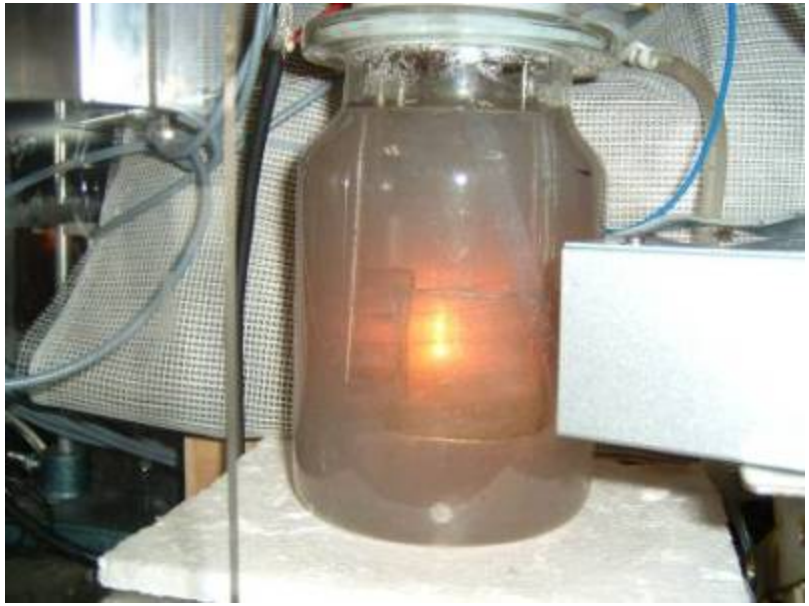
Experimental study of glow discharge in light water with W electrodes



D.Y. Chung (1)(2), Y. Aoki (2), F. Senftle (1) and T. Mizuno (2)

(1) Department of Physics, Howard University, Washington, D.C. 20059, USA

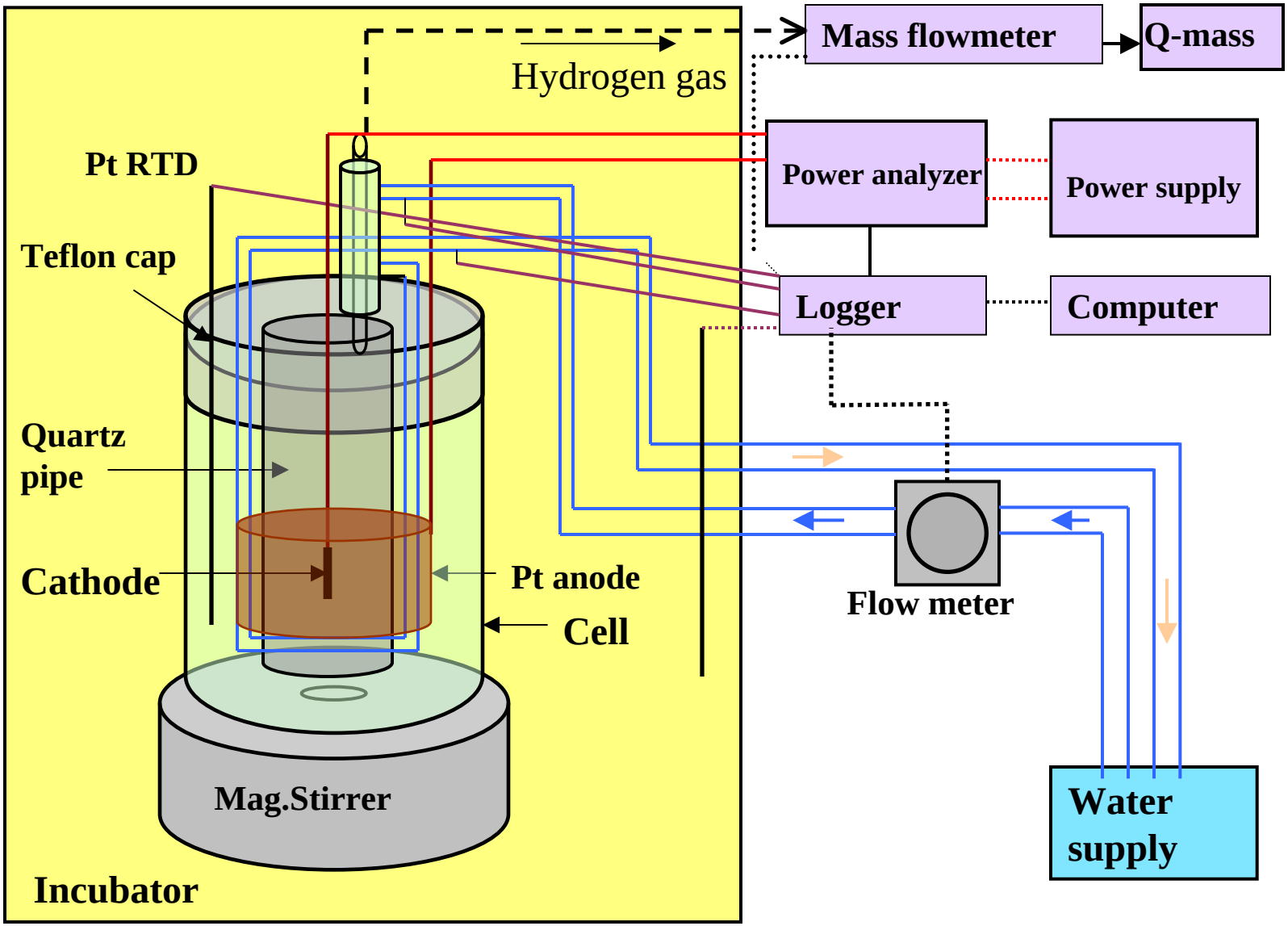
(2) Graduate School of Engineering, Hokkaido University, Sapporo 060-8628, Japan

Content

- **Experimental**
- Measurement; heat, hydrogen, gas composition and element
- **Results**
- Heat and element


View of plasma electrolysis
pyrometer
Neutron counting
RTD
Flow meter
pyrometer
Cell
X-ray detector
Power meter
Power supply

Sketch of experimental set up



Detail of the gas measurement

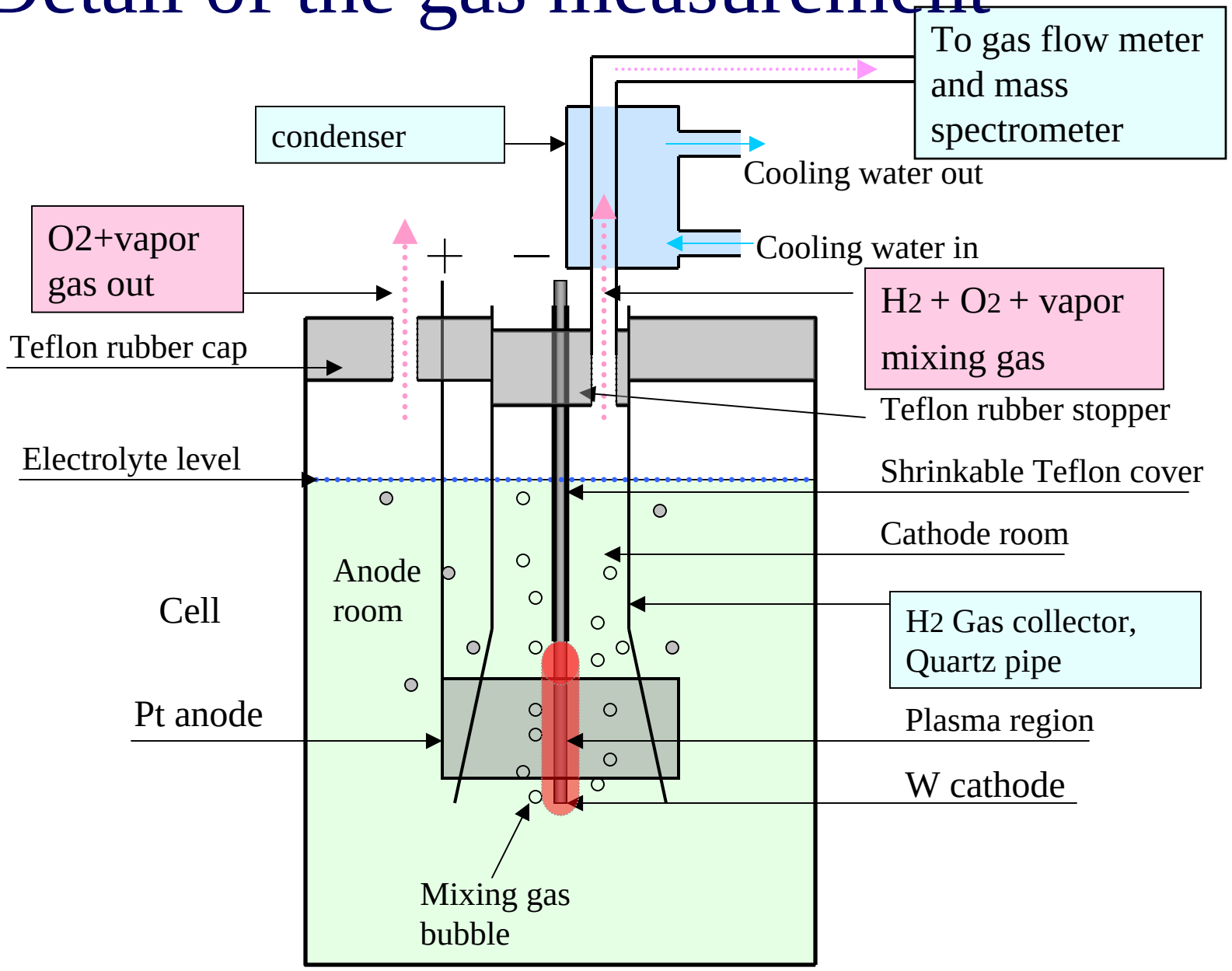


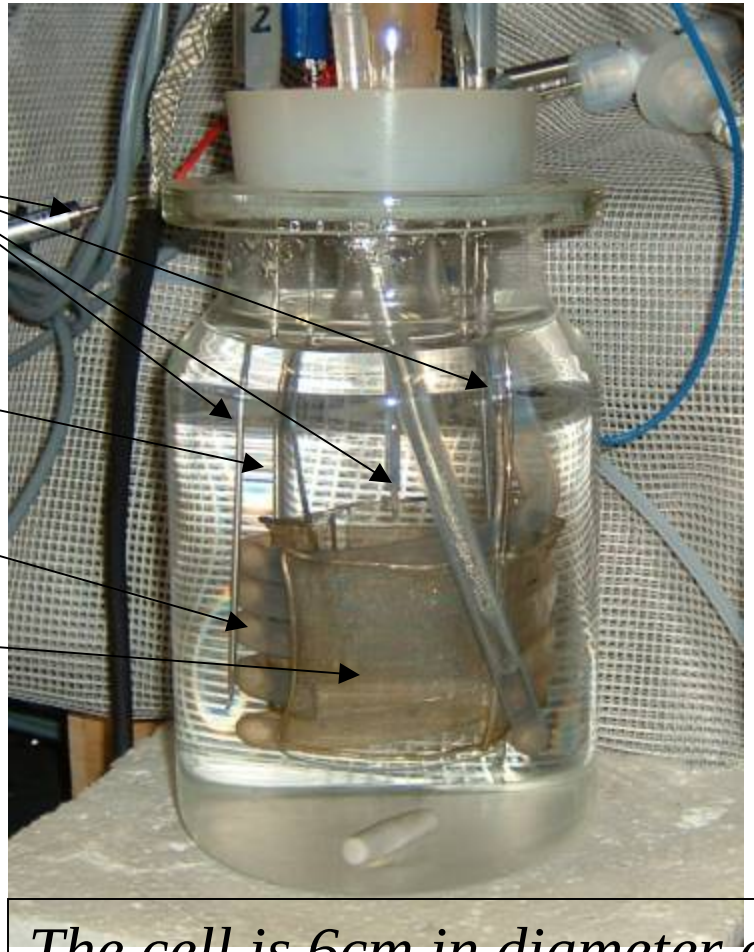
Photo of cell

RTD: *Pt resistance thermometer, 0.001deg*

glass dome

coolant coil

Pt anode



Rectangular Pt had an integral lattice constructed using a 15cm length of 0.1cm in diameter.

The cell is 6cm in diameter and 15cm in height.

Electrode

- The W wire; high purity (99.9%, Nilaco metals LTD).
- The cathode comprised a 1.5cm diameter and 15cm length of wire.

Before After

Electrolyte

- Light water; *purified through a milli-Q filter up to 18.3 Ohm-cm of resistively.*
- K_2CO_3 ; *Kanto Chem.CO., INC., 99.5%*

Input power supply

- Takasago Products LTD, EX-1500L and EX-750, 15A and 480v.
- Input power analyzer
- *Yokogawa-PZ4000, 50 μ sec sampling time, for 4s = 80000 data points*

Out put power measurement

- The logger converted input levels into a digital format acceptable to the computer software and the input voltage was directly measured between the two electrodes of the cell.

Coolant flow meter

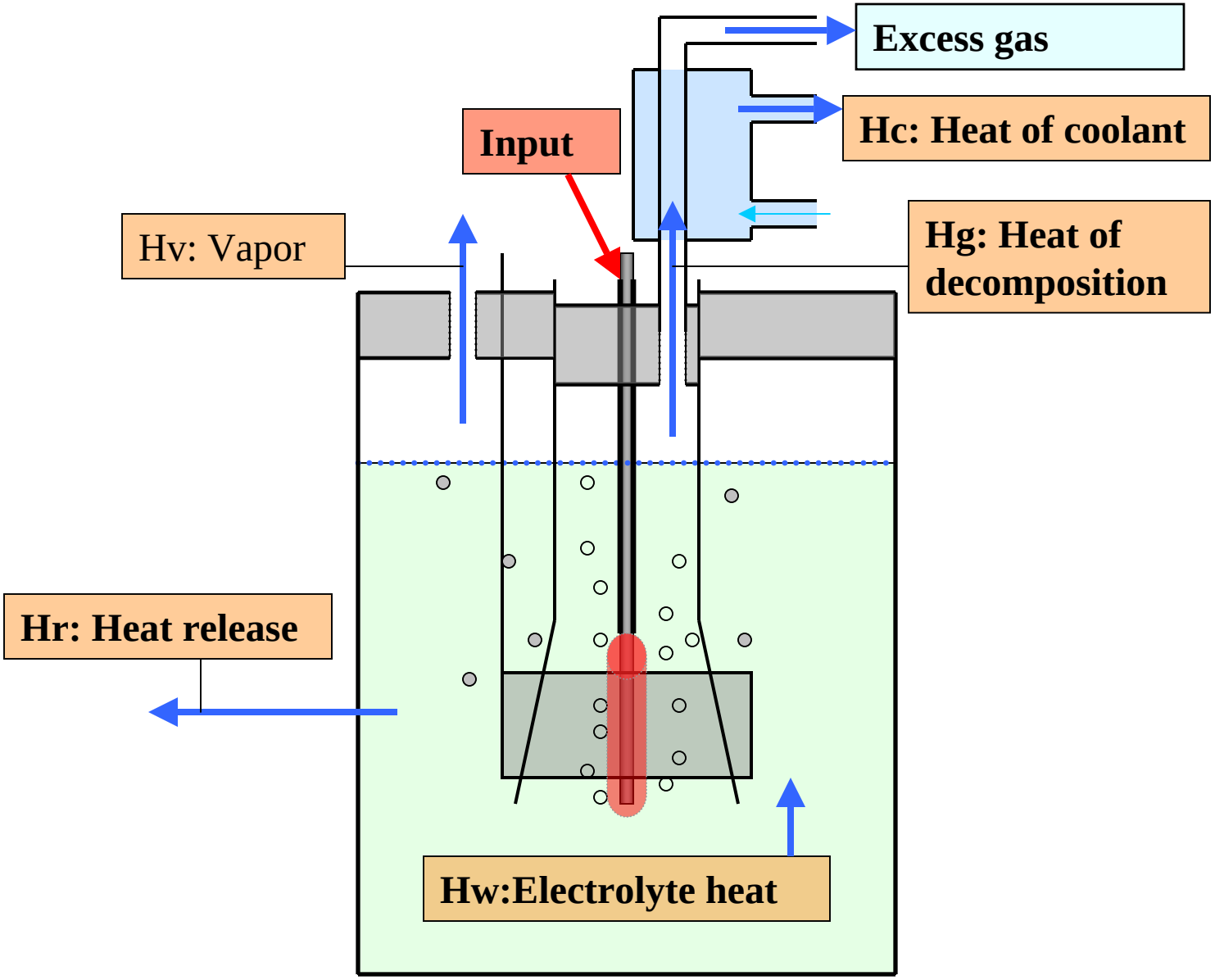
controller

Turbine meter:
0.0001g/s

Heat balance

- **Input** (J) = **I** (current) · **V**(Volt) · **t**
- **Out** = Hg + Hw + HC + Hr + Hv
- 1: Hg = Heat of decomposition $= \int 1.48 \cdot dI \cdot dt$
- 2: Hw = Electrolyte heat $= \int Ww \cdot Cw \cdot \delta T$
- Ww:electrolyte weight,Cw:heat capacity, δ T:temperature difference
- 3: Hc = Heat of coolant $= \int Wc \cdot Cc \cdot \delta T$
- Wc:coolant weight, Cc:heat capacity, δ T:temperature difference
- 4: Hr = Heat release $= \int (Ww \cdot Cw + Wc \cdot Cc)Tr$
- *Tr:temperature change*
- 5: Hv = vapor = $Wv \cdot Cc$

Heat balance



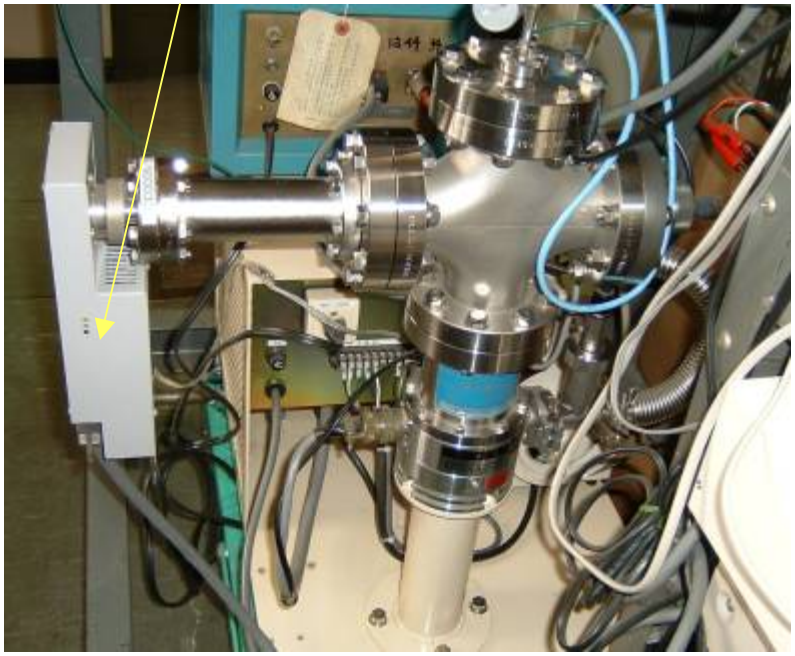
Photos of gas analysis equipment

Mass flow meter: model-3100 made by Kofloc Co

Mass flow controller:

CR-700 Kofloc

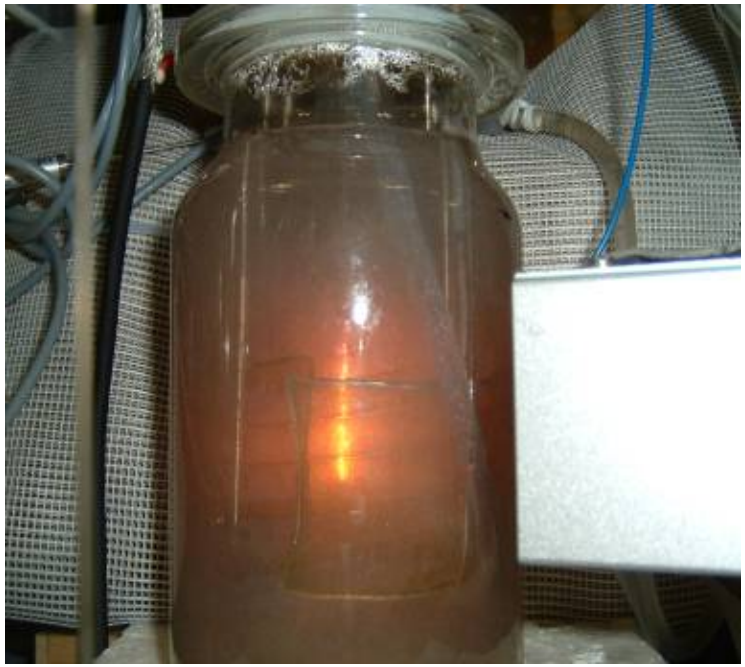
Q-mass spectrum analyzer



Elements Analysis

EDX analyzer

ICP mass analyzer



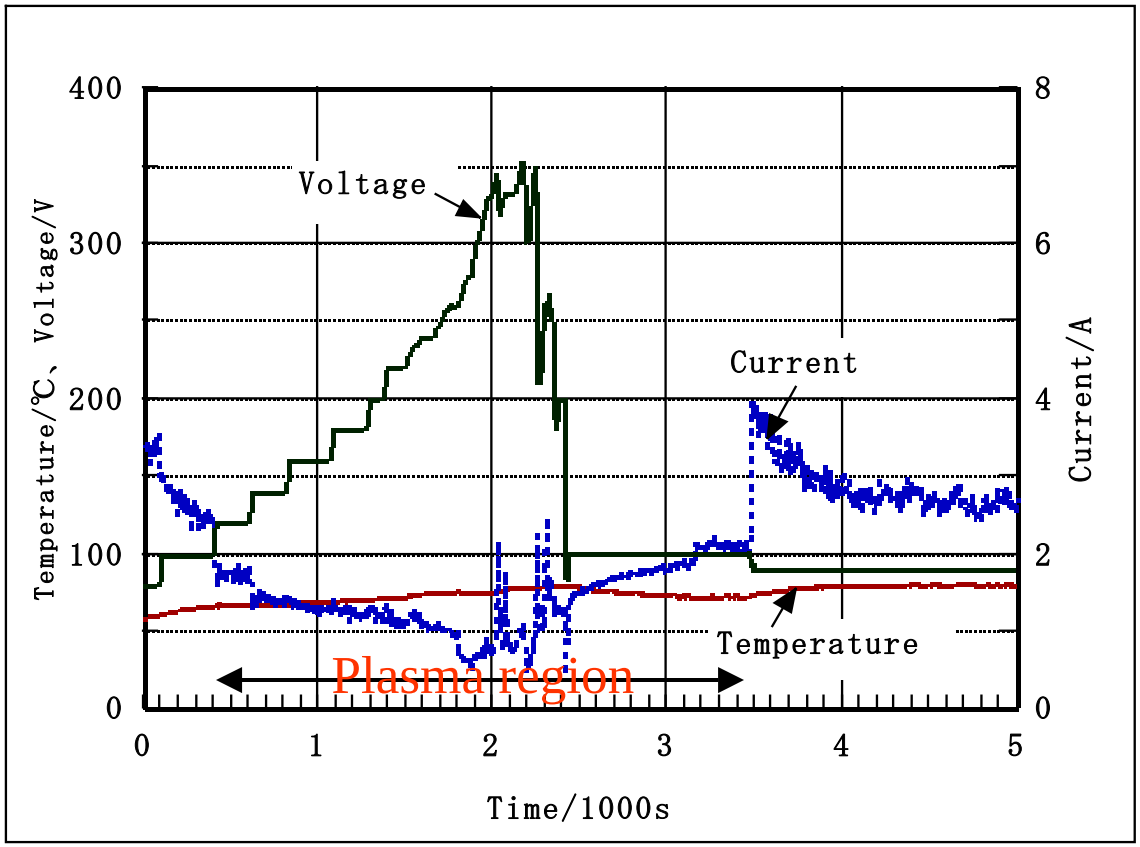
Plasma

W electrode 1.5 ϕ ,30mm

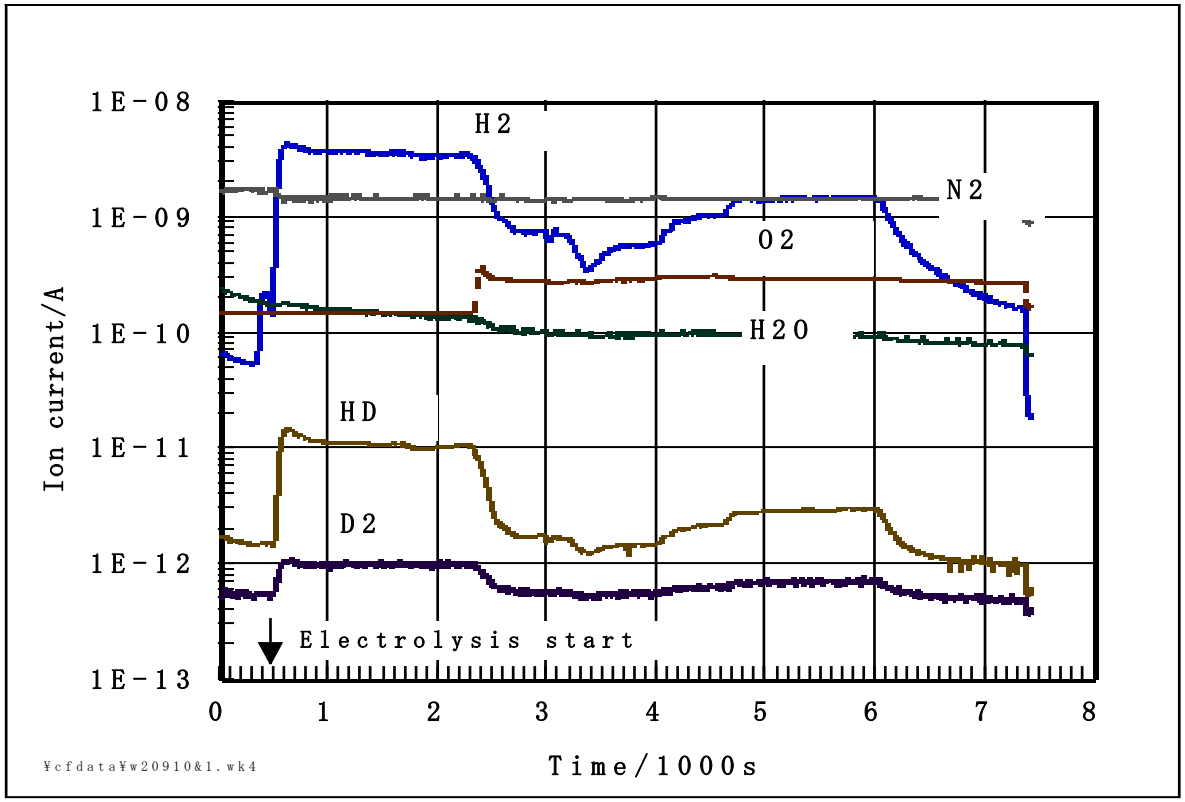
220V,1.2A,90C

Current efficiency;500%

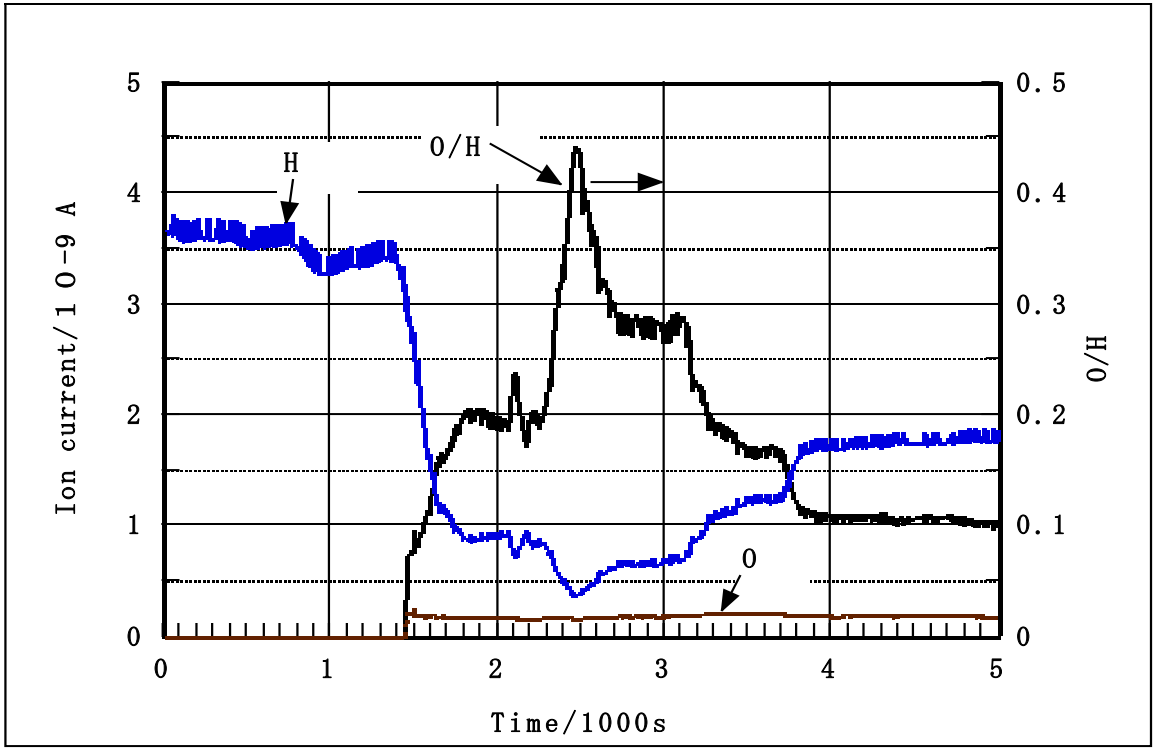
Time changes of input Voltage, current and solution temperature



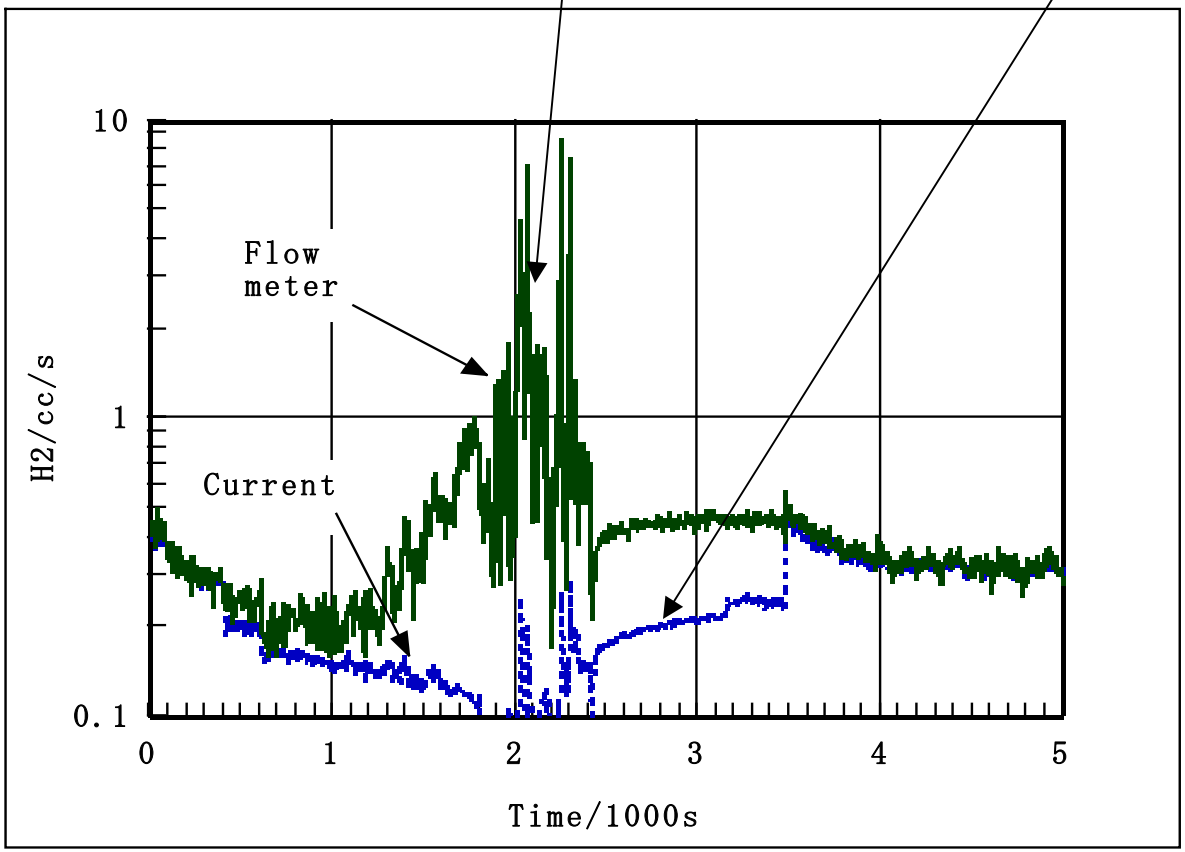
Time changes of various gas



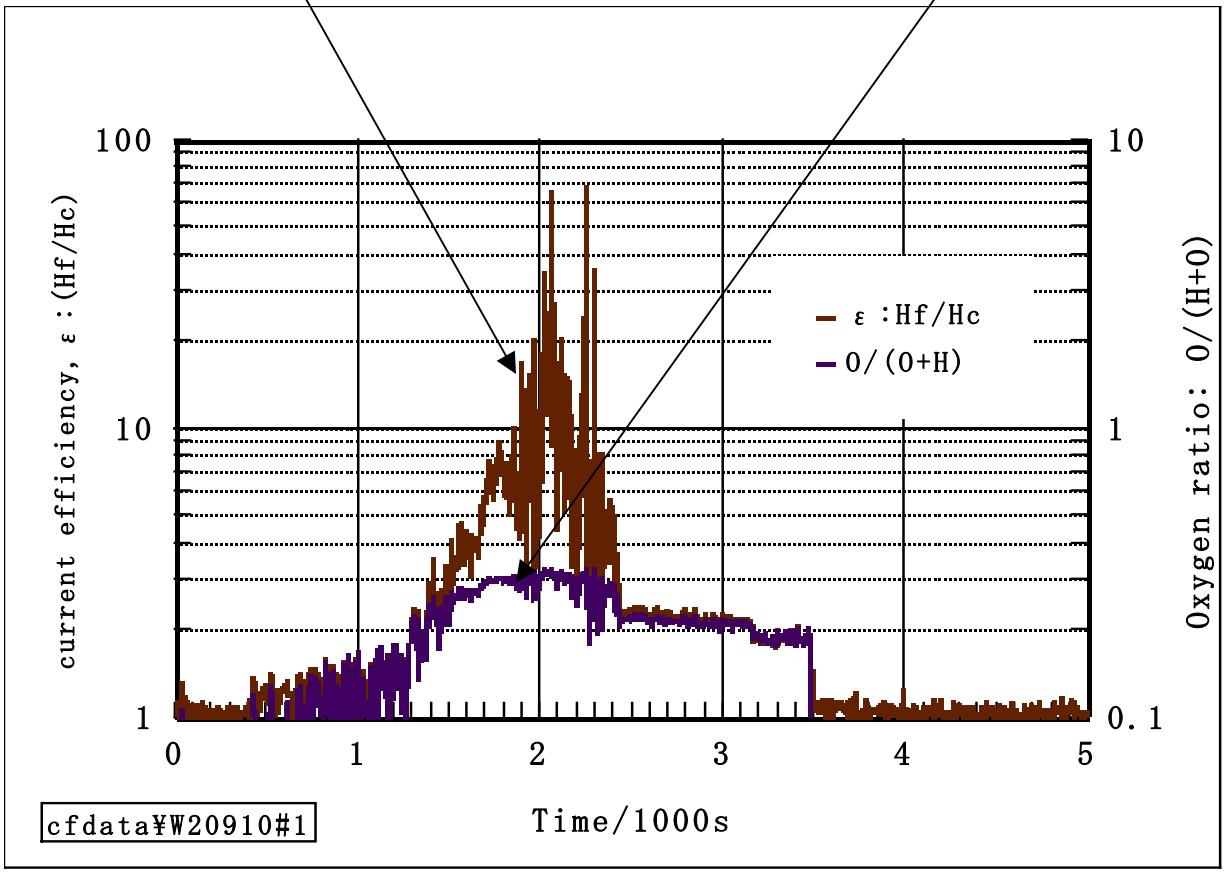
Time changes of H_2 and O_2



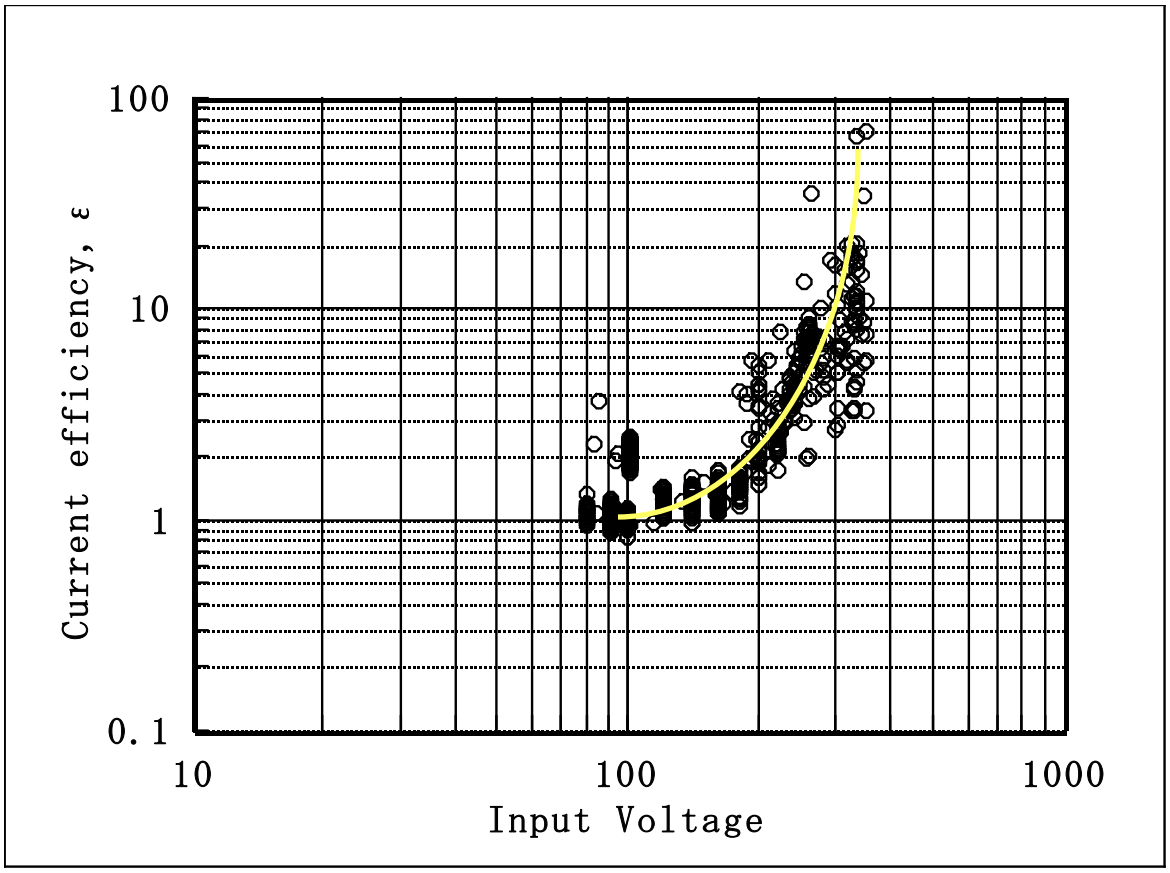
Time change of hydrogen generation; estimated by flow-meter and by current



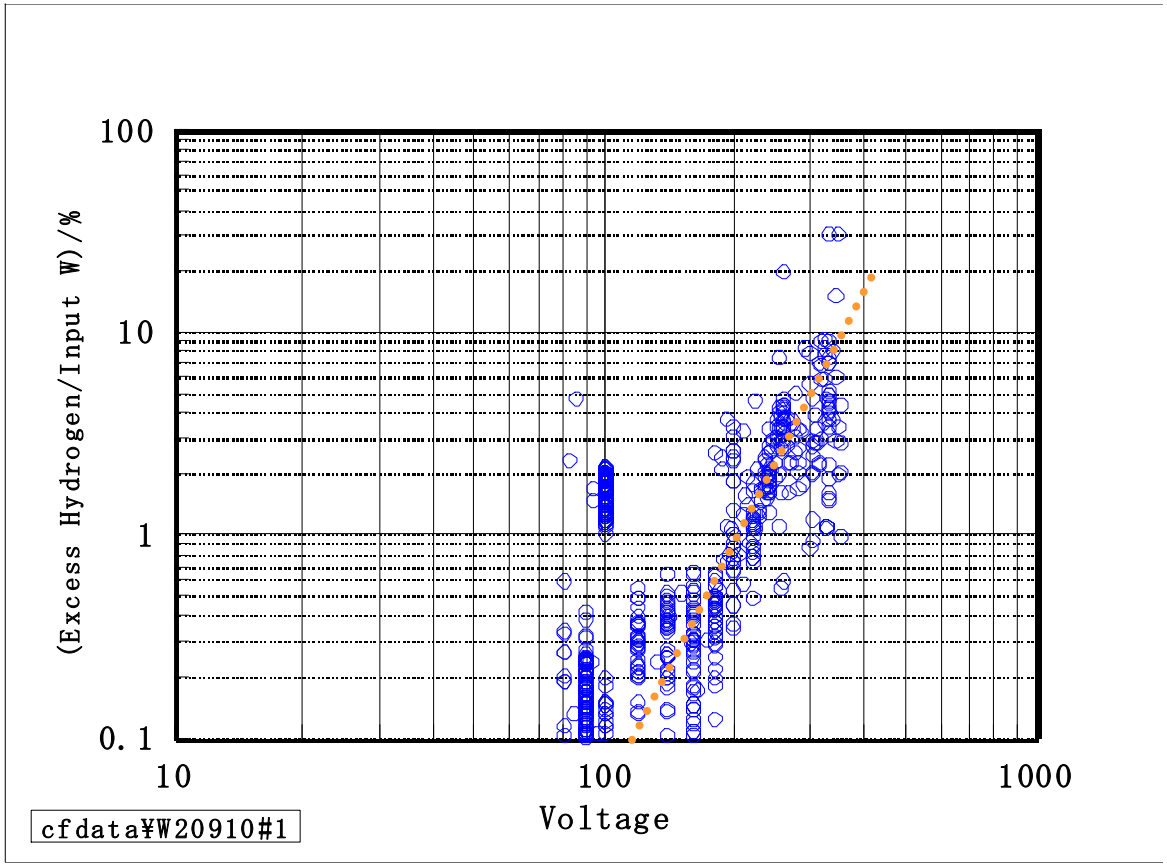
Time change of current efficiency and O_2 ratio



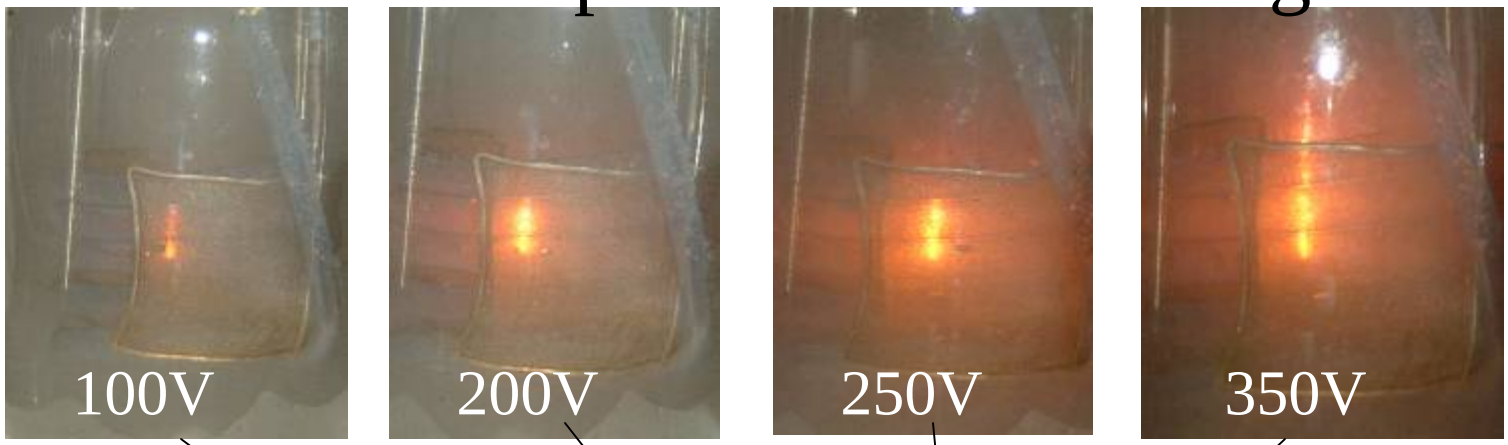
Dependence of current efficiency on input V

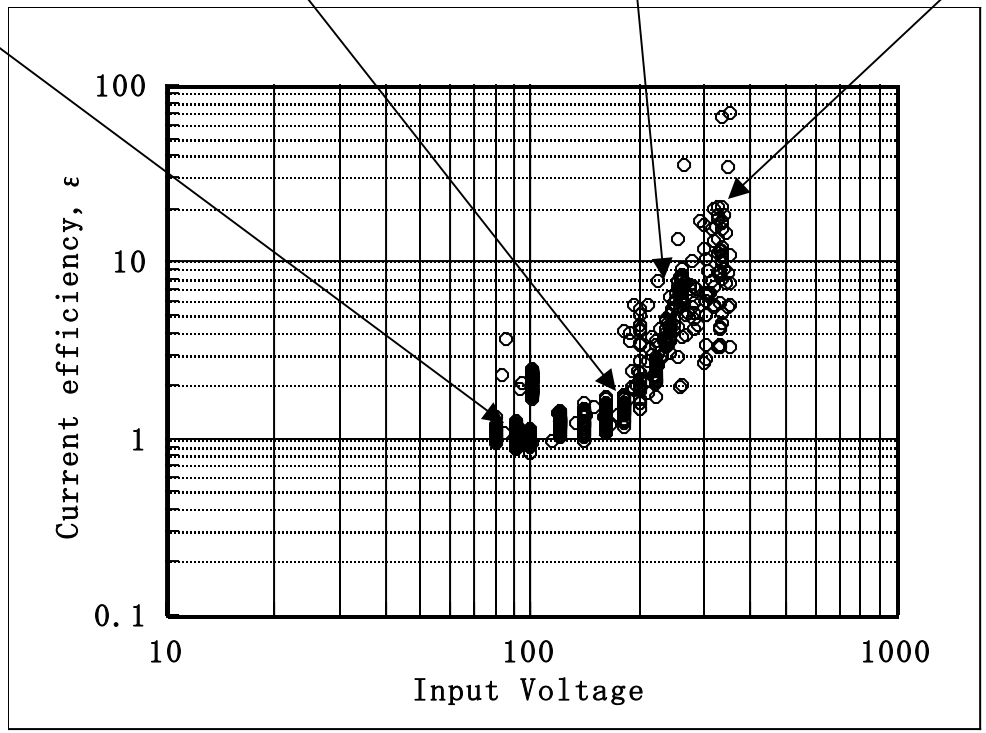


Voltage dependence of excess H2

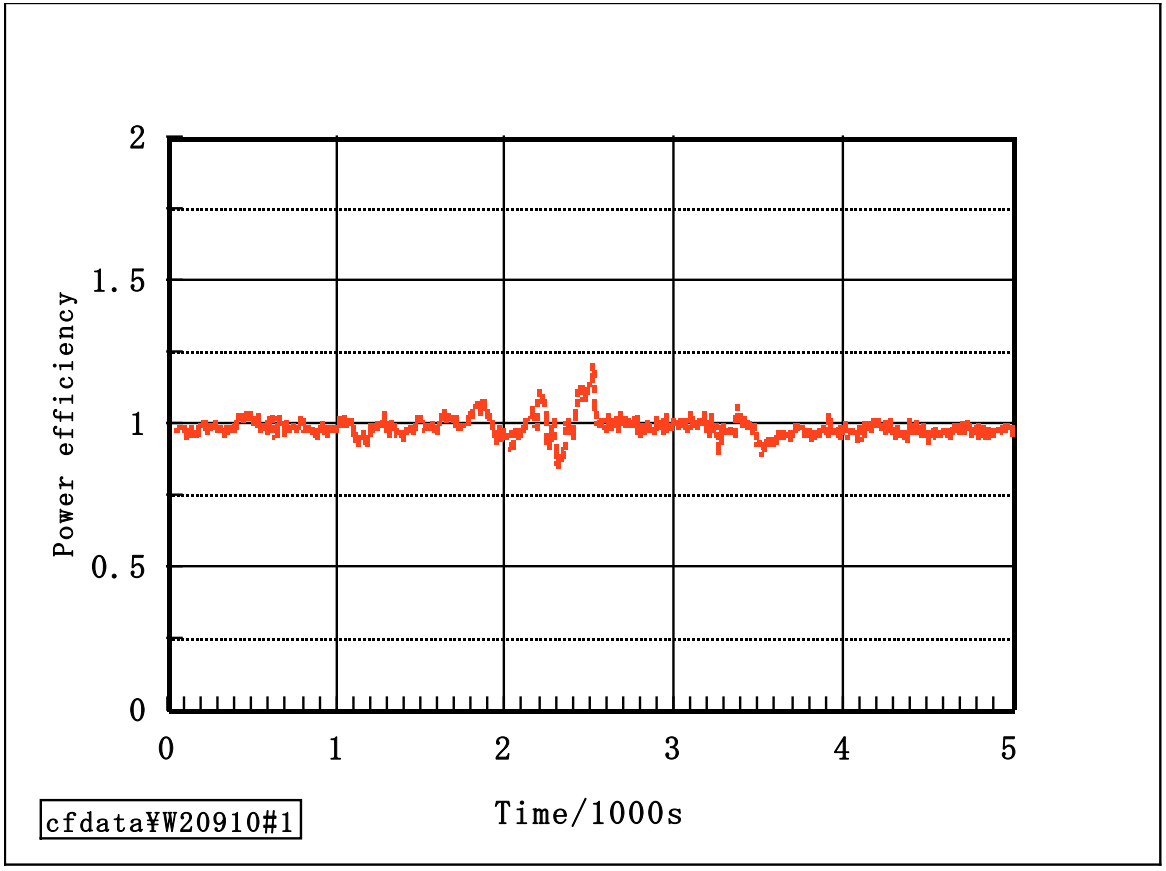


Photos of plasma at each voltages

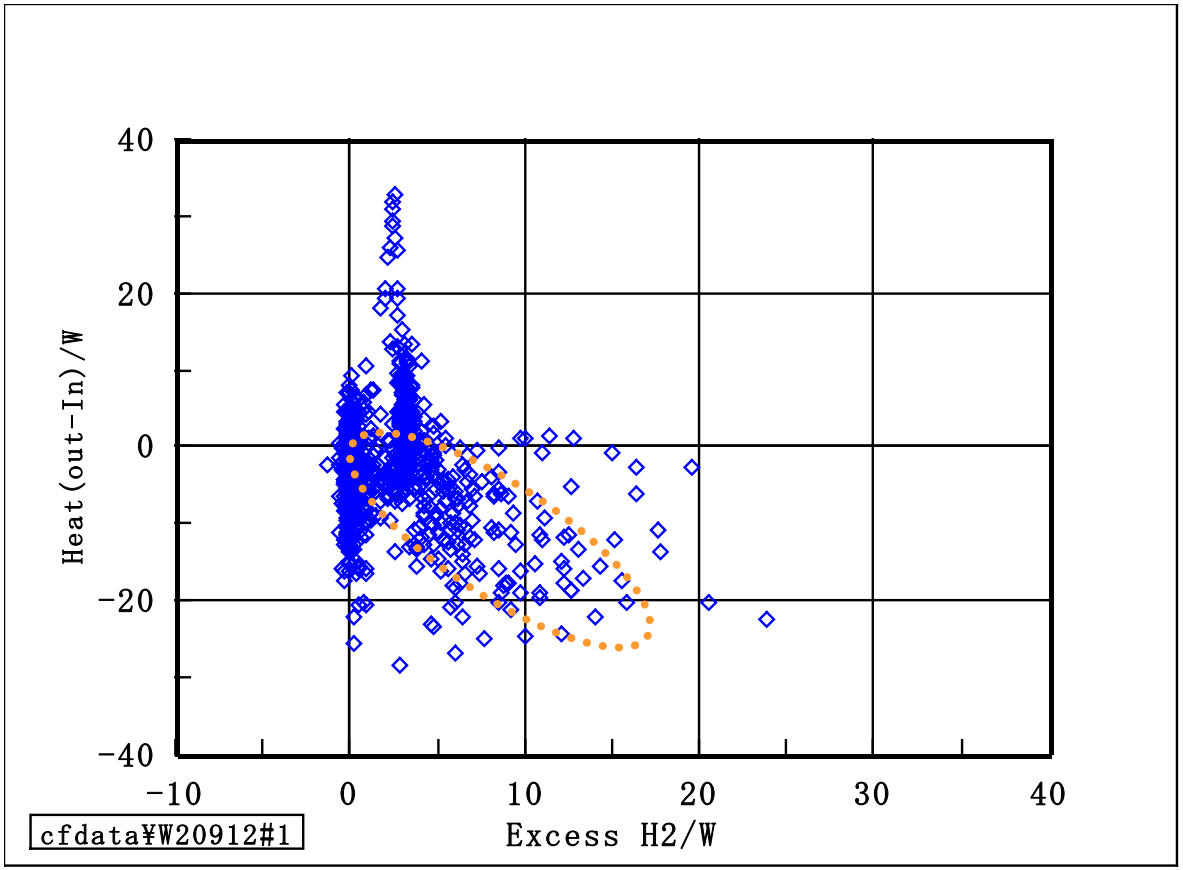




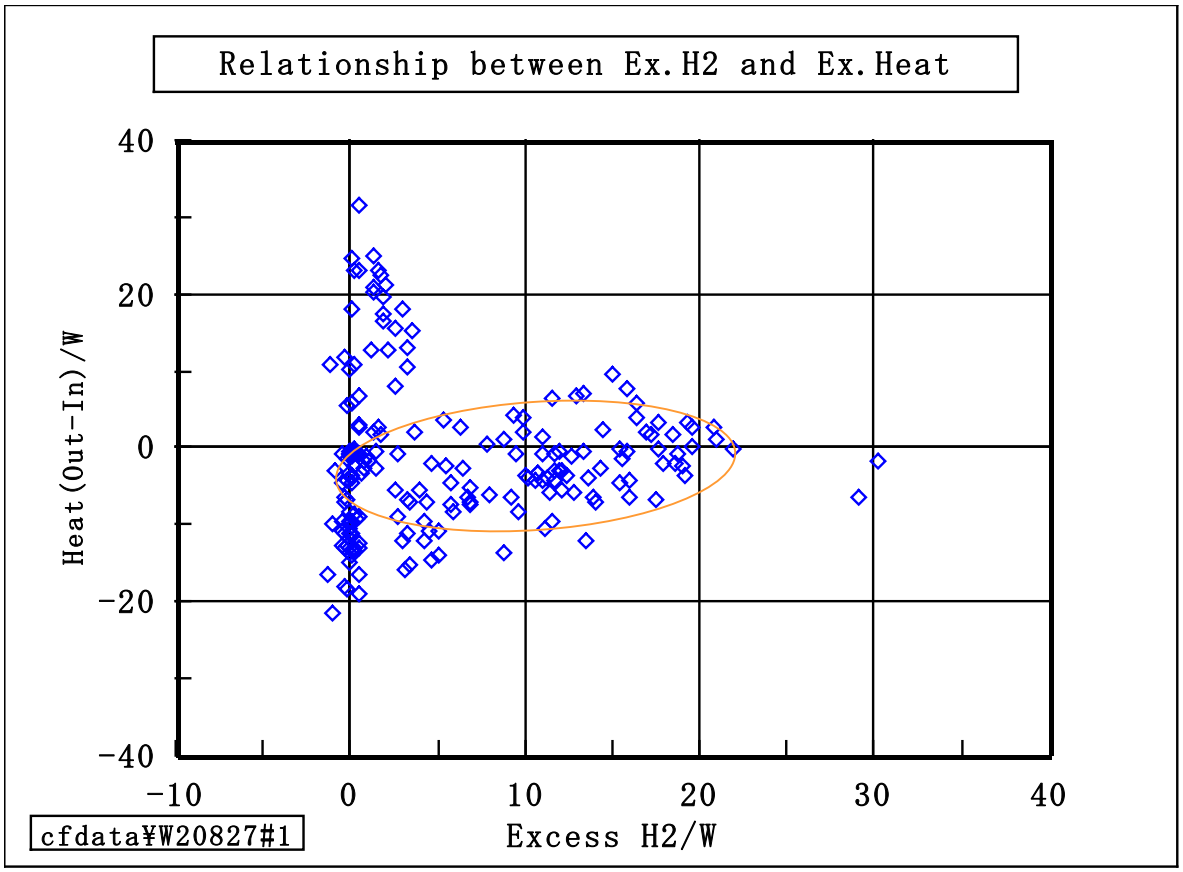
Time change of power efficiency



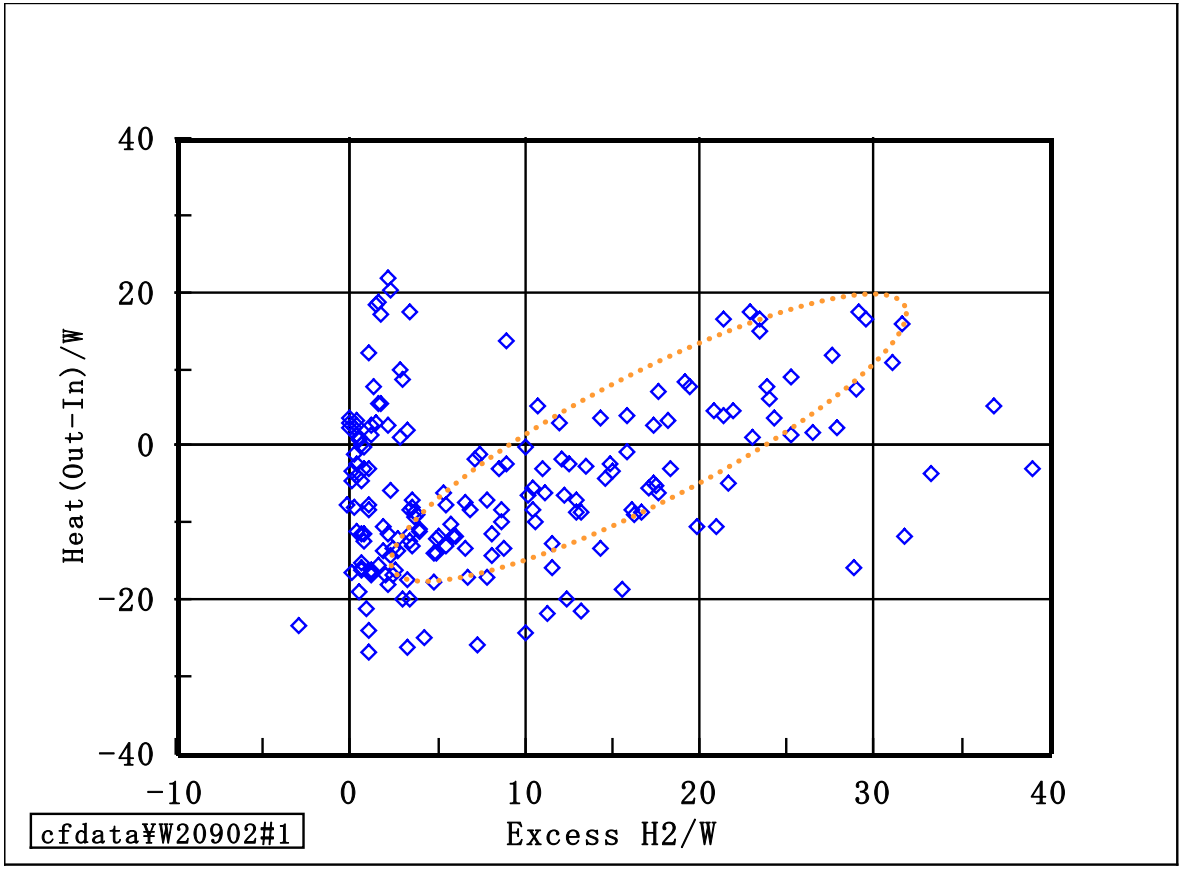
Endothermic result



No excess heat

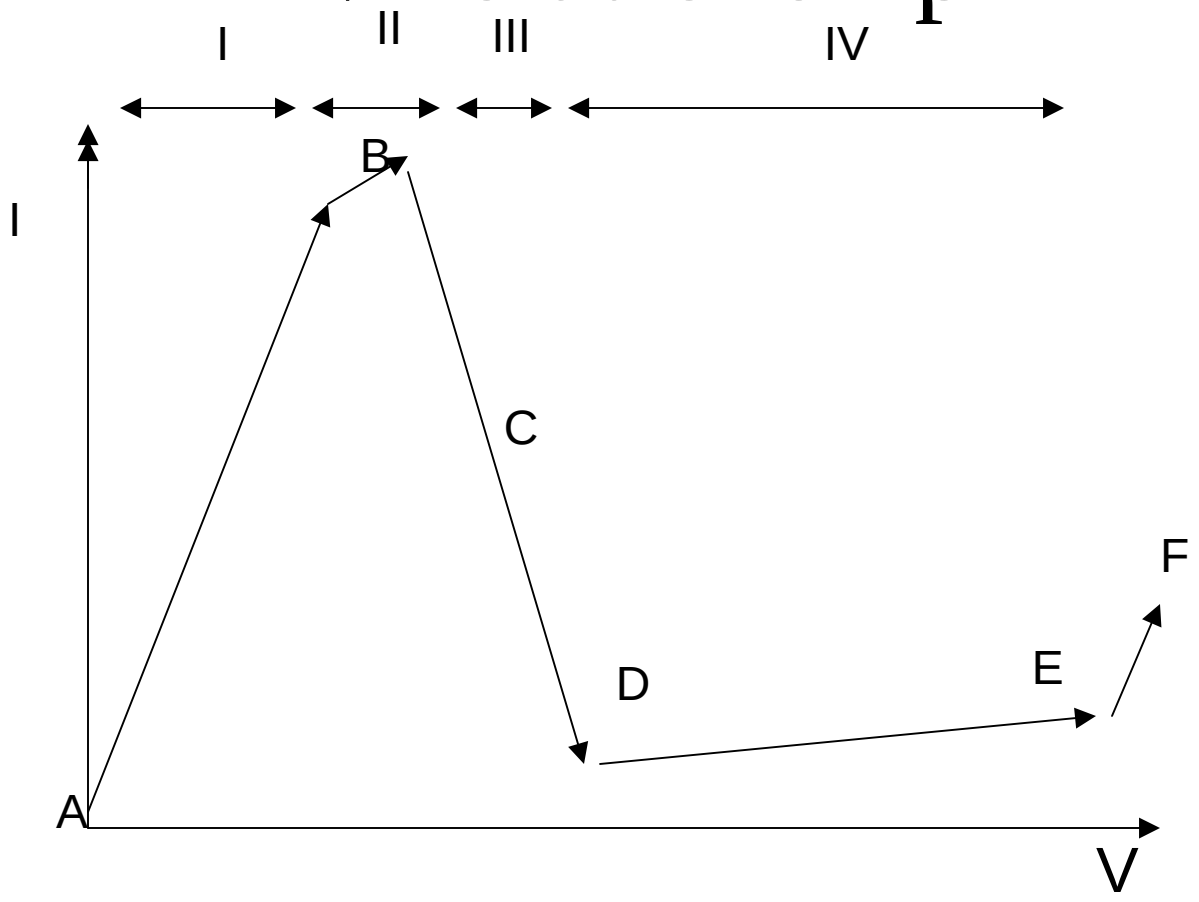


Excess heat generation



I-V relationship

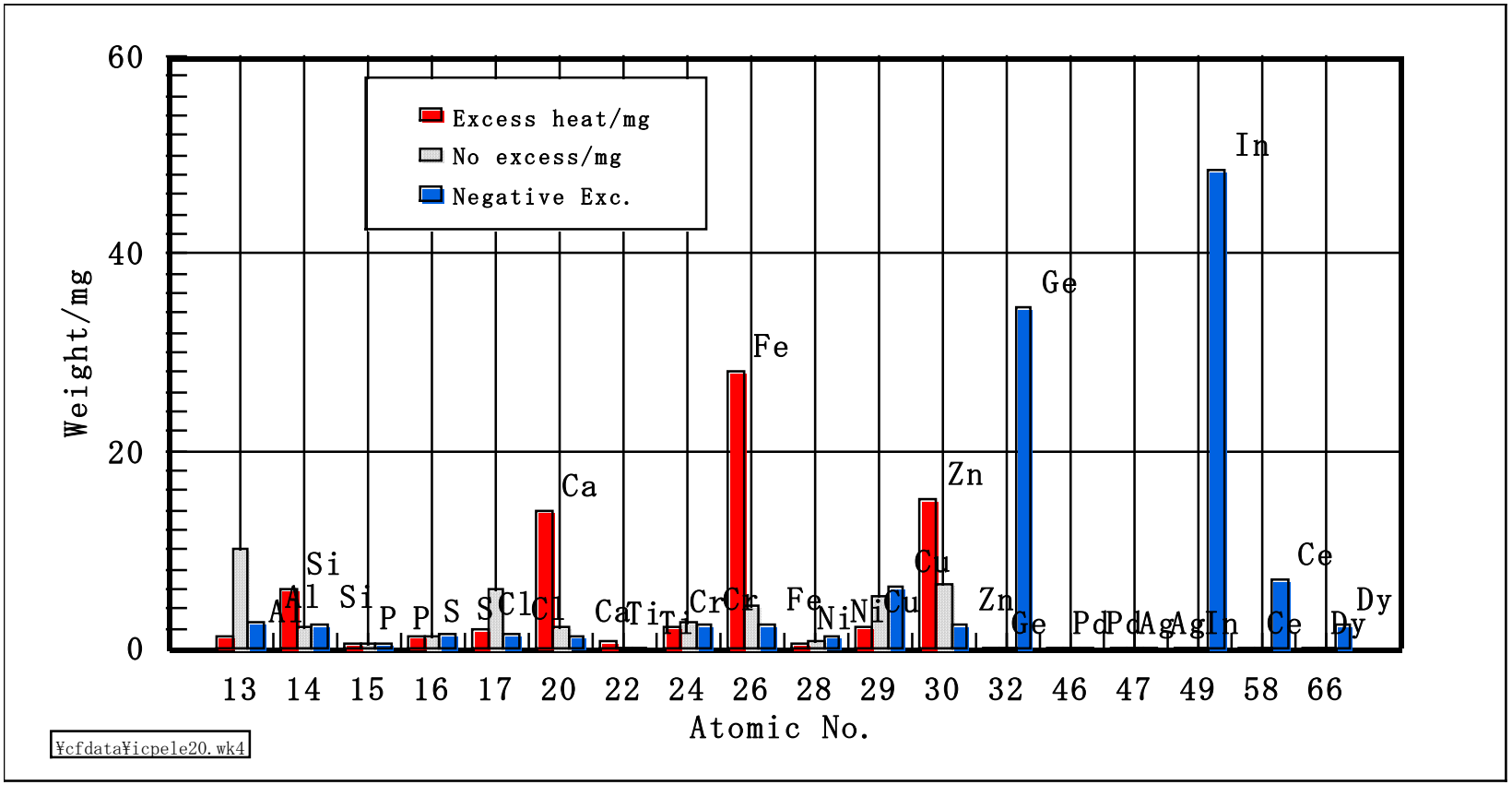
- E



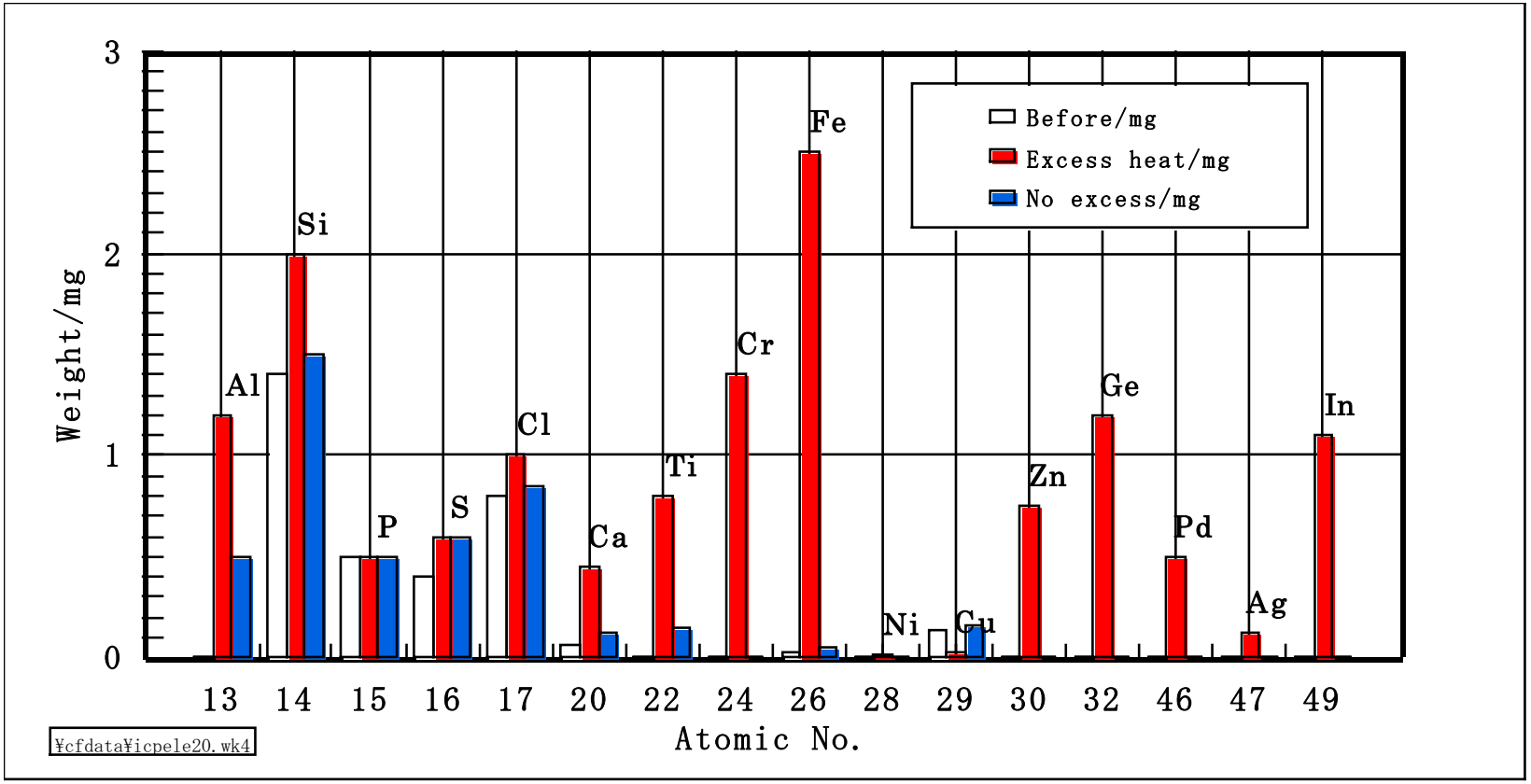
Characteristic element generation

- 1. Excess heat;
- Fe, Zn, Ca, Si: 2---30 mg
- 2. No excess heat;
- Al, Cl, K, Cu:2---10mg
- 3. Endothermic;
- Ge, In, Ce, Dy: 5---50mg

Difference of element distribution



Element distribution of Pd electrolyzed in D2O solution



Tetrahedral Symmetric Condensate: TSC

W186 (28.6%)

$$^{186}\mathrm{W} + 4\,^{1}\mathrm{H} \rightarrow$$

$$\rightarrow {}^{136}\mathrm{Xe} + {}^{54}\mathbf{Cr} + 129.5\mathrm{MeV}$$

$$\rightarrow {}^{142}\mathrm{Ce} + {}^{48}\mathbf{Ca} + 114.6\mathrm{MeV}$$

$$\rightarrow {}^{150}\mathrm{Nd} + {}^{40}\mathrm{Ar} + 95.1\mathrm{MeV}$$

$$\rightarrow {}^{154}\mathrm{Sm} + {}^{36}\mathbf{S} + 89.5\mathrm{MeV}$$

$$\rightarrow {}^{160}\mathrm{Gd} + {}^{30}\mathbf{Si} + 78.3\mathrm{MeV}$$

TSC for W184

$$^{184}\mathrm{W} + 4\,^{1}\mathrm{H} \rightarrow {}^{124}\mathrm{Sn} + {}^{64}\mathrm{Ni} + 138.9\mathrm{MeV}$$

$$\rightarrow {}^{130}\mathrm{Te} + {}^{58}\mathrm{Fe} + 133.3\mathrm{MeV}$$

$$\rightarrow {}^{136}\mathrm{Xe} + {}^{52}\mathrm{Cr} + 124.9\mathrm{MeV}$$

$$\rightarrow {}^{138}\mathrm{Ba} + {}^{50}\mathrm{Ti} + 123.0\mathrm{MeV}$$

$$\rightarrow {}^{142}\mathrm{Ce} + {}^{46}\mathrm{Ca} + 110.9\mathrm{MeV}$$

$$\rightarrow {}^{150}\mathrm{Nd} + {}^{38}\mathrm{Ar} + 91.3\mathrm{MeV}$$

$$\rightarrow {}^{154}\mathrm{Sm} + {}^{34}\mathrm{S} + 85.7\mathrm{MeV}$$

$$\rightarrow {}^{160}\mathrm{Gd} + {}^{28}\mathrm{Si} + 72.7\mathrm{MeV}$$

Results

- 1. Current efficiency for the H2 generation reached 8000% to the input current.
- 2. Power efficiency for the plasma electrolysis reached 20% to the input V.
- 3. In some cases, excess heat was observed.
- 4. In other cases, no and endothermic heat were confirmed.
- 5. The reaction products after electrolysis were changed with the heat balance.