CO₂ + H₂O...

Plasma/Pulsed Power Lab.

We have studied the fundamental characteristics and applications of high voltage pulsed power system and plasma discharge.

Prof. Koichi Takaki
Dr. Katsuyuki Takahashi

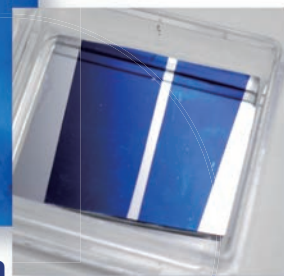


High voltage pulsed power system
Generating plasma, Ion accelerator
Development of nanosecond pulse generator
Evaluation of SiC devices
Application to accelerator



High density plasma
Deposition, Etching

Evaluation of film properties
Improvement of deposition rate
Development of high density plasma source
Diagnosis of plasma



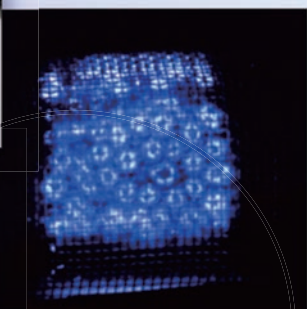
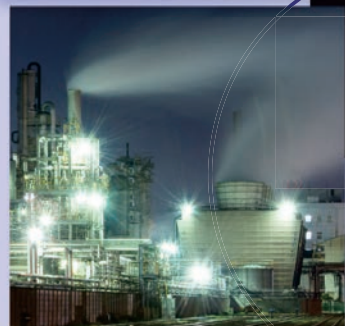
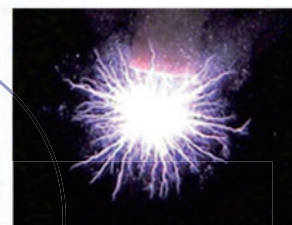
Plasma in water

Water remediation

Decomposition of organic compounds
Development of treatment system

Hydroponic culture

Reduction of infection risk
Sterilization
Nutrient supply by plasma
Pilot trial on farm



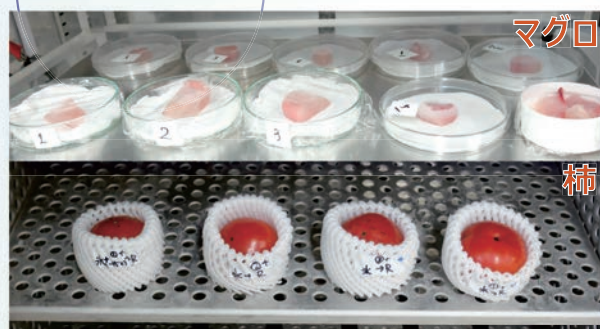
Atmospheric plasma
Gas treatment, ion generating

Treatment of exhaust gases (NO_x)
Removal of ethylene released by fruits
Combined system of catalyst
Development of electrostatic eliminator

High electric field

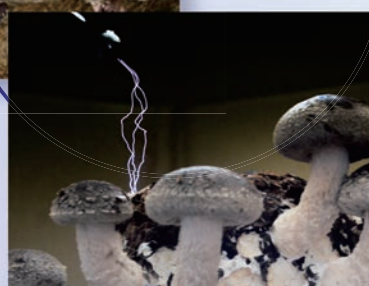
Keeping freshness of marine and agricultural products

Evaluation of conformational change of protein



Artificial lightning
Stimulation for mushroom cultivation

Improvement of yield
Elucidation of mechanism based on enzyme expression



Science events

Science events for children
Development of educational materials

