ECOTOPIA SCIENCE AND ENERGY SYSTEMS à LA CARTE
PRINCIPLES AND TECHNOLOGIES

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EcoTopia
NAGOYA UNIVERSITY
Memorandum of Understanding Signing Ceremony
on
ACADEMIC EXCHANGE

Nagoya, Japan
名古屋

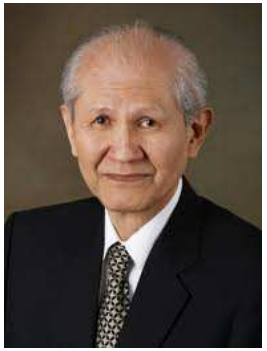
TOYOTA

名 古 屋 大 学

2004 Two Nobelists!

Akasaki

Noyori



Shimomura

Amano

Masukara

Kobayashi

Akasaki Memorial Research Building

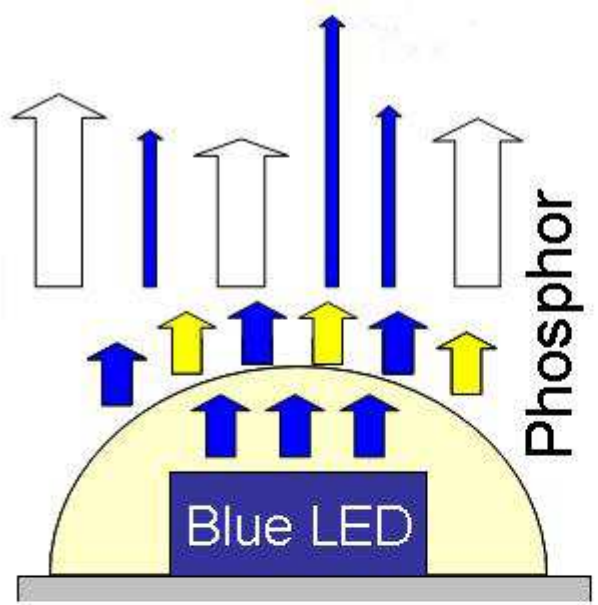
・LED signal lamp
・Full color LED display

2014Nobel Prizes:Profs. Akasaki & Amano

Invention of blue color LED with suitable crystal of gallium nitride

Without Blue LEDs, you can not create any colors you want, and no white color LEDs are available.

Great energy saving: W-lampx(1/8) and FL(1/2)

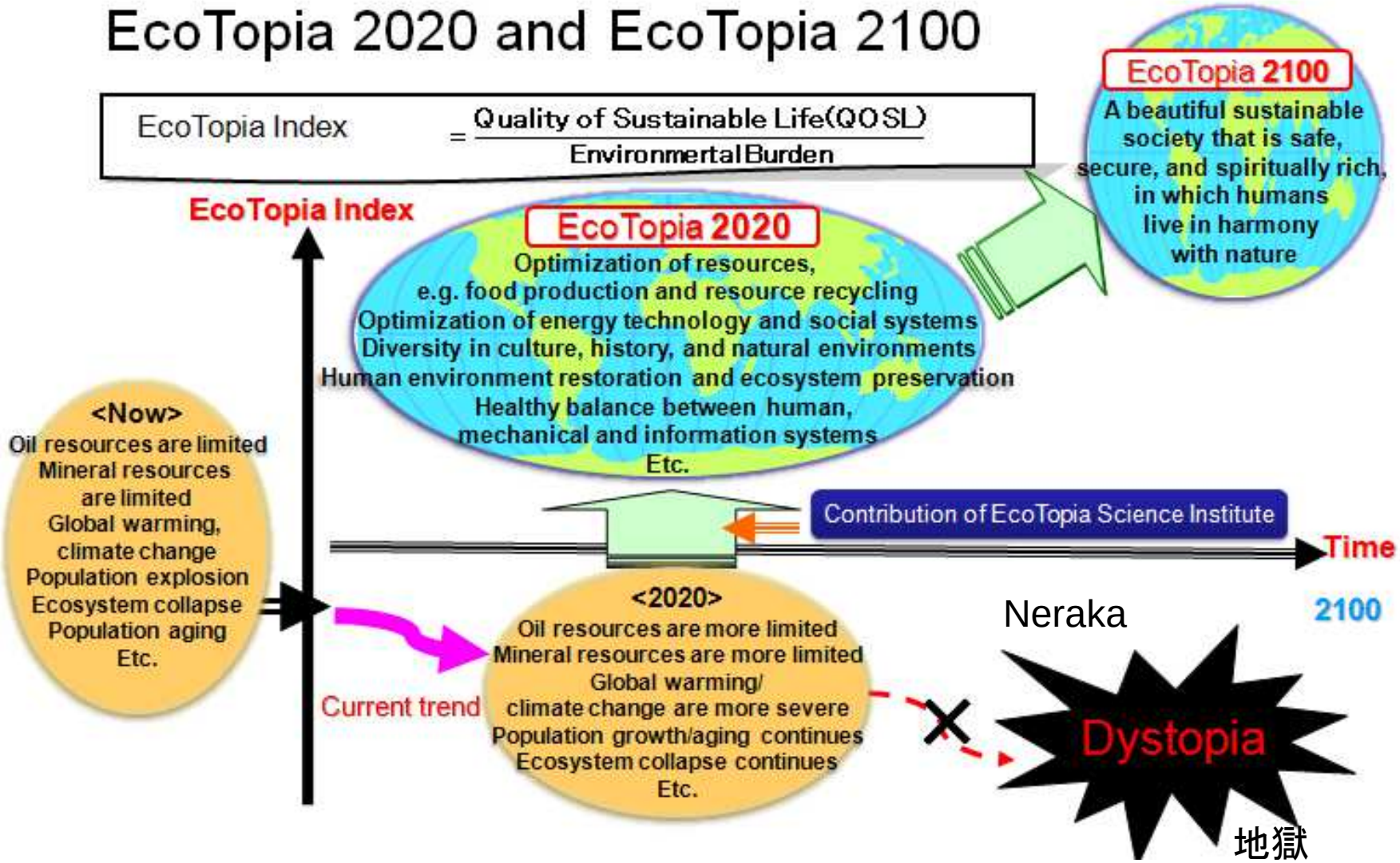


Gallium nitride

EcoTopia Science for Sustainable Society via Interdisciplinary (Natural and Social Sciences) Research

Towards the Realization of EcoTopia

- Research Goals and Basic Strategies of the EcoTopia Science Institute -



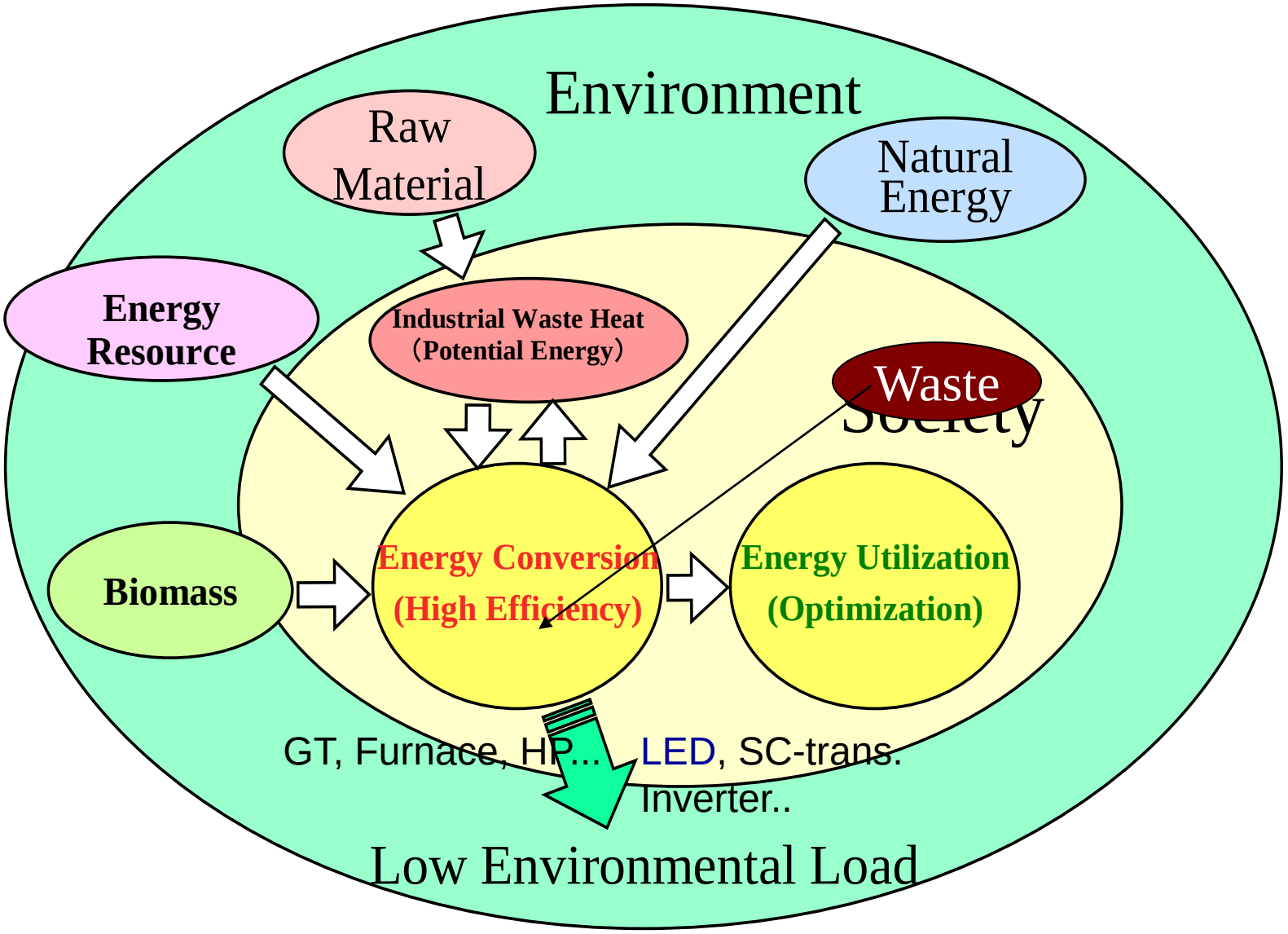
EcoTopia Index and pathway to EcoTopia realization

$$\text{EcoTopia Index} = \frac{\text{Quality of Sustainable Life(QOSL)}}{\text{Environmental Burden}}$$

- ***QOSL*** can refer to quality of life on either a per-person basis and for society as a whole. It can also be plotted as a variable against time. In addition, the perspective of the environment's natural circulation of living things and resources is also taken into consideration. And note that the aim of **EcoTopia Science** is to ensure that QOSL is maintained or increased.

- On the other hand, the denominator "***Environmental Burden***" takes into account for the reduction in the total load imposed on the environment collectively, as well as the environmental load per person, for various environmental threats, including global warming, ozone layer destruction, resource depletion, waste generation, deforestation, biodiversity loss, and environmental pollution.

Energy World Concept



Miyachi Corporation Limited

since 1953

ミヤチ株式会社

We supply “Solutions for Better Life”

via Earth-benign Advanced Systems of Water, Solar Power and LED

Kiyokazu Miyachi

President

Kuniyuki Kitagawa

Technology consultant

Smart LED lighting system

- LEDs are very attractive for energy saving in that their energy consumption is ca. 1/8 compared to tungsten lamps and ca. 1/2 to fluorescent tubes(FL), and that LED life time is much longer by ca.7-10 times than those of FLs. Effects of LED lighting system were examined on human eye fatigue and hormone. And the controlling the blue spectral intensity was attempted to improve the daily human life of aged people.

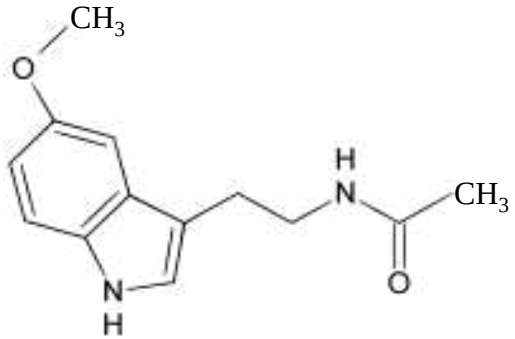
- E-Smart lighting System for
  "*Spectrotherapy*"

- Special lighting System for Improvement of Living rhythms

Advantages of LEDs

- Long life 70000hrs:7-10 times FL
- No Hg waste (ca.3 tons/year in Japan)
- Safety: Low voltage

A possible physiological problem



Melatonin :N-acetyl-5-methoxytryptamine

A hormone with
physiological rhythm adjustment and hypnotic effect
Commercially available as medicine for anti-jet lag but forbidden in Japan.

The residue blue radiation of **440-490 nm** used for the excitation of white LEDs has possibility to suppress the hormone secretion (at 464 nm) and to interrupt sleeping.

↓

Adjustment of color temperature to suppress the blue radiation using 3-color LEDs.

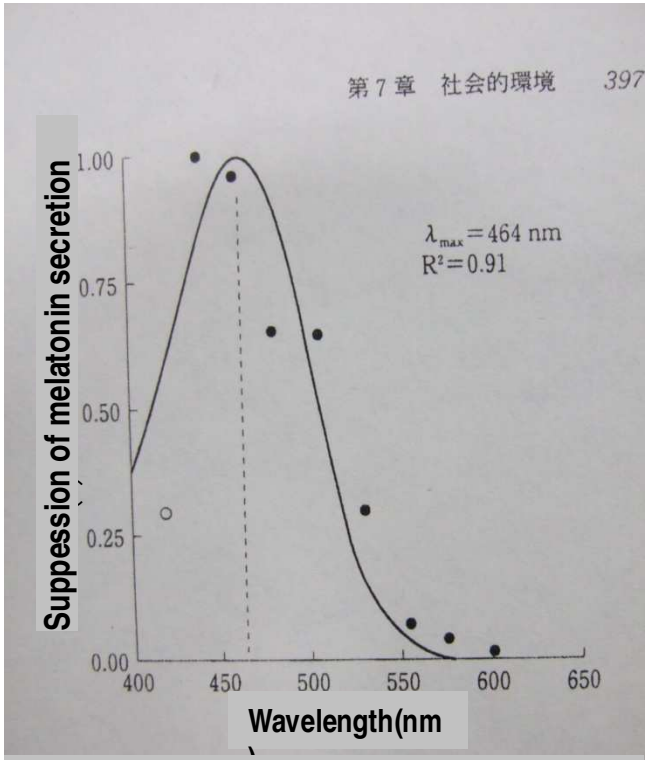
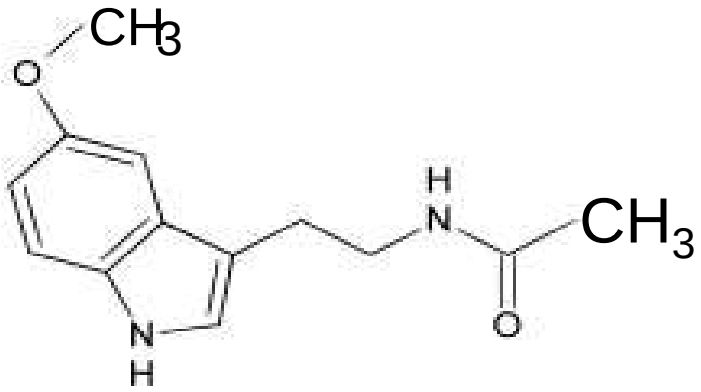
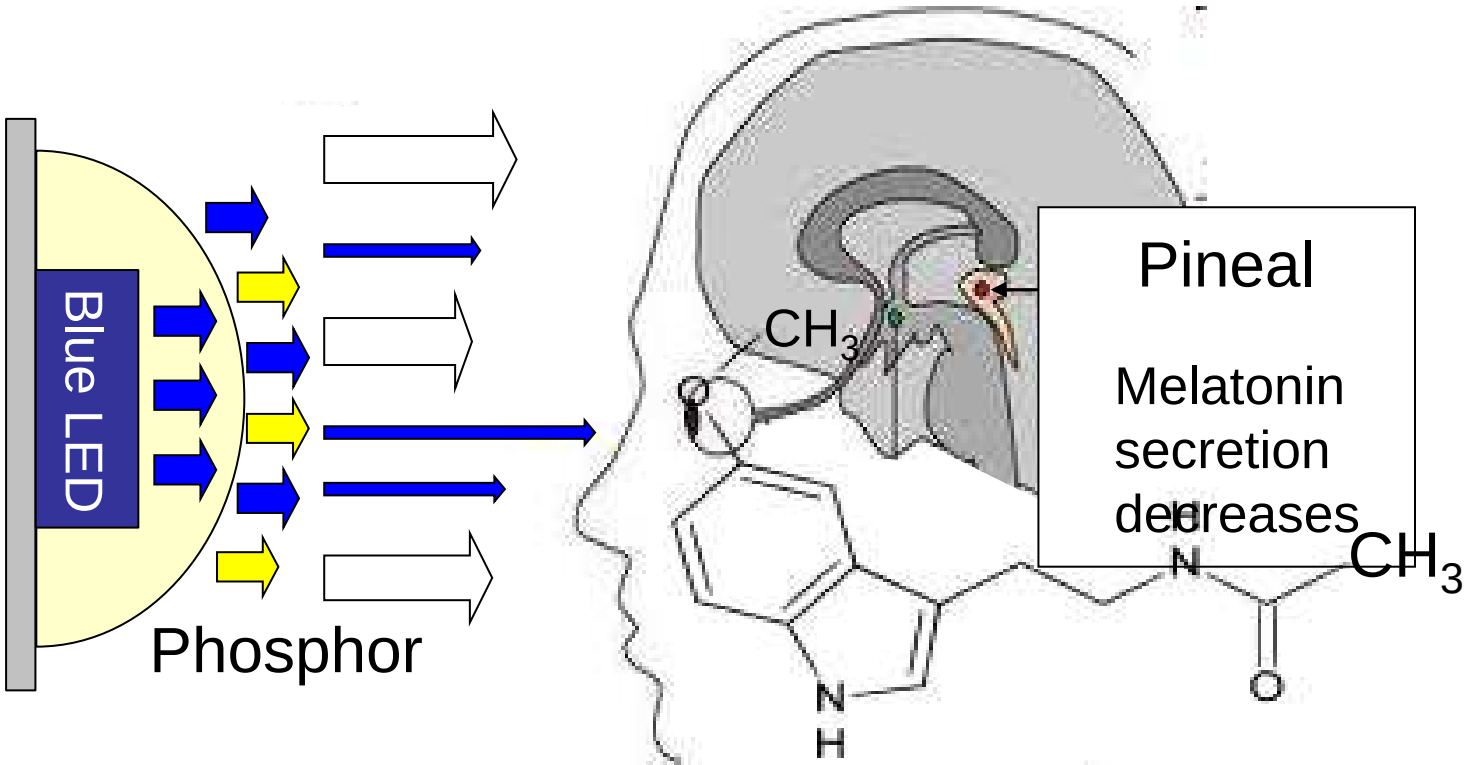
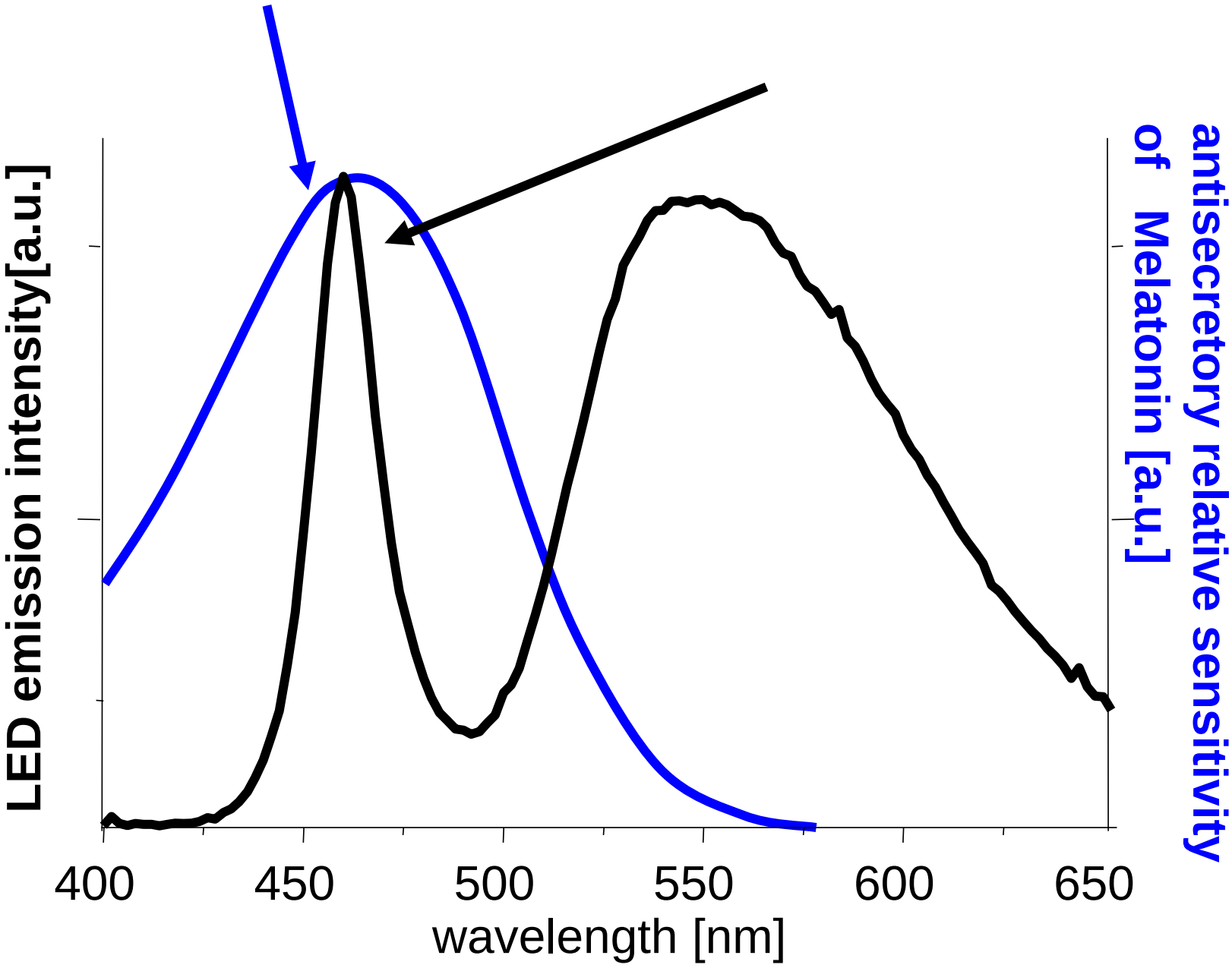


Fig. Effect of wavelength on suppression of melatonin secretion (cf. Brainard t. al., 2001)

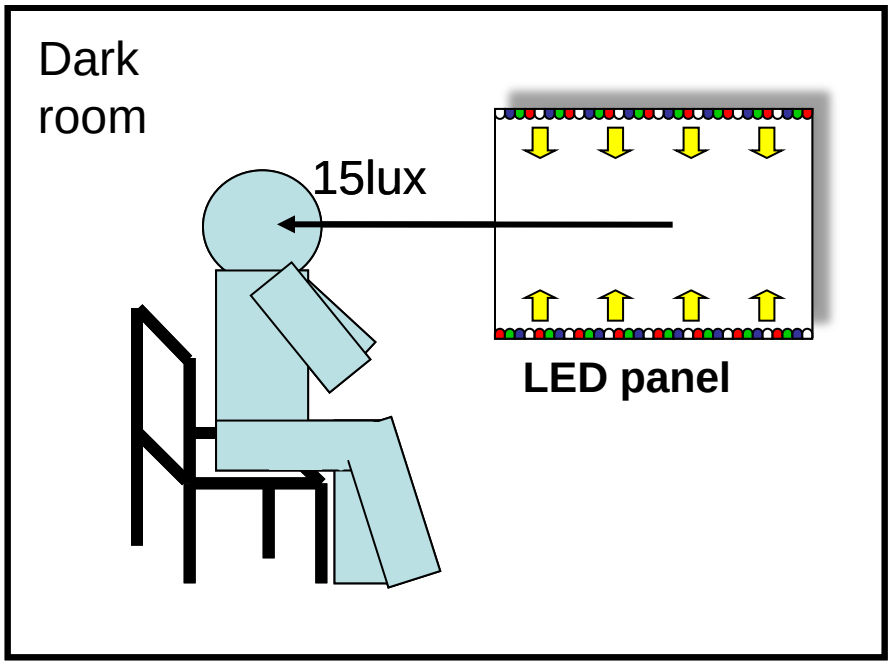
It has been is known that the wavelength peak of blue LEDs has a suppressing effect on the secretion of a hormone *melatonin* that expedites human drowsiness.






LED emission intensity[a.u.]
antisecretory relative sensitivity of Melatonin [a.u.]
400
450
500
550
600
650
wavelength [nm]

④実験方法



① Collect saliva samples (control)

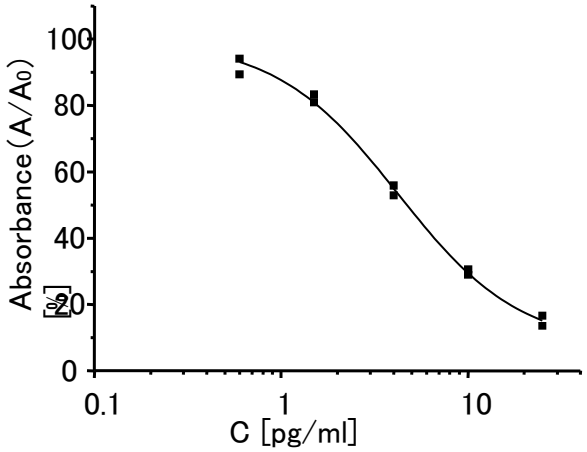
② Expose eyes to LED for 45 min. from 11am

③ Collect saliva samples again

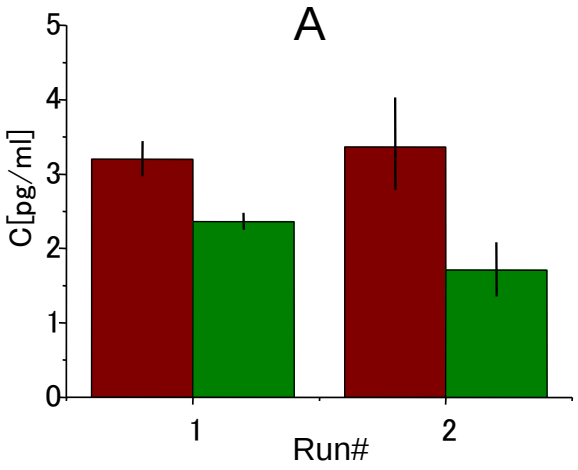
④ Determine the concentration of the hormones in the saliva samples by ELISA
（Enzyme-Linked Immuno Sorbent Assay）

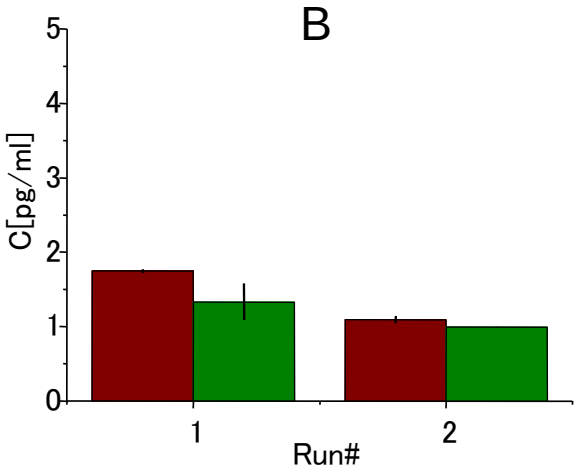
Five males(20esx4+40esx1)

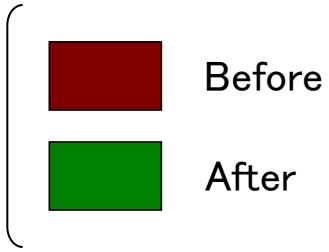
λ＝450nm

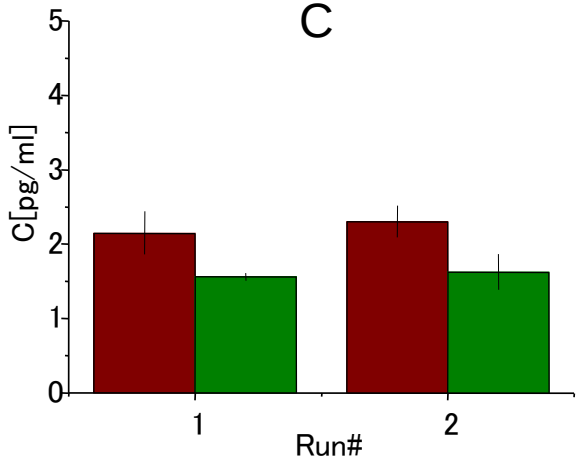


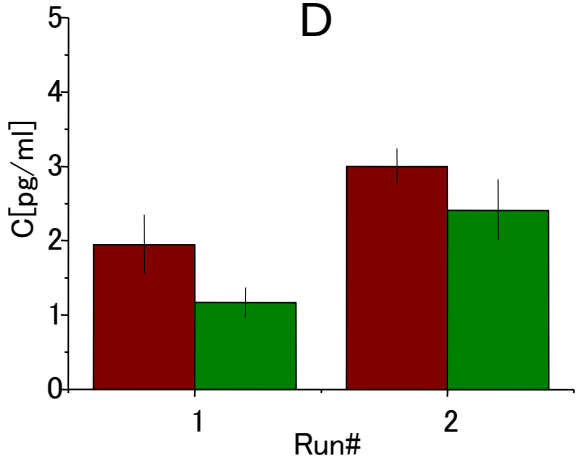
Melatonin decrease after Blue Exposure

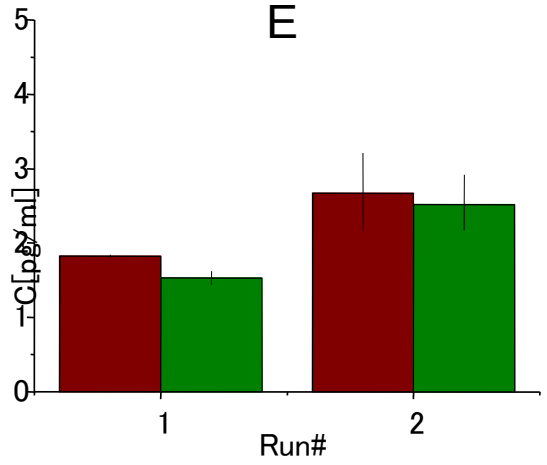




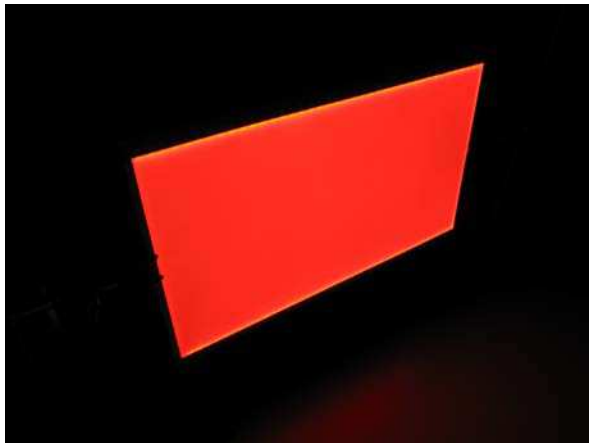


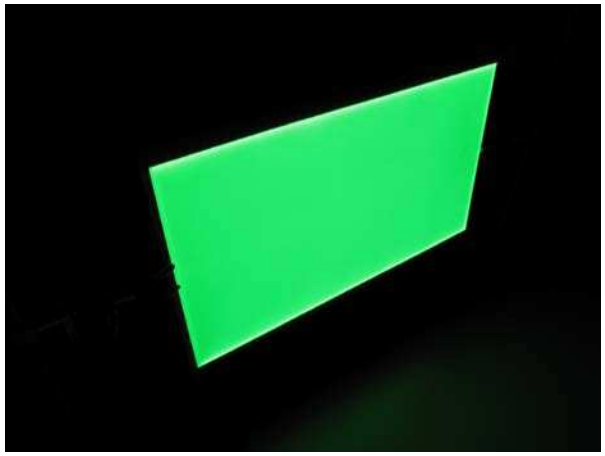


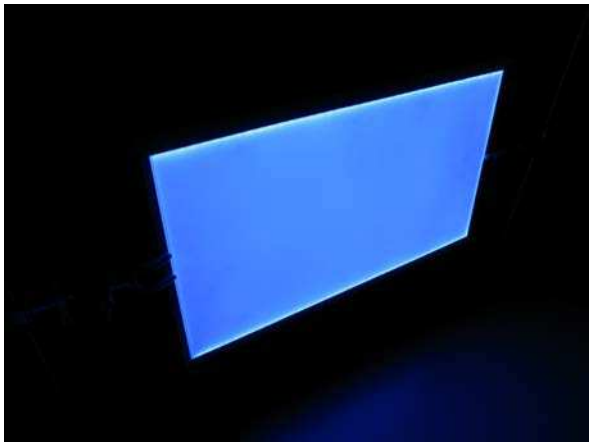


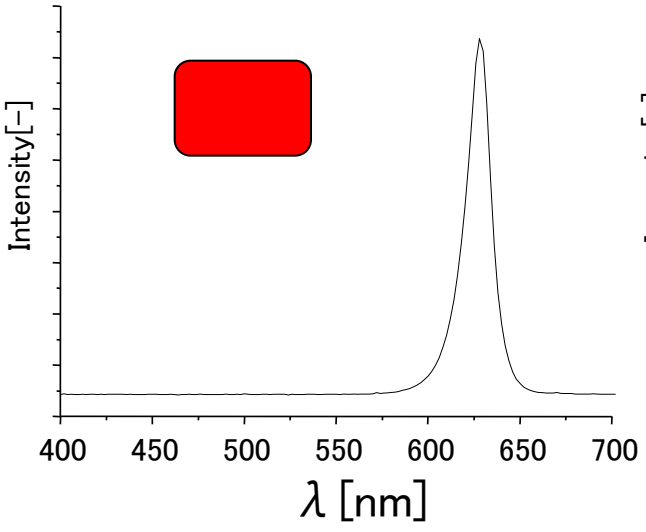


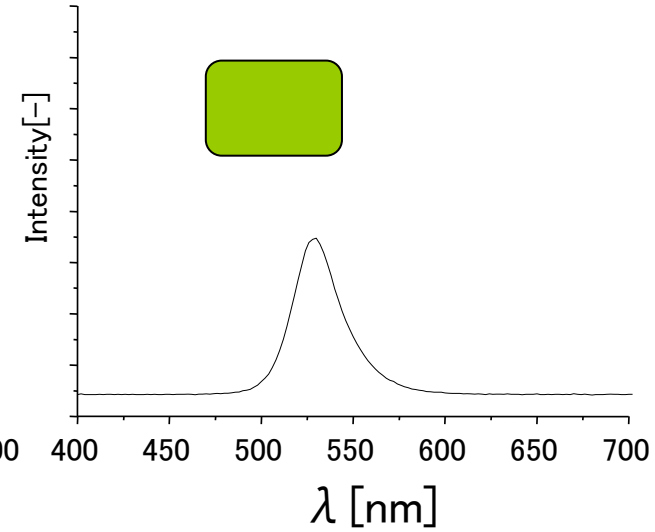
Spectra of RGB LEDs

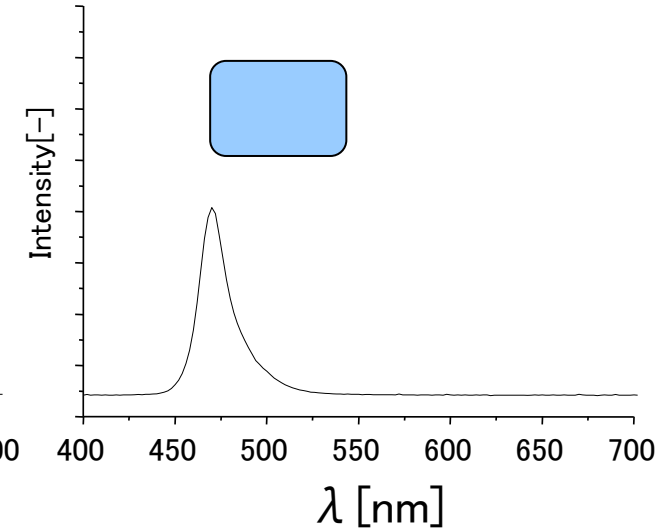












Degree of melatonin decrease

	R#1	R#2	G#1	G#2	B#1	B#2
A	9.9$_0$	16.$_3$	27.$_6$	45.$_8$	26.$_3$	49.$_2$
B	32.$_9$	3.6$_0$	-1.2$_8$	4.2$_4$	24.$_0$	9.3$_0$
C	19.$_7$	1.4$_2$	12.$_2$	7.8$_4$	27.$_4$	29.$_4$
D	-3.9$_9$	-24.$_2$	1.4$_7$	0.22	40.$_0$	19.$_7$
E	26.$_7$	25.$_2$	2.2$_8$	3.5$_6$	16.$_1$	5.7$_0$

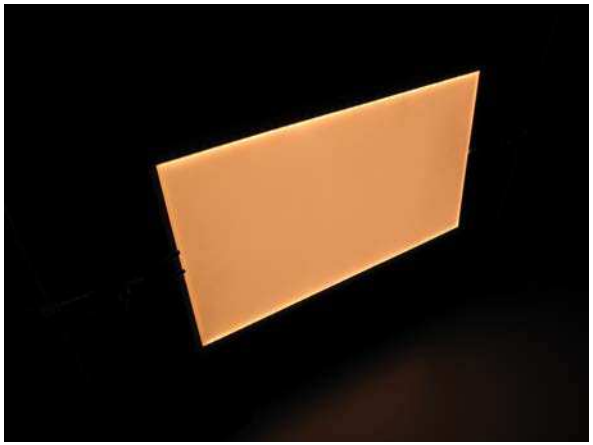
Average

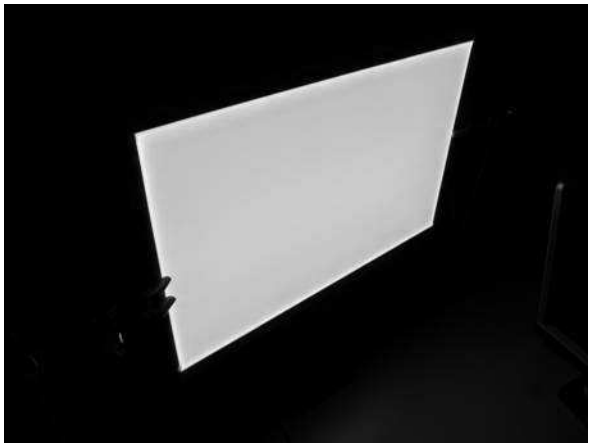
	R	G	B
[%]	10.$_{8\pm16.2}$	10.$_{4\pm14.2}$	24.$_{7\pm12.5}$

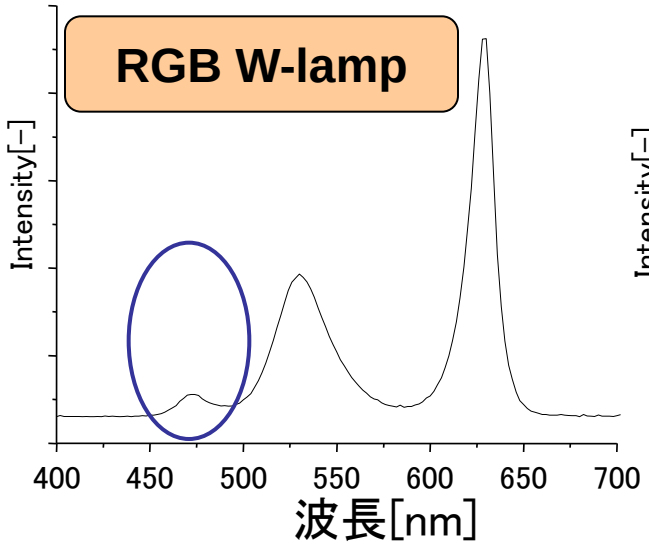
Greater decrease for Blue

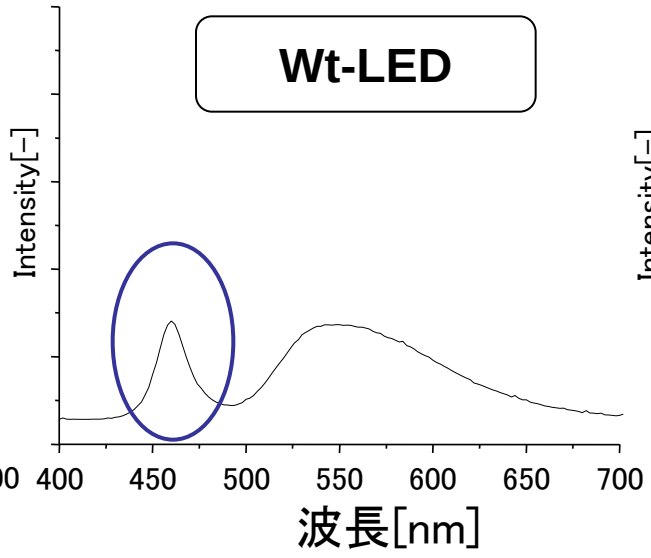
Possibility to control of melatonin by B-LED

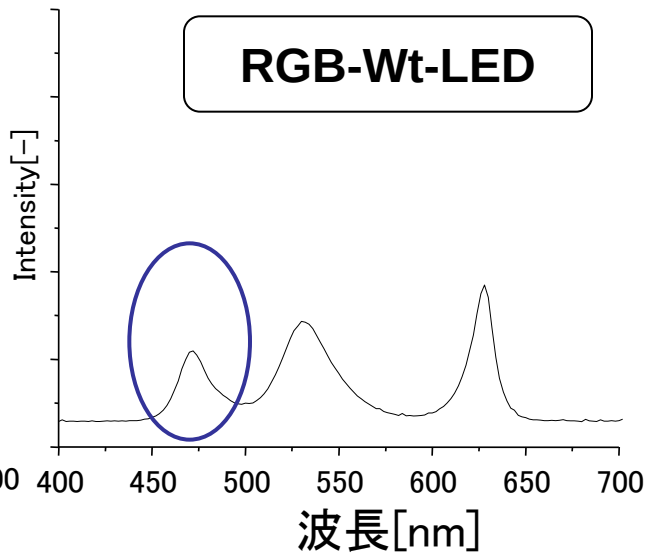
Different color LED with different spectrum











Melatonin decrease after composite-color LED Exposure

	RGB-WL#1	RGB-WL#2	Wt-LED#1	Wt-LED#2	RGB-Wt-LED#1	RGB-Wt-LED#2
A	10.6	13.7	19.0	18.6	23.4	24.5
B	-4.93	5.74	31.5	28.4	13.5	20.2
D	-10.2	12.4	20.4	5.25	-2.16	5.57

Average decrease rate

	RGB-WL	**Wt-**LED	RGB-**Wt-LED**
[%]	4.55±9.04	20.5 ±8.38	14.2 ±9.74

Greater than RGB-WL

Higher intensity of blue light at 450nm

Practical applications to improve human living: focused on aged people

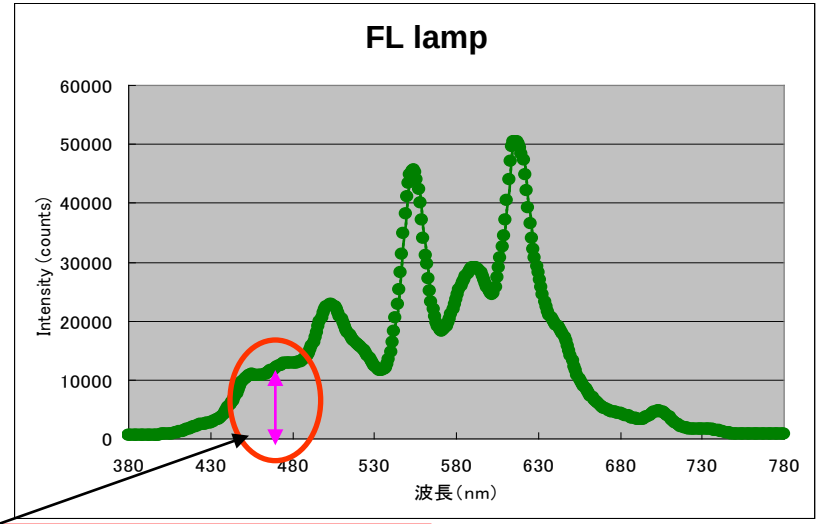
Experiment under casual living conditions

1. healthy aged people at a pay nursing home
2. Hospital rooms in a domentia ward
3. Group nursing home

Installation of E-smart LED lighting System

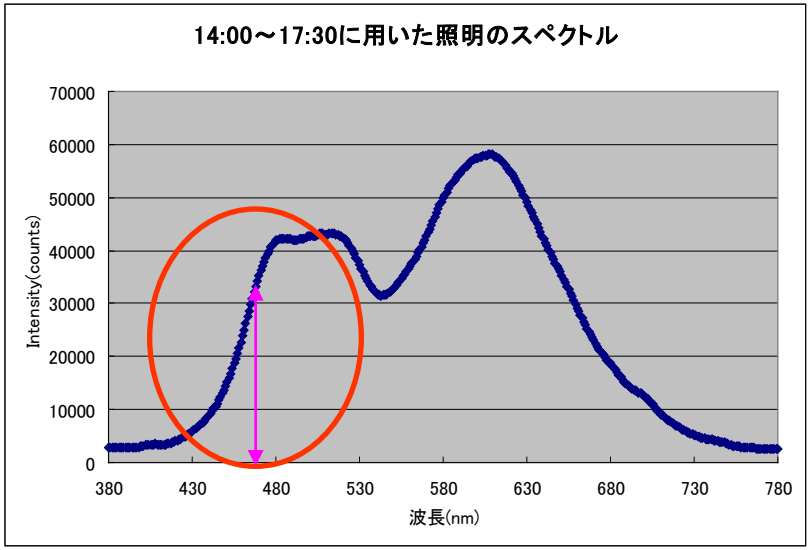
- 600 lx on the floor from the ceiling at a height of 1.5 m in private rooms.

Control of spectrum

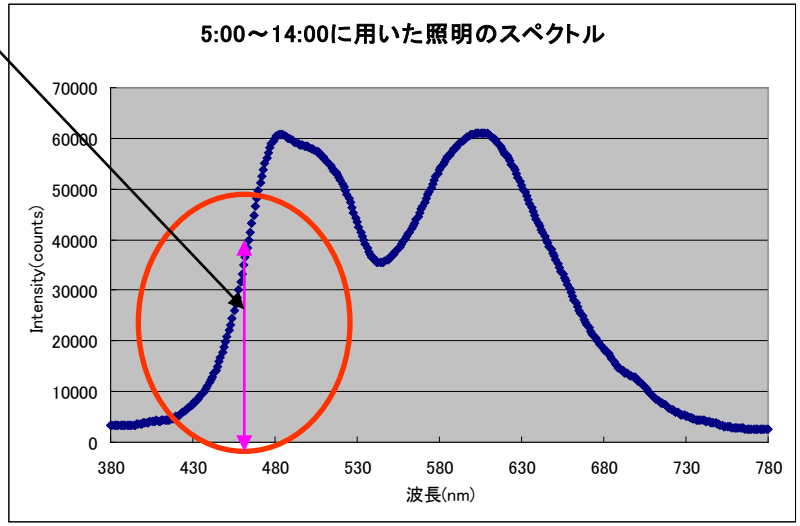


Intensity at 450nm is higher

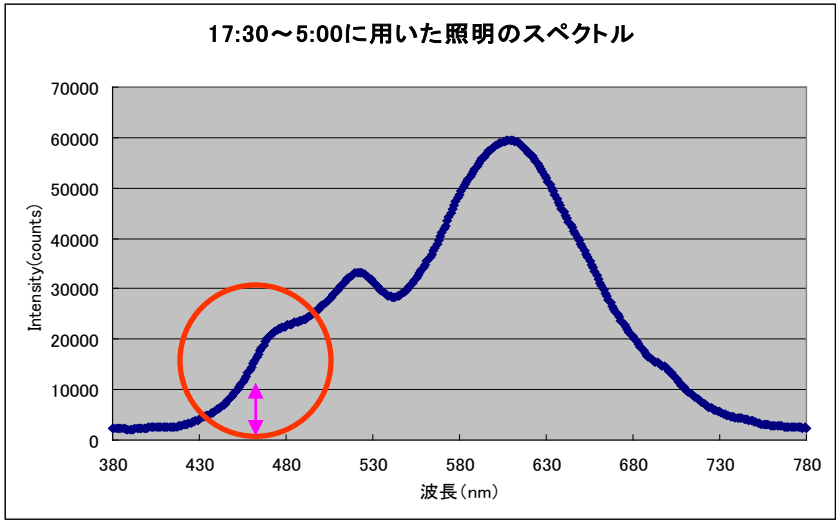
Daytime



Morning



Evening



Experimental

○At 8am and 6pm, saliva samples were taken by setting a small sponge between a lip and alveolar for 3 min, followed by the ELISA analyses to determine melatonin concentrations.

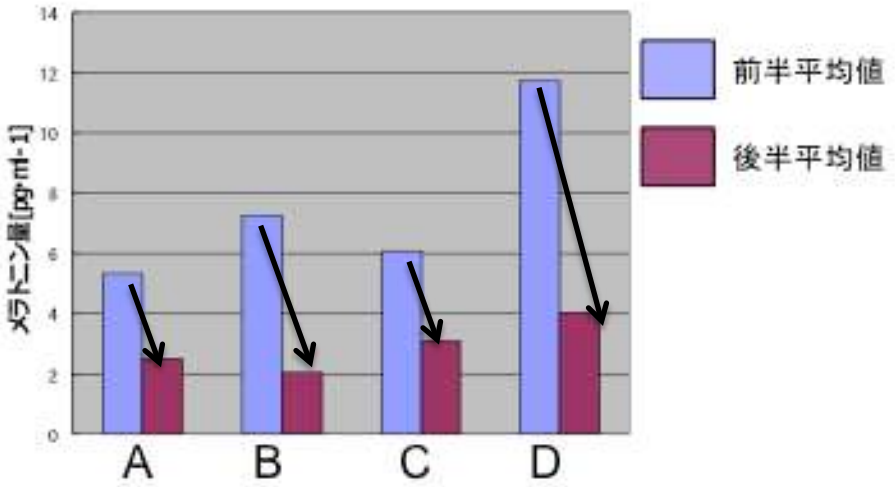
○ Sleeping and Living conditions were obtained by interviewing through nurses.

- Awareness: conducted by a modified Hasegawa test using vegetable names remembered.
- Sleeping：nurse reports involving **Night arousal, Early morning arousal, Day dreaming and Night furor**

○ Communication

1. Healthy aged people at a pay nursing home

Melatonin Decrease Blue bar:1-2 w after
Purpule bar 3-4 w after:



Decrease rate(%)	53.0	71.8	48.6	65.7	Av.	59.8

Circadian & awareness improvements

	Night arousal		Early morning arousal		Day dreaming		Night furor		Vegetable names	
	Before	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
A	+	−	+	−	+	−	+	−	4	5
B	−	−	−	−	−	−	−	−	9	10
C	+	−	+	−	+	+	+	−	7	8
D	+	−	+	+	+	+	−	−	4	5

Happy episode

Aged woman on a meddle stage of dementia

Until the E-smart LED exposure, her communication was difficult.

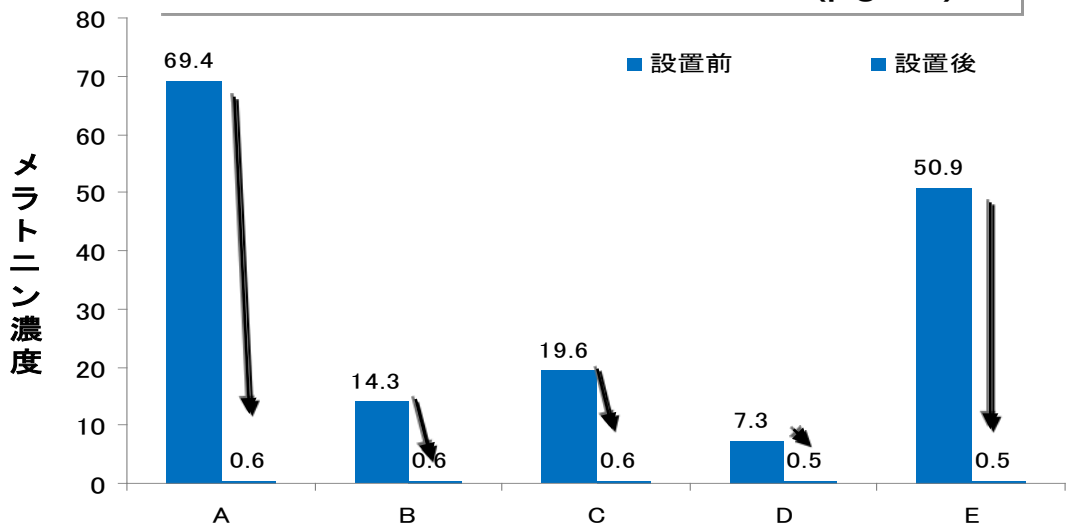
After 1 month exposure, she could talk with her daughter.

The daughter and surrounding people reported that my mother changed and improved.

!

2. Hospital rooms in a dementia ward

Decrease in melatonin concn.(pg/ml)



	Night arousal		Early morning arousal		Night furor		Vegetable names		Communication	
	Bfr	Aft	Bfr	Aft	Bfr	Aft	Bfr	Aft	Before	After
A	+	−	+	−	+	−	3	4	−	Simple talk
B	−	−	−	−	−	−	5	11	Simple talk	Simple talk
C	+	−	+	−	+	−	4	7	−	Simple talk
D	+	−	+	+	+	+	5	6	−	Simple talk
E	+	−	−	−	+	−	3	4	−	Simple talk

Report from nurses: Stable mind under e-smart LED, followed by instability after its removal.

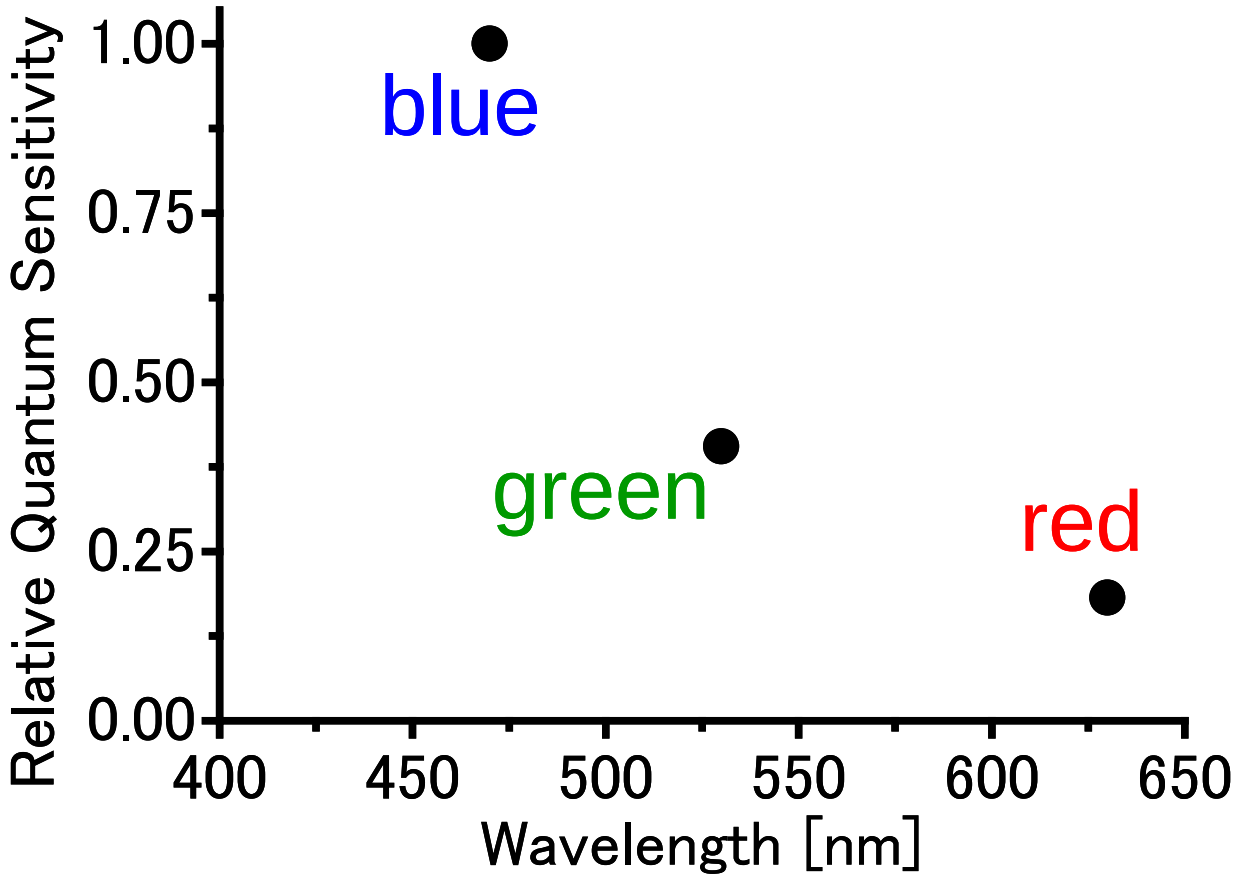


Fig.6. Wavelength of serotonin enhancing in the morning

Mechanism

★ Enhancement of melatonin secretion suppression

↓

Enhancement of serotonin secretion → Awareness inprovement

↓

Enhancement of melatonin secretion in evening/night →

Deep and sufficient sleeping

Summary of E-smart LED lighting system

- Improvement of human circadian rhythms
- Possibility to improve awareness and dementia.
- Stabilization of human mind:

Future work include psychological study in addition to physiological ones conducted in our researches.
Really, interdisciplinary subject over technology,
also leading to business!

Miyachi Integrated Energy System for rural Areas

- Tiny size experiment in the mountain village of East Jawa
- This integrated system is in a tiny size and consist of solar panels, a biogas engine, batteries and Miyachi controllers for battery charging and discharging. The biogas is generated from milk cow dunk in a gas tank, and fed to cooking burners and a gasoline engine. Drinkable water was produced from rain water through a filter.

Rain, Pond & River Waters

Water Pump

Filtration

(Removal of Suspending Turbid substances etc.)

LED Lighting System

(Replace Mercury Lamps.)

Solar Cells

Solar Controller

Invertor

Battery Bank

Solar Power System

Biogas Electric Generation System

秘

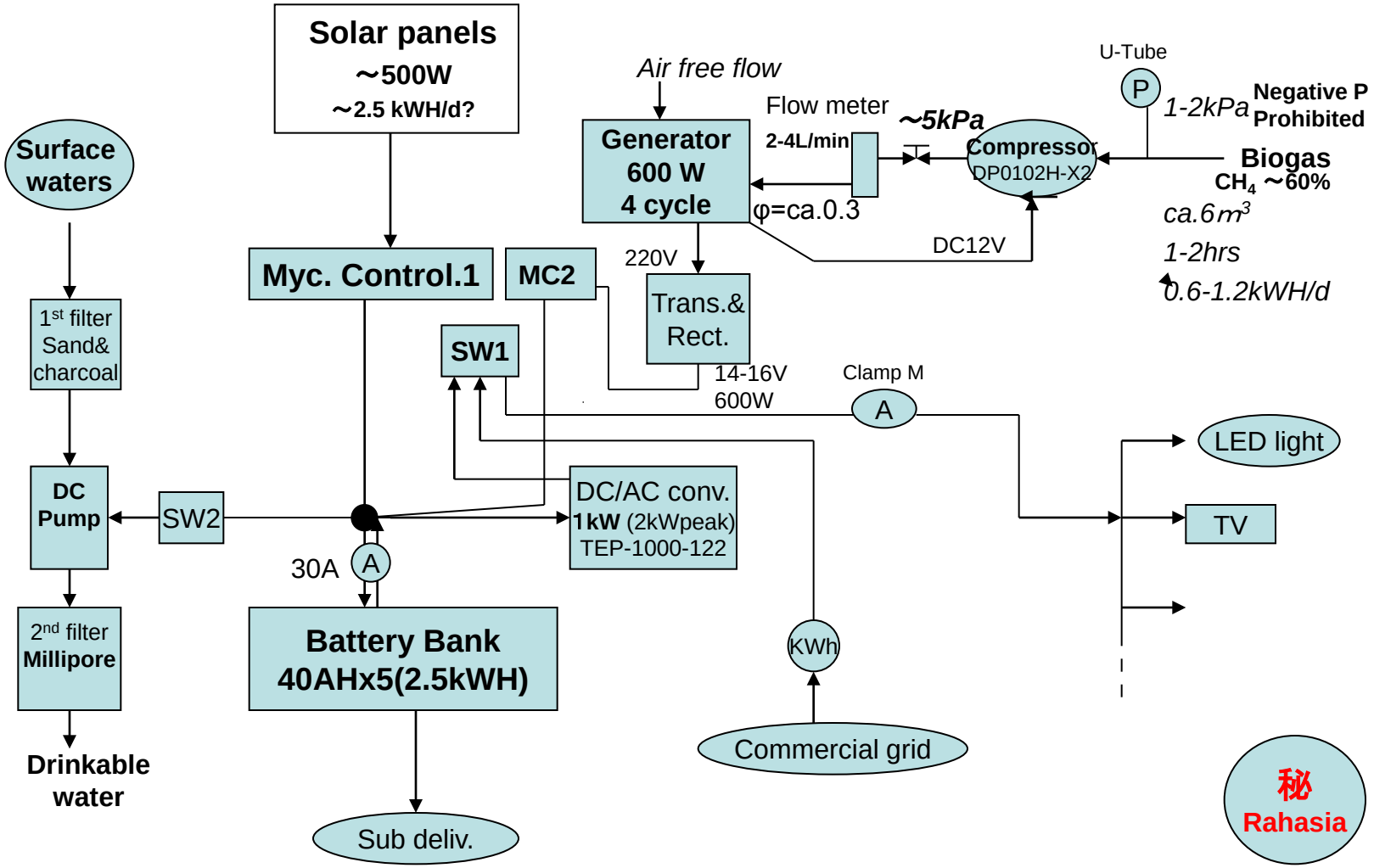


Fig. Miyachi Integrated Energy System (MIES) for rural areas(Ver.4S)

Miyachi Sistem Terpadu Energi (MSTE) untuk daerah pedesaan (Ver.4S)

JULY 3, 2015 by Kitagawa

Geger, Sendang, Tulungagung, Jawa Timur

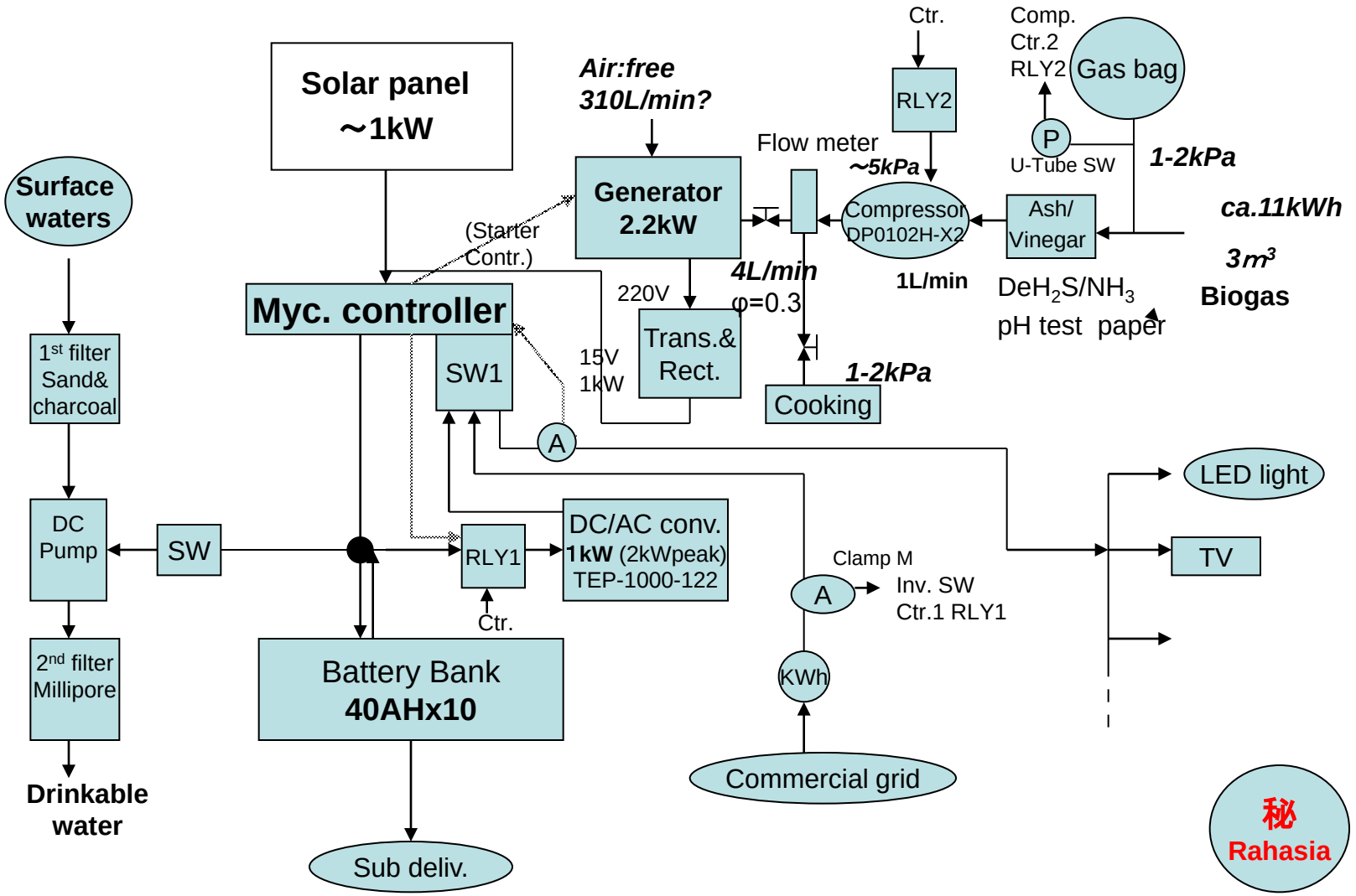
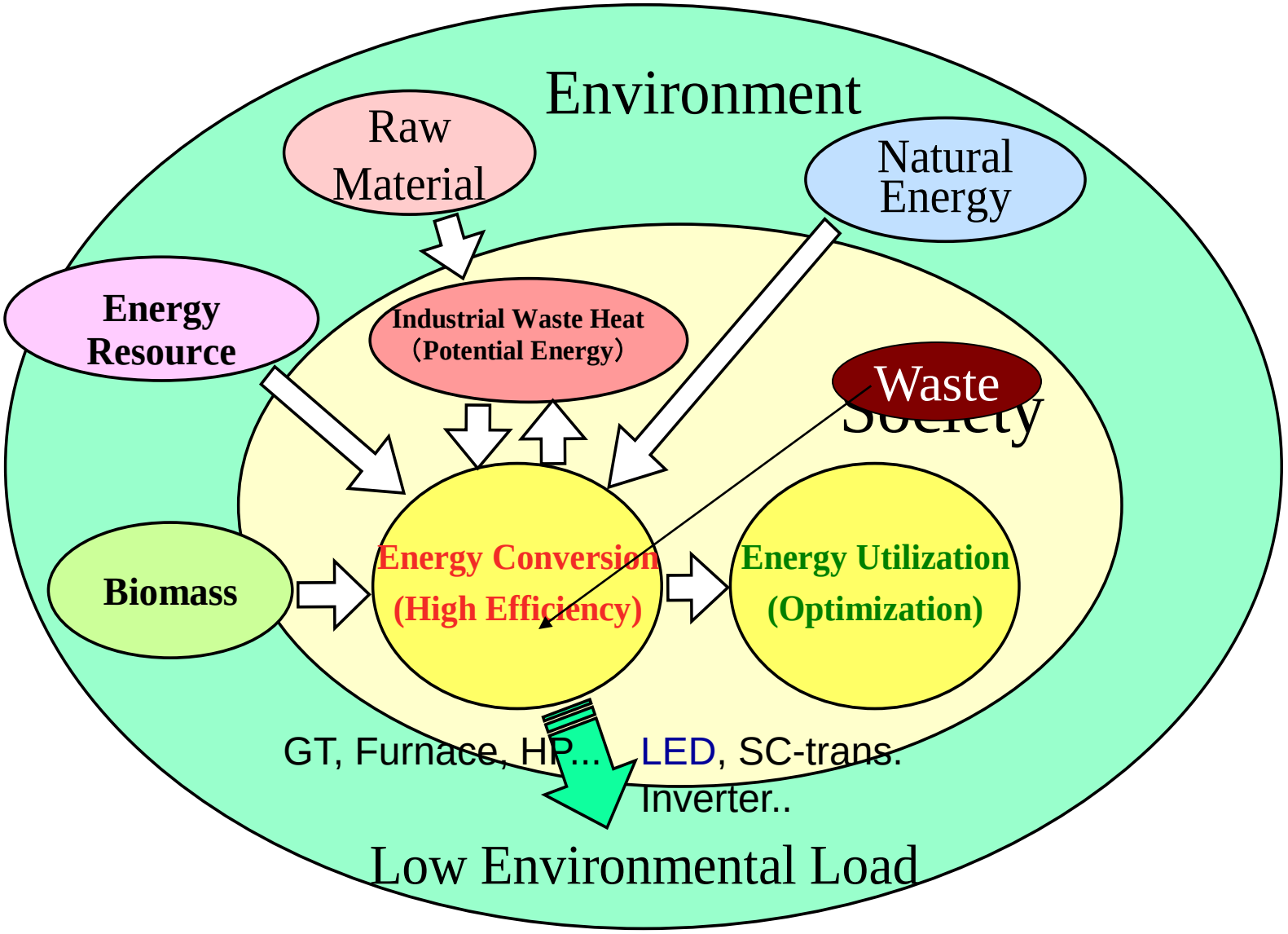


Fig. Miyachi Integrated Energy System (MIES) for rural areas(Ver.4)

10/4/2015 by Kitagawa

Energy World Concept



＜Energy Resources＞		＜disadvantages＞
Hydraulic Resource		Disturbance on the ecological systems
Gas turbine/stem tubine		
fossil Fuel	Coal (carbon, sulfur)	carbon dioxide :greenhouse effect
	Petroleum (hydrocarbon)	SOX and NOX:acid rain
	Natural gas (methane)	
Nuclear energy :	Nuclear fission	cost of waste disposal
	Nuclear fusion	no neutrons? Reactor wall
New energy	wind energy	unstable supply, noisy
	solar energy	unstable supply, lifetime
	geothermal energy	unstable supply
	tidal energy	unstable supply
	biomass	high cost(recycling of waste)
	waste incineration	poisonous emission

Spectroscopic visualization of temperature and chemical species

- In conjunction with highly efficient energy systems with lower environmental burdens, we have developed several spectroscopic visualization systems and applied to in-situ monitoring of a new type of industrial furnace for steel making and a fusion plasma reactor. The temperature profiles which is the most important physical property to determine the NOx emission was in-situ monitored by a newly developed temperature video camera. In addition, intermediated chemical species produced in flames were also visualized. The temperature in plasmas and excited atomic/molecular species were also visualized as two-dimensional distributions.

- Low NOx Emission from Regenerative Industrial Furnace for 30% Energy Saving
- Spectroscopic Observation

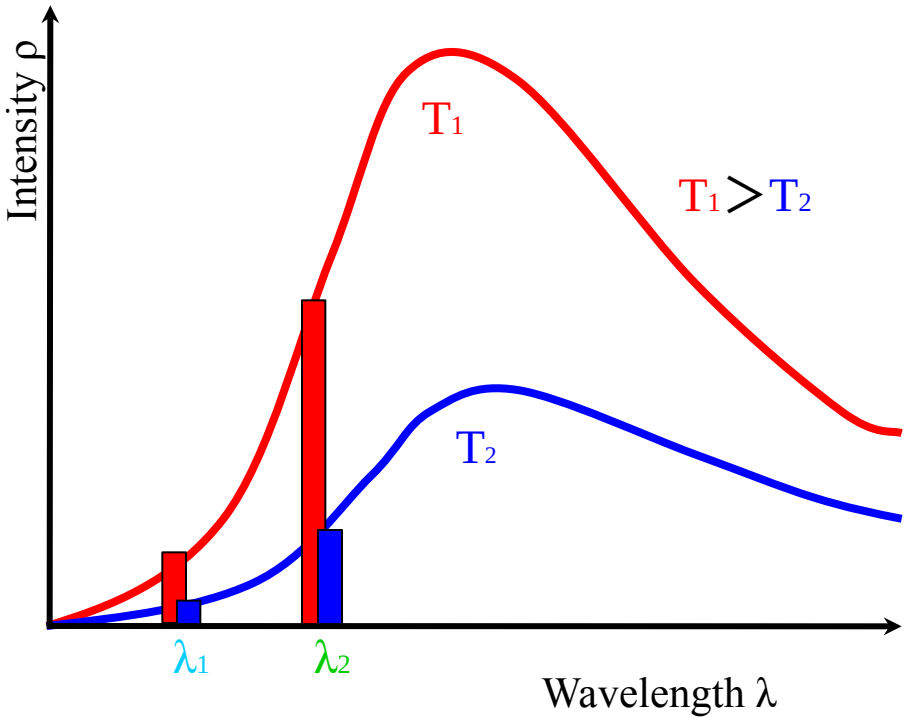
Two-color method

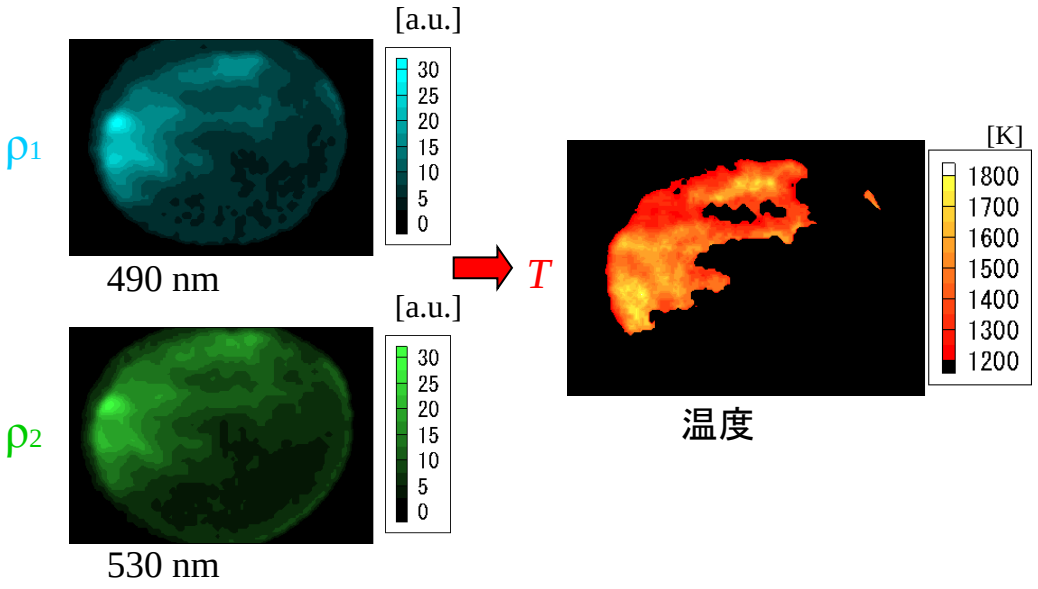
Planck's law

$$\rho = \varepsilon_\lambda \cdot \frac{8\pi hc}{\lambda^5} \cdot \frac{1}{\exp(hc/\lambda kT)-1}$$

Taking a ratio of intensities at 2 wavelengths,

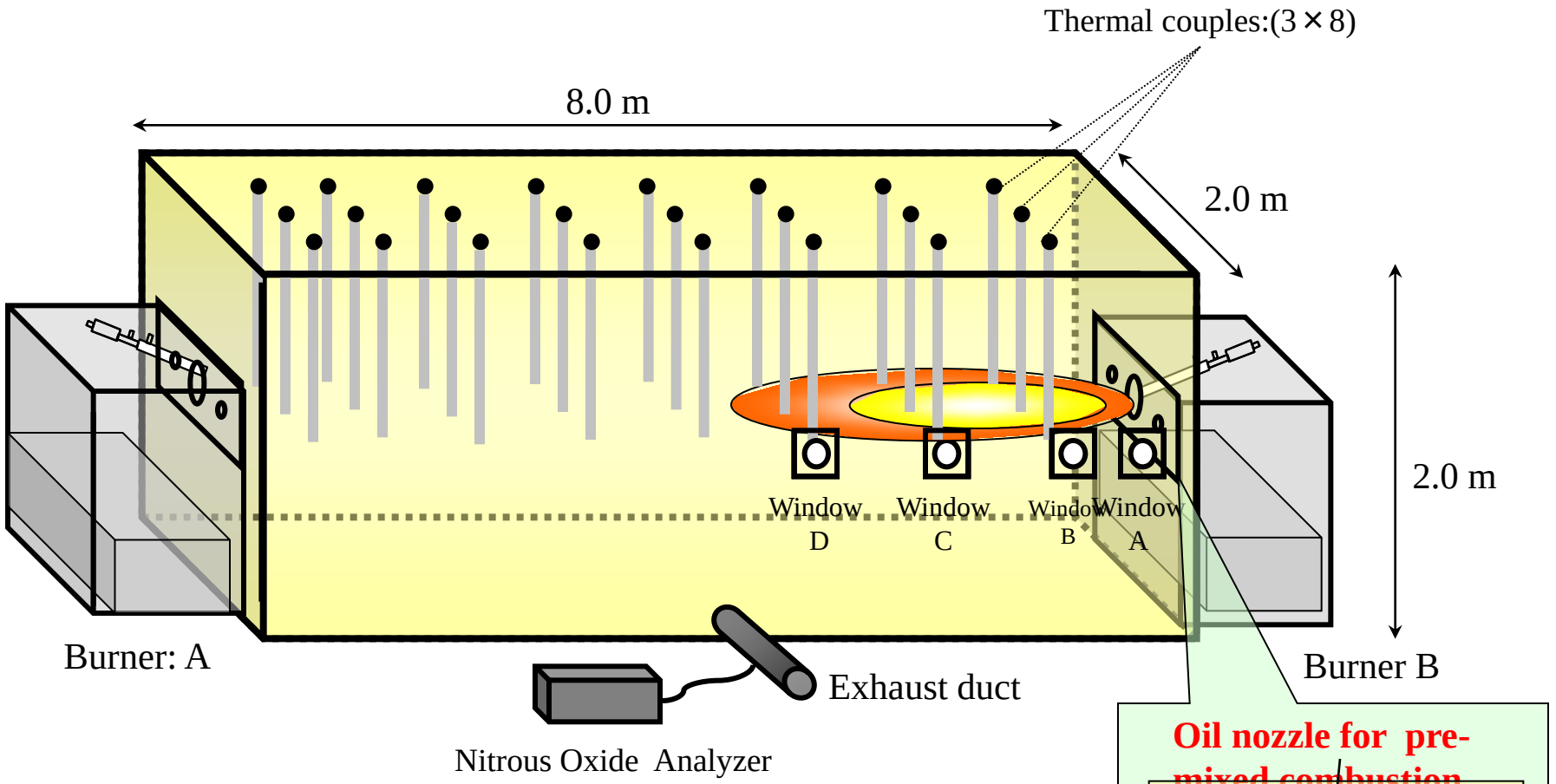
$$\frac{\rho_2}{\rho_1} = \left(\frac{\lambda_1}{\lambda_2}\right)^5 \cdot \frac{\exp(hc/\lambda_1 kT)-1}{\exp(hc/\lambda_2 kT)-1}$$





ρ : Unit radiation energy [Jm^{-4}]
h : Planck's const 6.62608×10^{-34}[Js]
λ : Wavekength [m]
c : light velocity 2.99792458×10^{8} [ms^{-1}]
k : Boltzmann const 1.38066×10^{-23}[JK^{-1}]
T : Temperature [K]
ε_λ : Emissivity [-]

Object :Test Furnace of Keihin Iron Plant, NKK (Currently JFE)



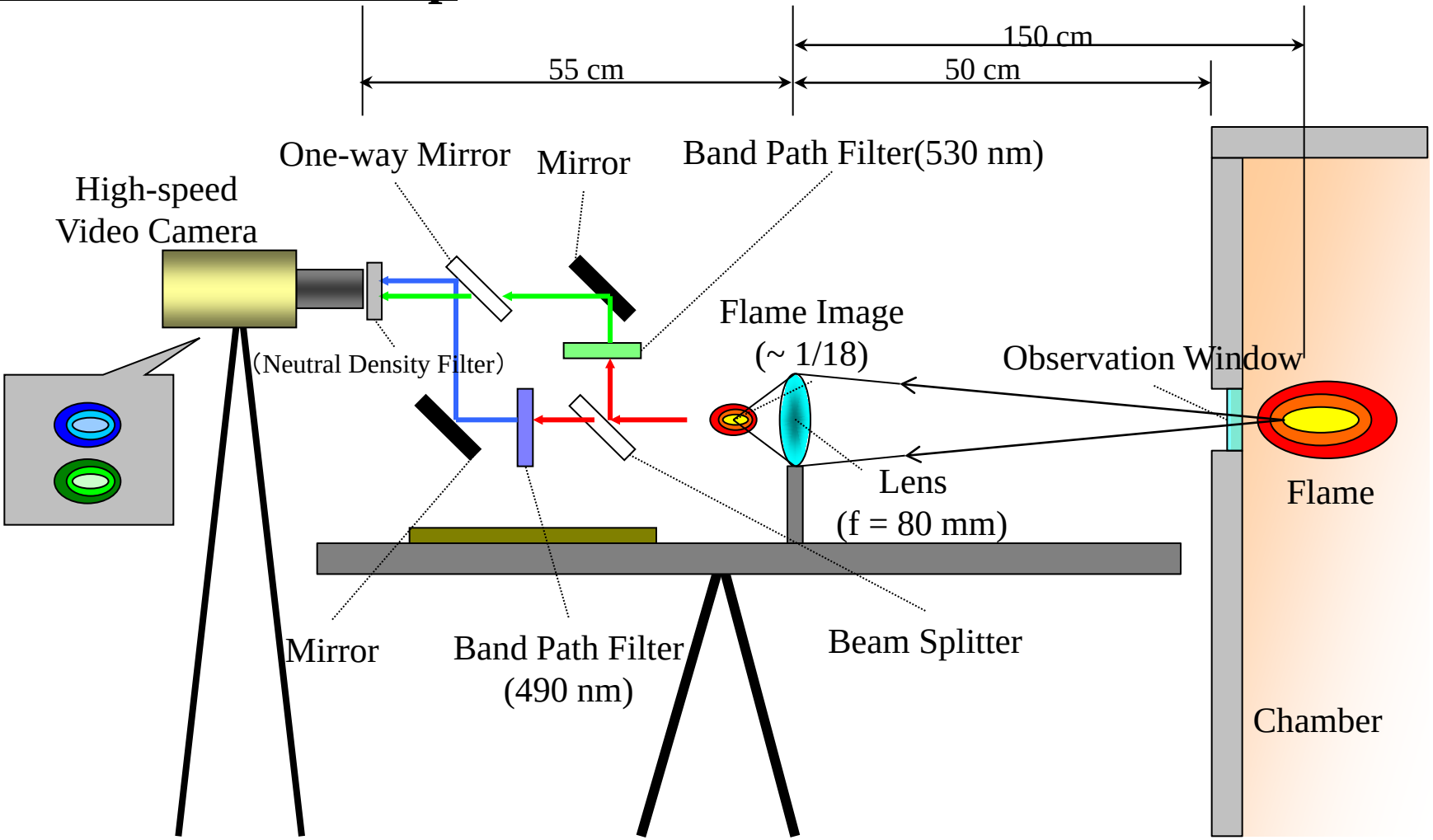
Fuel : Heavy Oil

Combustion:

Pre-mixed combustion : combustion of fully mixed air and fuel takes place in the chamber

Diffusion combustion : Combustion and mix of fuel and air takes place at the same time in the chamber

Measurement Set-up



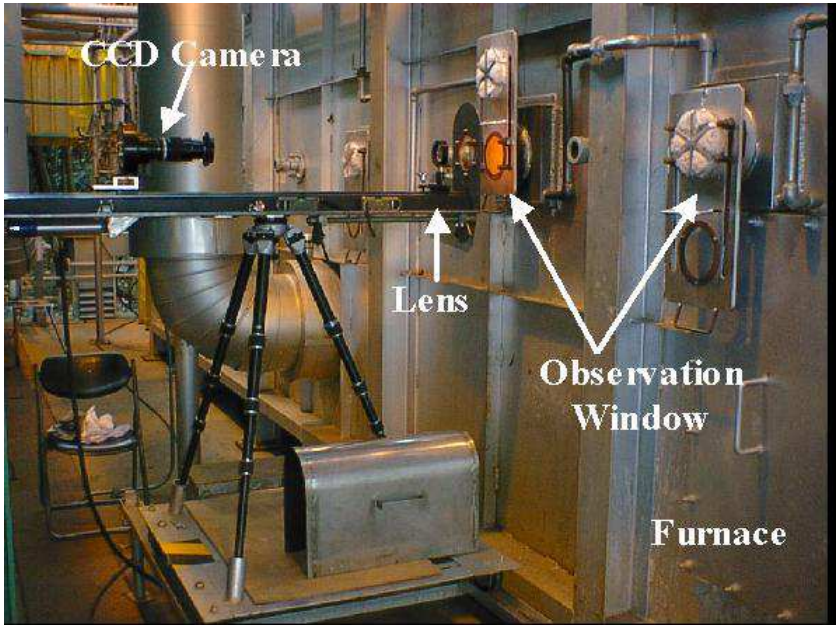
Band Path Filter:

530.88 nm(Half Width 8.77 nm)

490.0 nm (Half Width 28.0 nm)

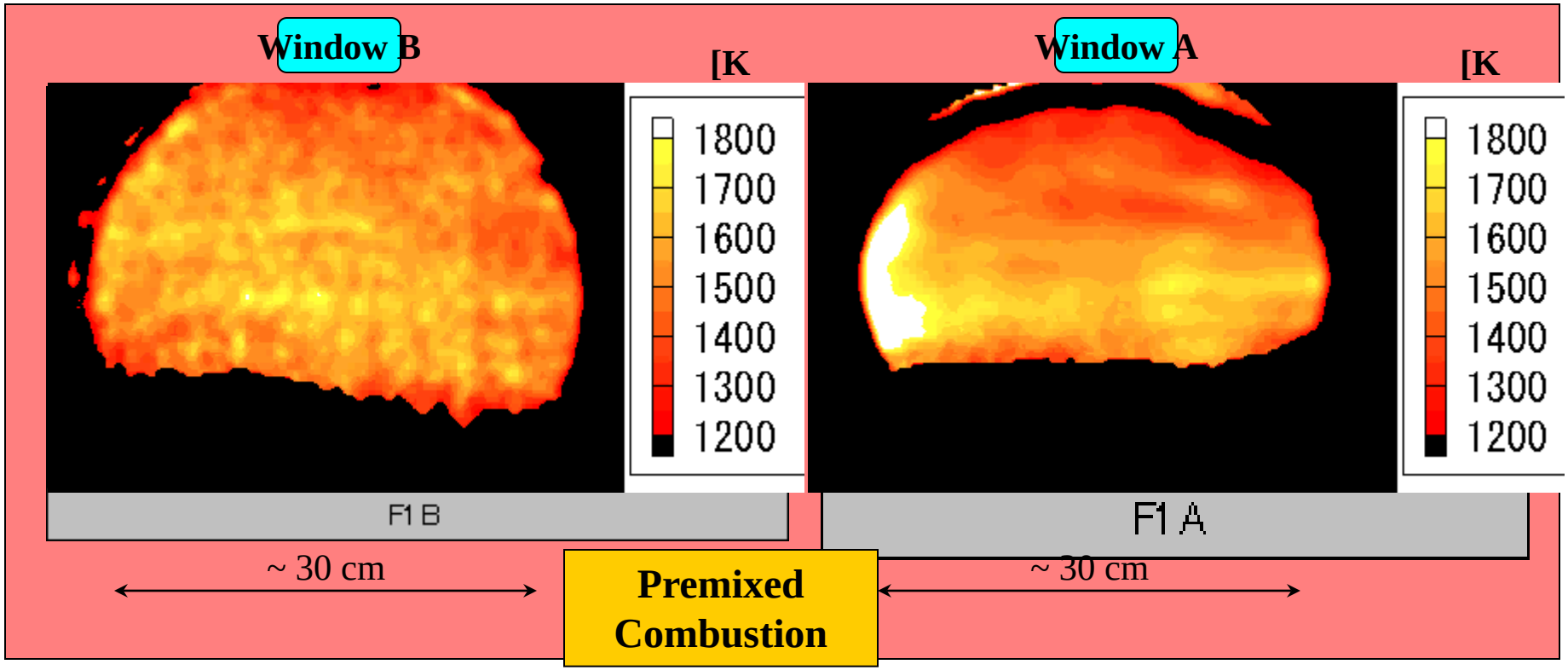
High-speed video camera（photron,FASTCAM ultima 40K）

Top Speed: 125 frame/sec Exposure Time: 1/125 sec


CCD Camera
Lens
Observation
Window
Furnace

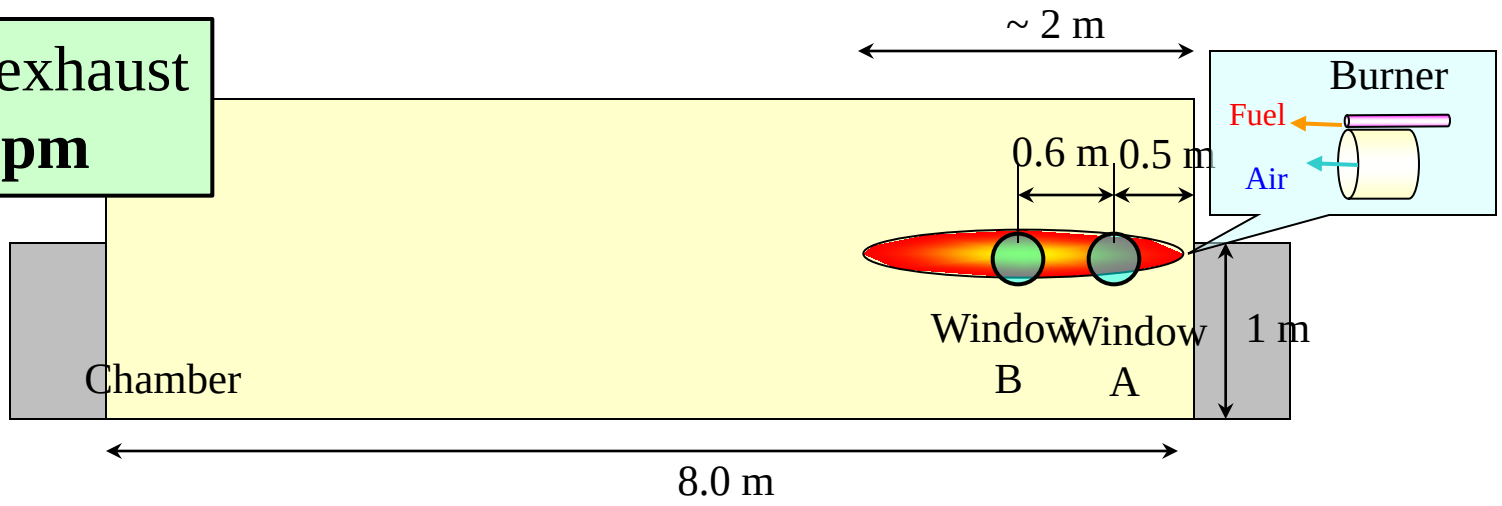
Temperature profiles (premixed combustion)

(Slow Motion(~1/10))

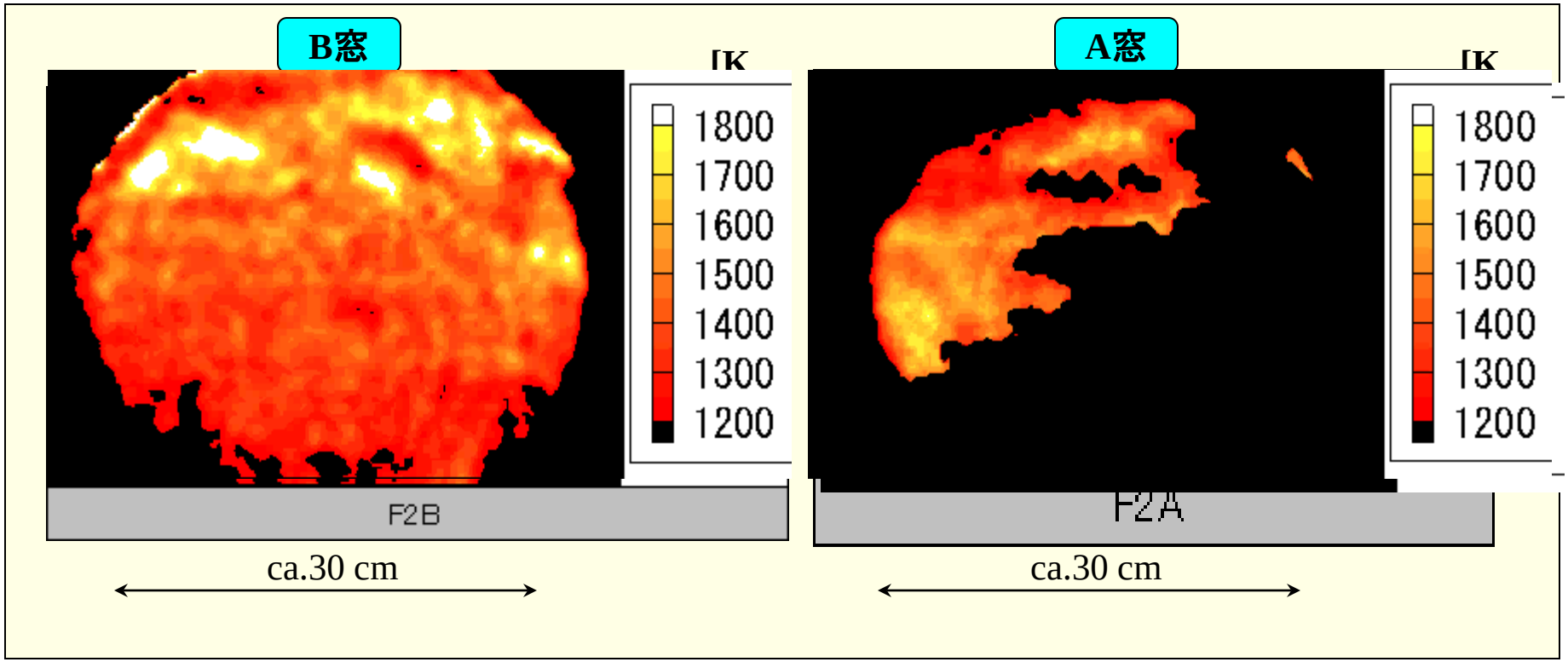


[NO_x] in the exhaust

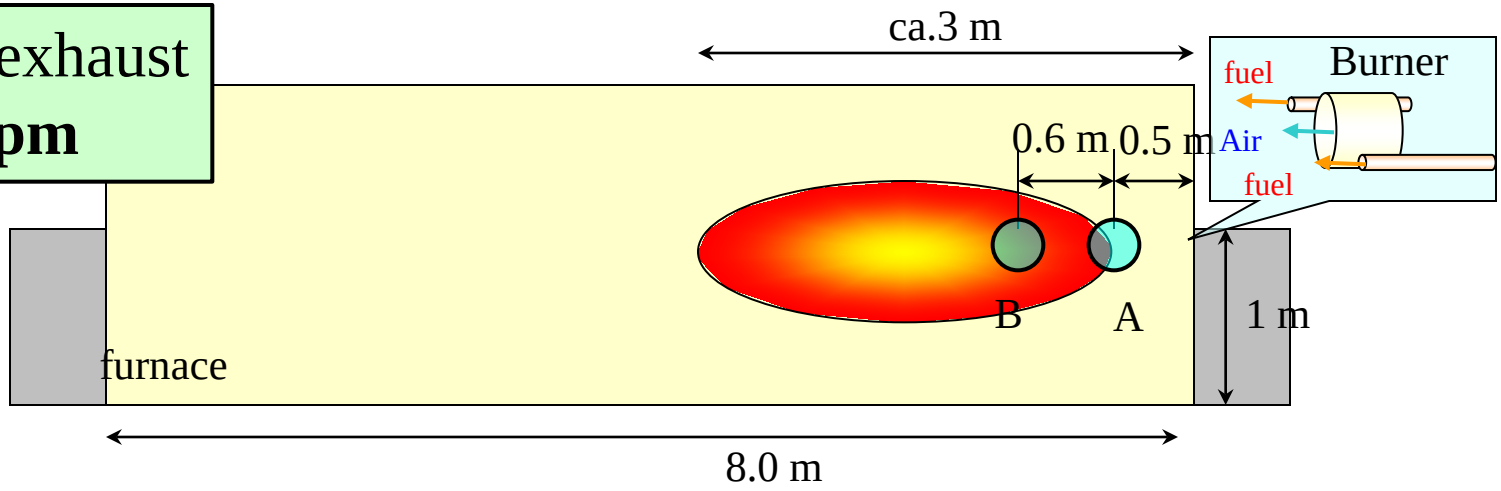
126～144 ppm

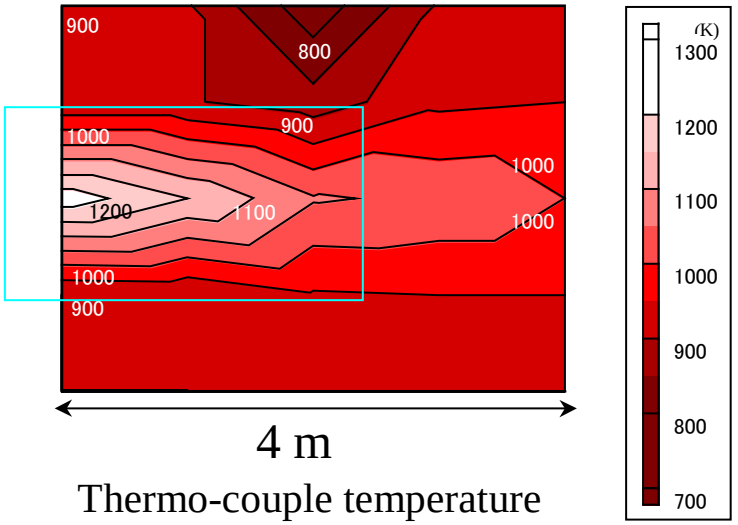


Temperature profiles (diffusion combustion)

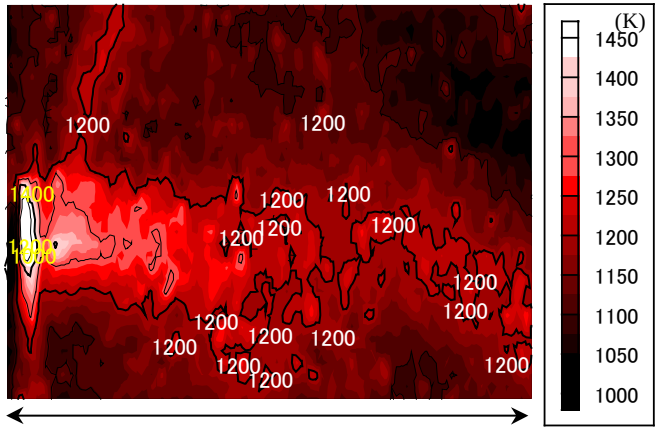


[NO_x] in the exhaust
24～33 ppm





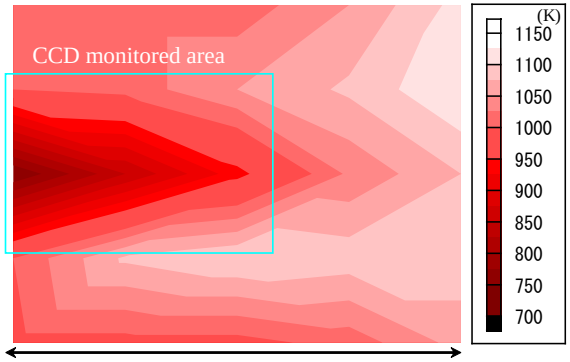
Thermo-couple temperature



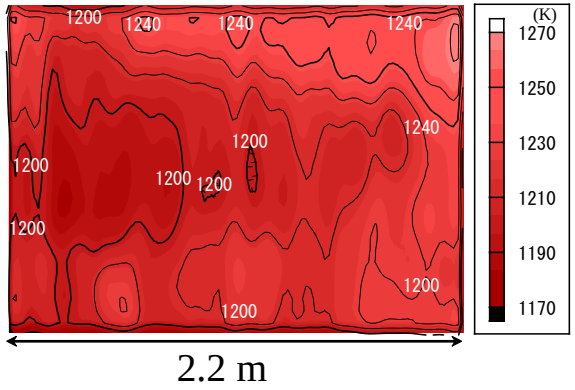
C_2 vibrational temperature

Premixed flame Exposure time 0.01[s]

Figure 5 Temperature distribution



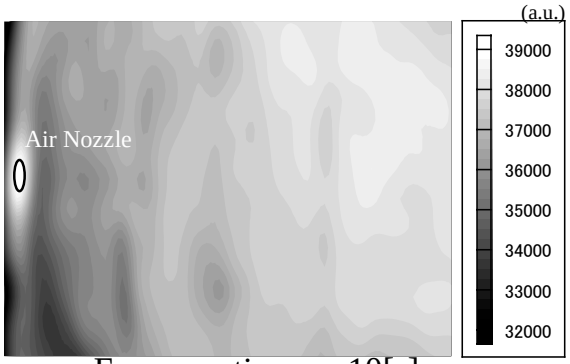
Thermo-couple temperature



C_2 vibrational temperature

Diffusion flame Exposure time 0.01[s]

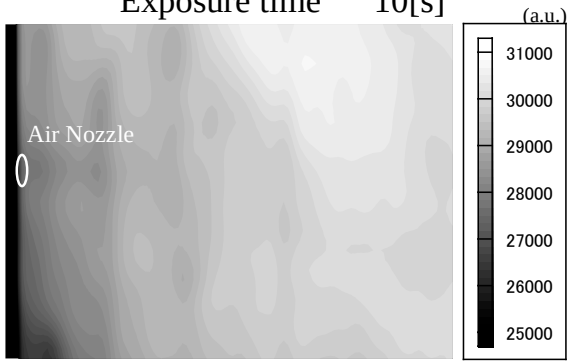
Figure 4 Temperature distribution



Exposure time 10[s]

Premixed flame

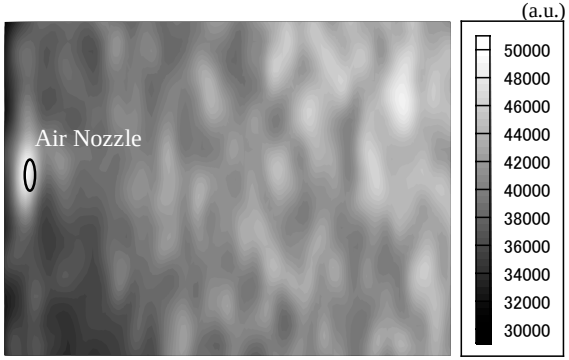
Exposure time 10[s]



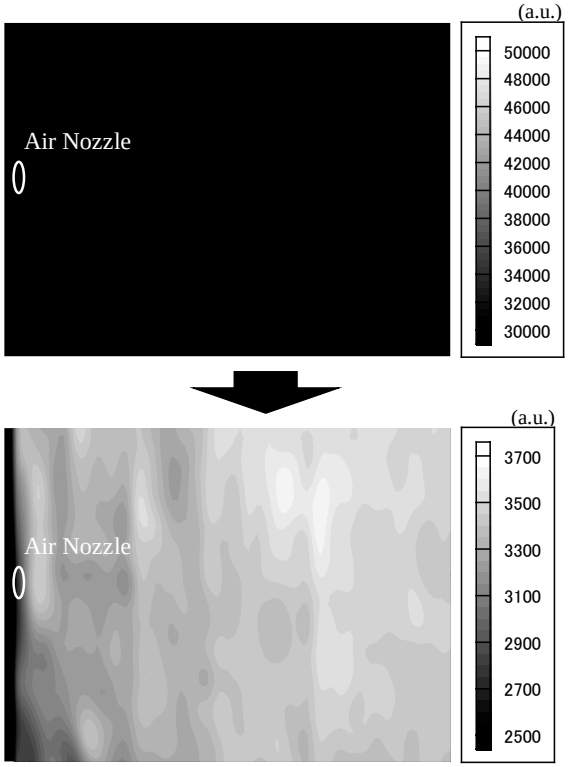
0.01[s]

Diffusion flame

Figure 9 OH Emission Intensity



Premixed flame



Diffusion flame

Figure 8 NO Emission Intensity


시판품 사 주세요
7000만원
SPRITE

Hydrogen and valuable material productionfrom biomass/biowastes by hydrothermal process

- In utilization of biomass or even biowastes, the suitable energy conversion system is required to convert chemical forms into fuels. Particularly for PEFCs, hydrogen is necessary. We have succeeded to produce pure hydrogen from biomass/biowastes such as waste wood, cattle/chicken dung, tofu waste etc. A valuable material, hydroxylapatite has also successfully been obtained.

Hydrothermal Process

- Biomass sample : 0.1 g
- Distilled H_2O / D_2O : 3 ml
- Additives :
  - Sodium carbonate (Na_2CO_3)
  - Nickel catalyst (Ni / SiO_2)

- Reaction Temp. : 400ºC
- Pressure : ca. 25 MPa

Microtube reactor
(10.5 ml)

Hydrothermal gasification of biowaste

- Cellulose

  (Model biomass sample)

- Real biomass

Wasted wood

C: 46.1 wt% H: 6.1 wt%
N: 1.5wt% S: 0.7 wt%

"Okara"

C: 46.2 wt% H: 6.7 wt%
N: 6.1 wt% S: 0.9 wt%

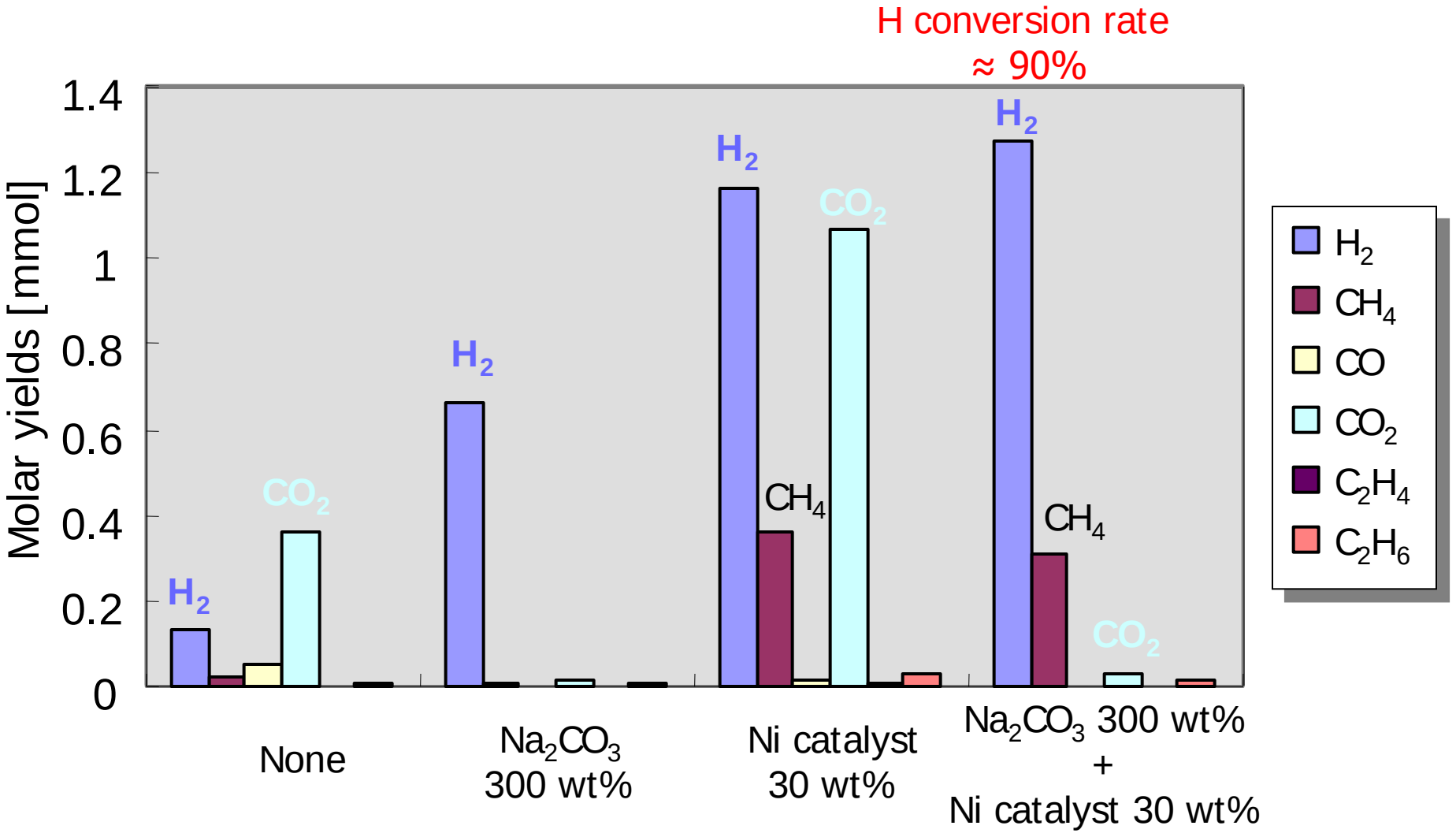
Fertilizer

C: 34.8 wt% H: 5.3 wt%
N: 7.6 wt% S: 1.3 wt%

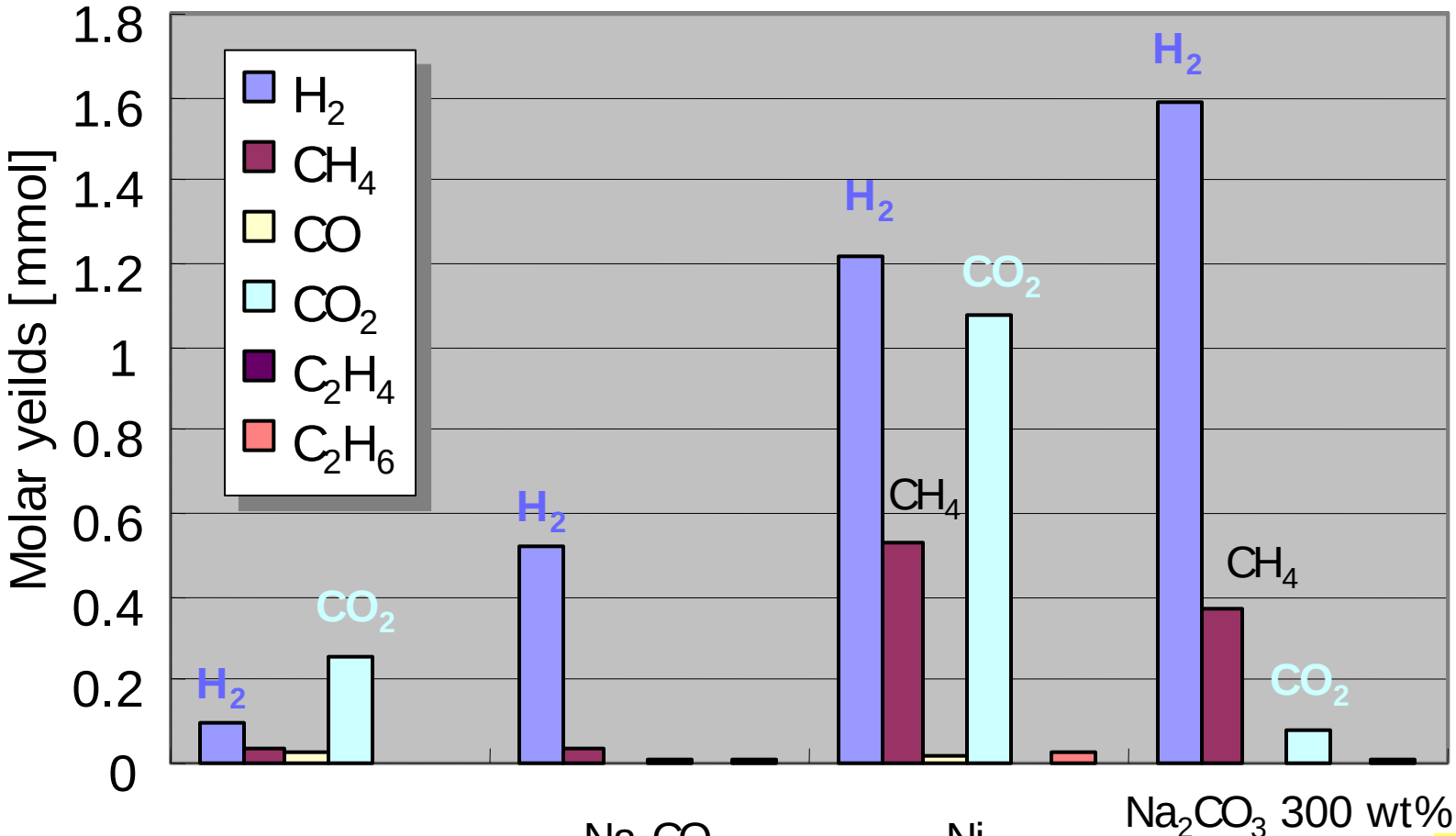
Peat

C: 46 wt% H: 5 wt%
N: 1 wt% O: 38 wt%

Effect of Na_2CO_3 and Ni Catalyst on Hydrothermal Reaction of Cellulose

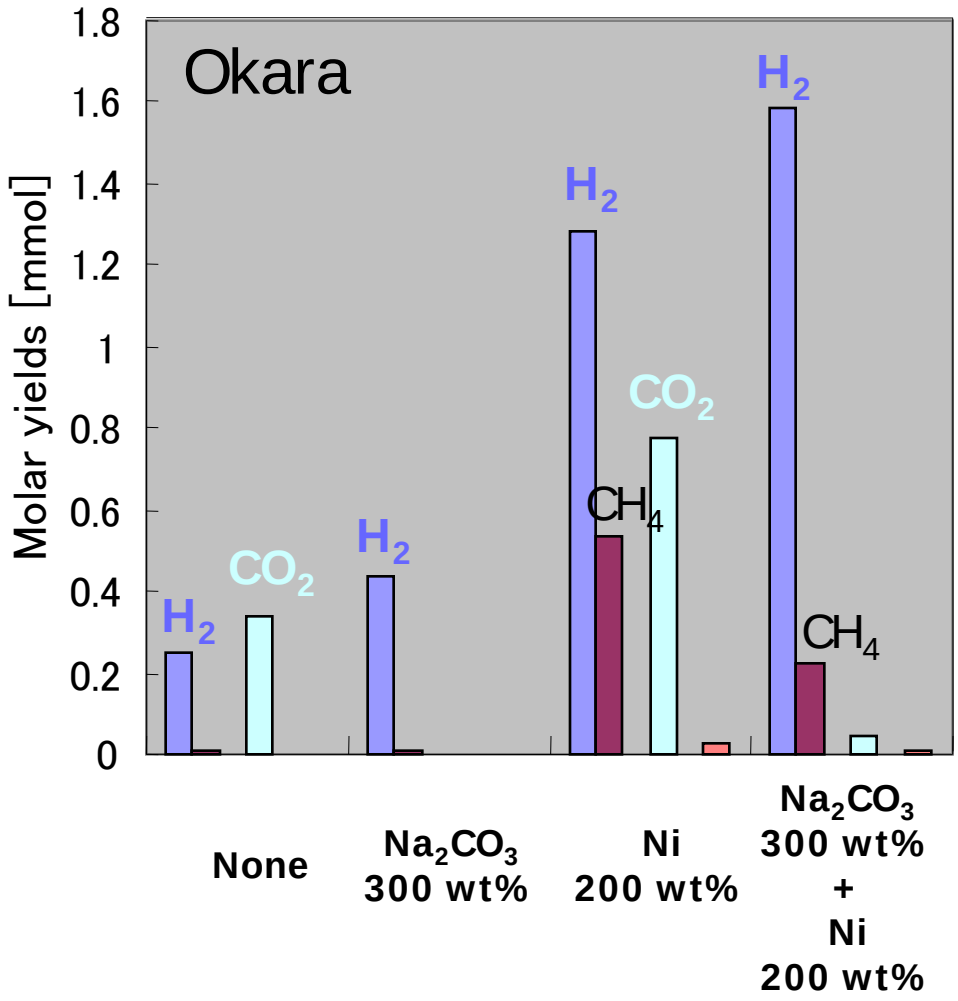


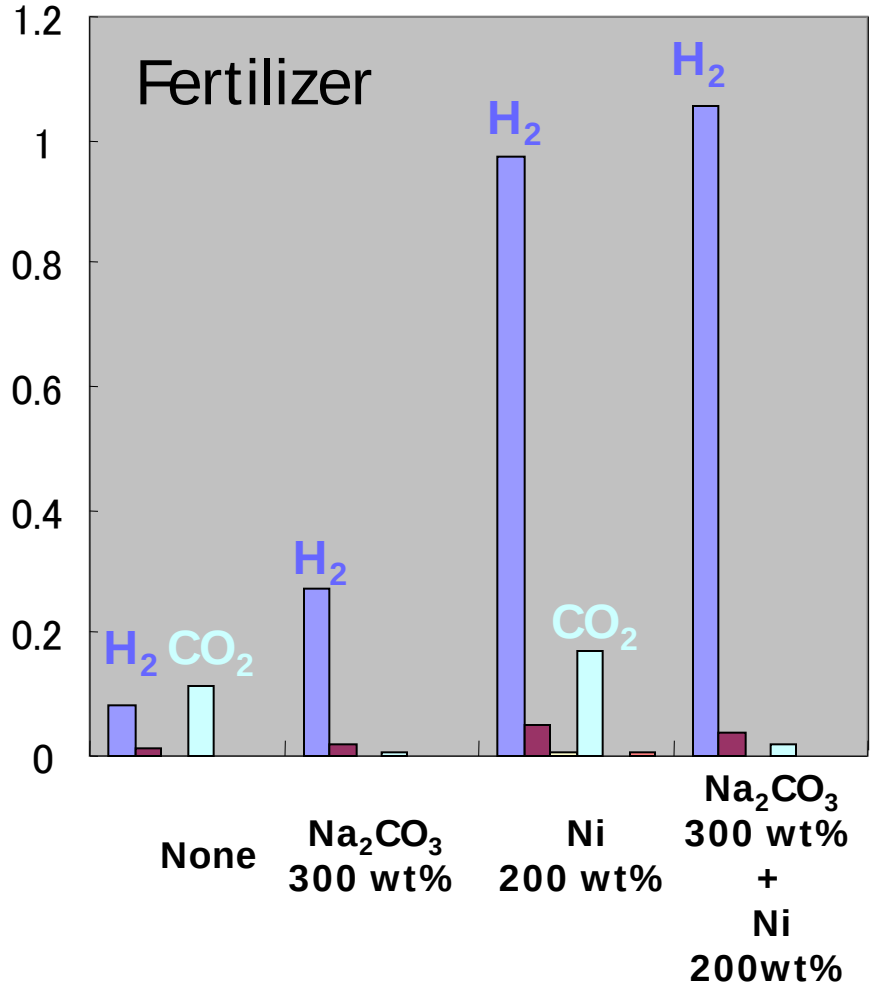
Effect of Additives on Hydrothermal Reaction of Wasted Wood

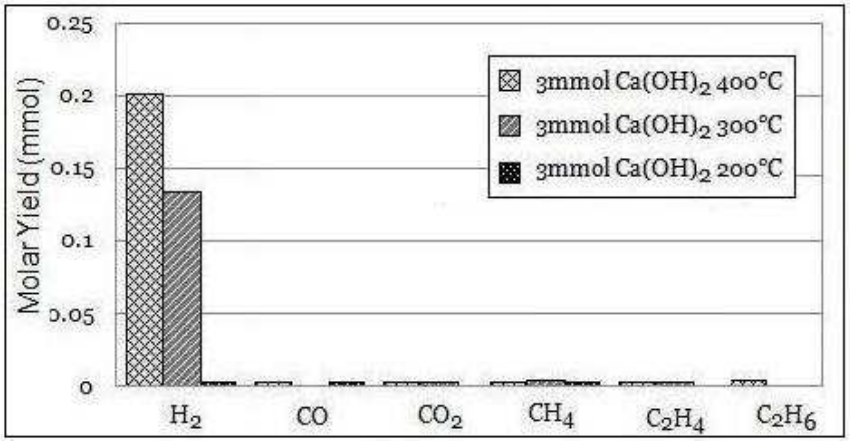


30 wt% (cellulose

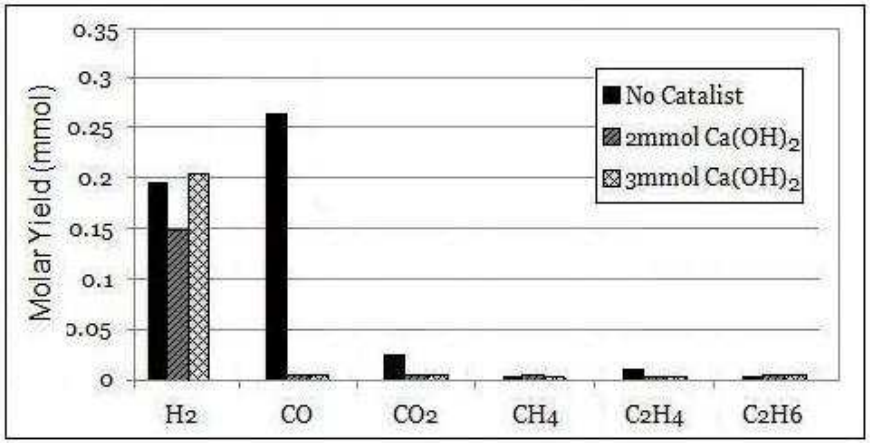
Effect of Additives on hydrothermal Reaction of Okara and Organic Fertilizer



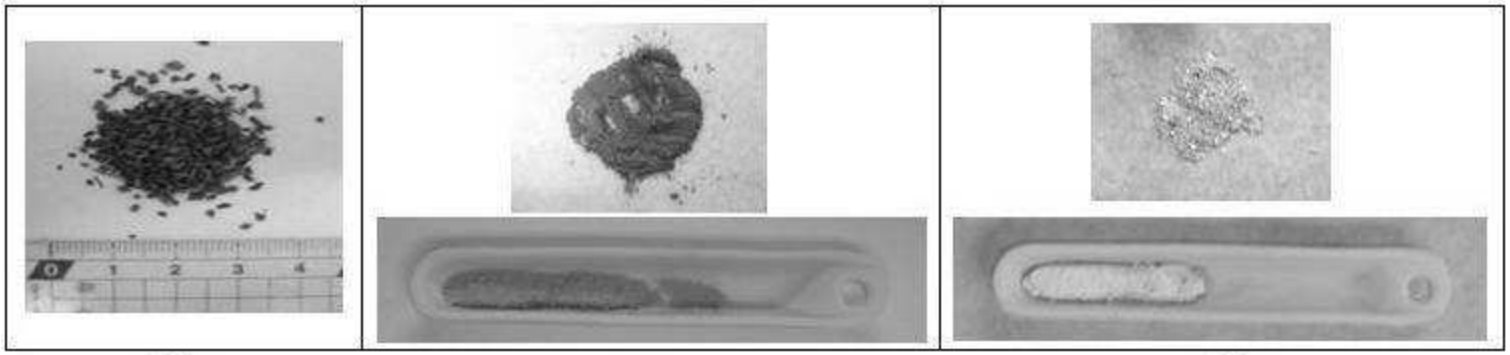


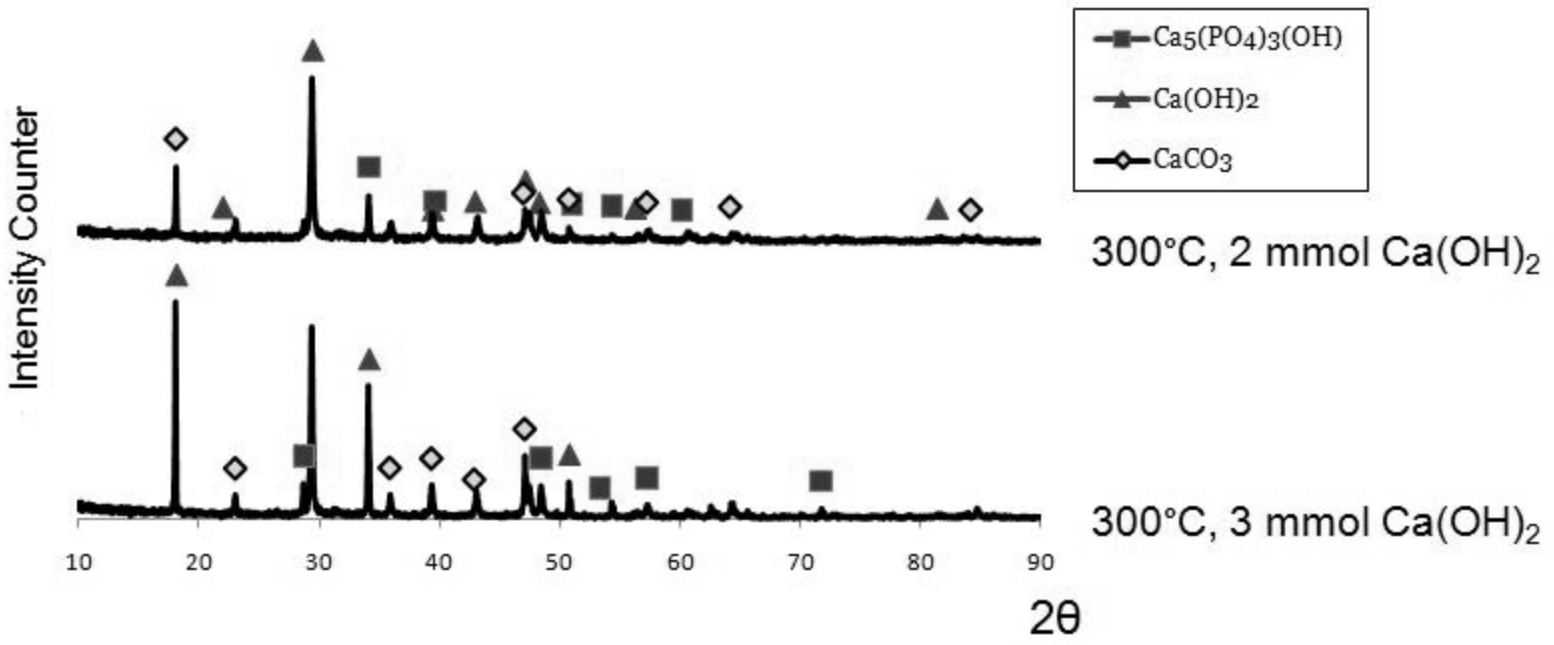

0.25
0.2
0.15
0.1
0.05
0
Molar Yield (mmol)
3mmol Ca(OH)2 400°C
3mmol Ca(OH)2 300°C
3mmol Ca(OH)2 200°C
H2
CO
CO2
CH4
C2H4
C2H6

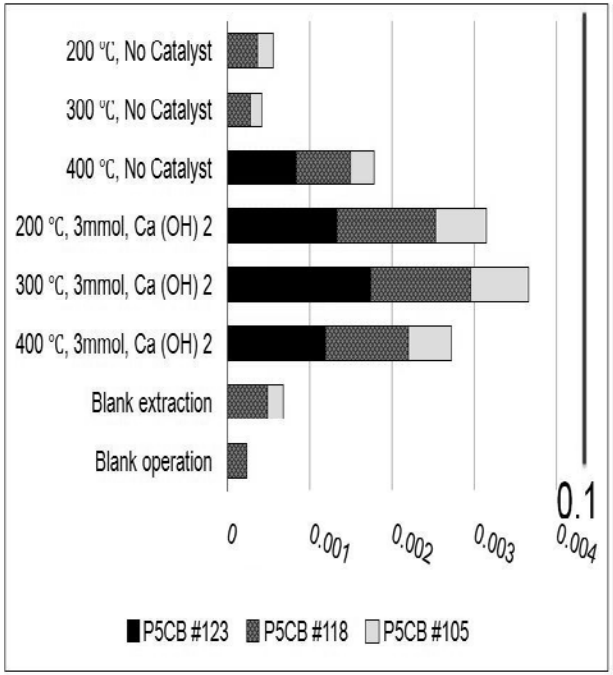
(a)


0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Molar Yield (mmol)
No Catalist
2mmol Ca(OH)2
3mmol Ca(OH)2
H2
CO
CO2
CH4
C2H4
C2H6

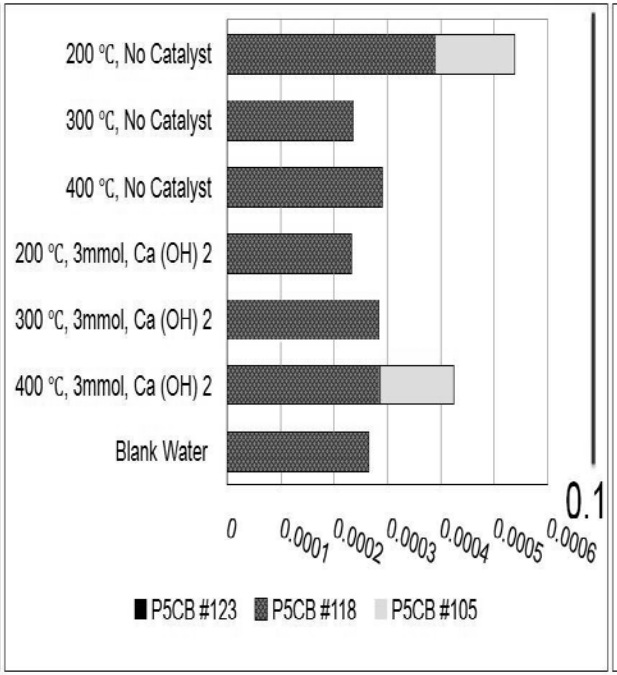
(b)


(a)
(b)
(c)

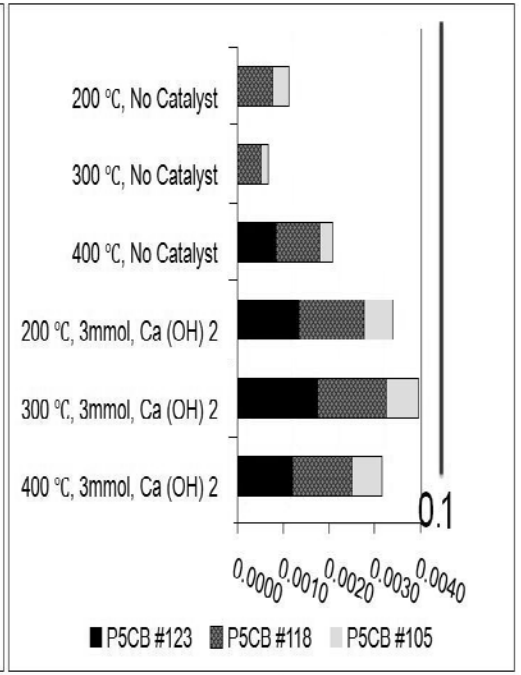

Intensity Counter
Ca5(PO4)3(OH)
Ca(OH)2
CaCO3
300°C, 2 mmol Ca(OH)2
300°C, 3 mmol Ca(OH)2
10
20
30
40
50
60
70
80
90
2θ


200 ℃, No Catalyst
300 ℃, No Catalyst
400 ℃, No Catalyst
200 ℃, 3mmol, Ca (OH) 2
300 ℃, 3mmol, Ca (OH) 2
400 ℃, 3mmol, Ca (OH) 2
Blank extraction
Blank operation
0
0.001
0.002
0.003
0.004
0.1
P5CB #123
P5CB #118
P5CB #105

(a)


200 ℃, No Catalyst
300 ℃, No Catalyst
400 ℃, No Catalyst
200 ℃, 3mmol, Ca (OH) 2
300 ℃, 3mmol, Ca (OH) 2
400 ℃, 3mmol, Ca (OH) 2
Blank Water
0
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0.1
P5CB #123
P5CB #118
P5CB #105

(b)

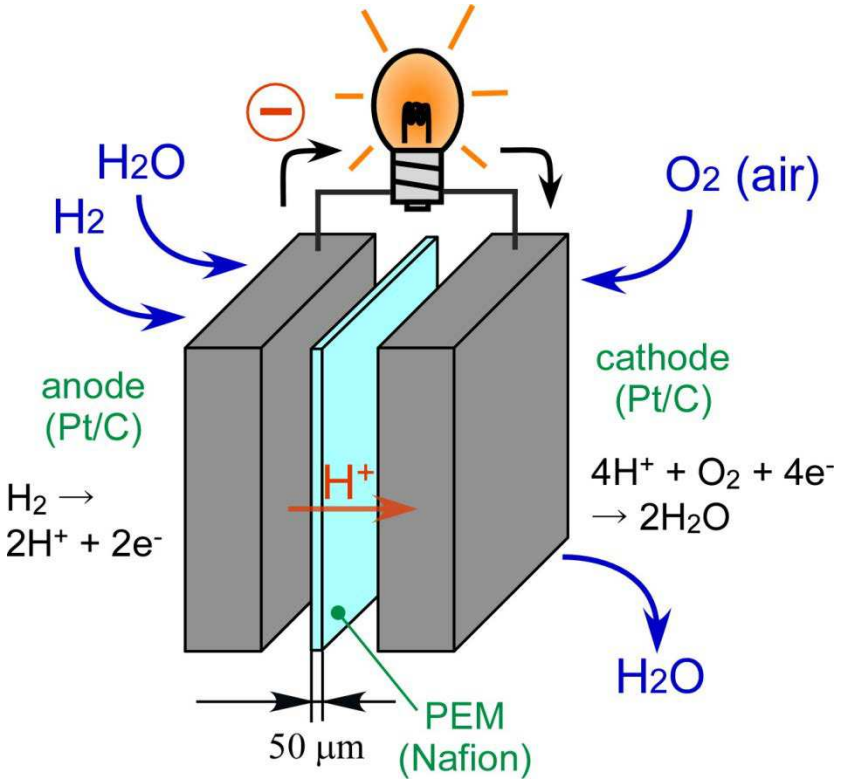

200 ℃, No Catalyst
300 ℃, No Catalyst
400 ℃, No Catalyst
200 ℃, 3mmol, Ca (OH) 2
300 ℃, 3mmol, Ca (OH) 2
400 ℃, 3mmol, Ca (OH) 2
0.0000
0.0010
0.0020
0.0030
0.0040
0.1
P5CB #123
P5CB #118
P5CB #105

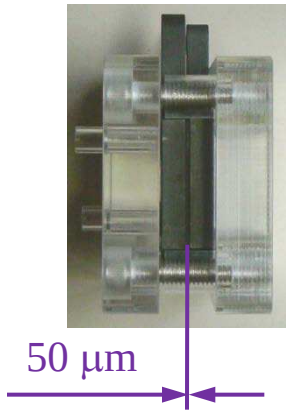
(c)

Moisture and CO monitoring and controls in polymer electrolyte fuel cells(PEFCs)

- PEFCs are among silent and clean energy conversion systems. However, there are two serious issues in conjunction that the strict control of water concentration in the electrolyte polymer films are indispensable to maintain the stable electric output, and that the trace level of CO greater that 10 ppm deactivates the catalytic activity of the cell anode, leading to the output decrease. We have developed a new methods to monitor these phenomena and also to mitigate the anode deactivation caused by CO.

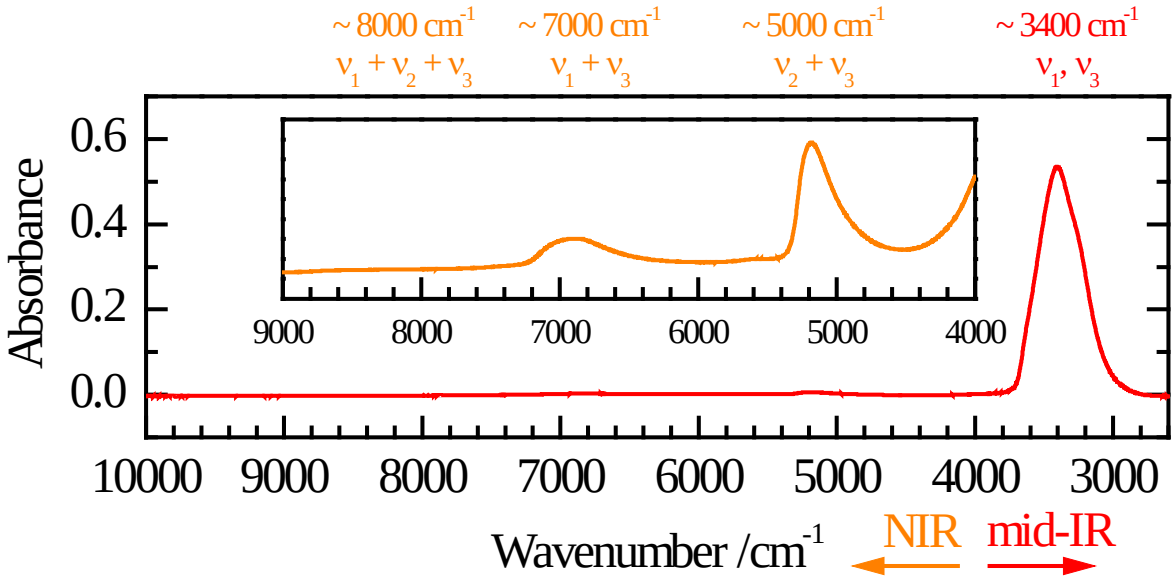
In situ monitoring of water in a PEM

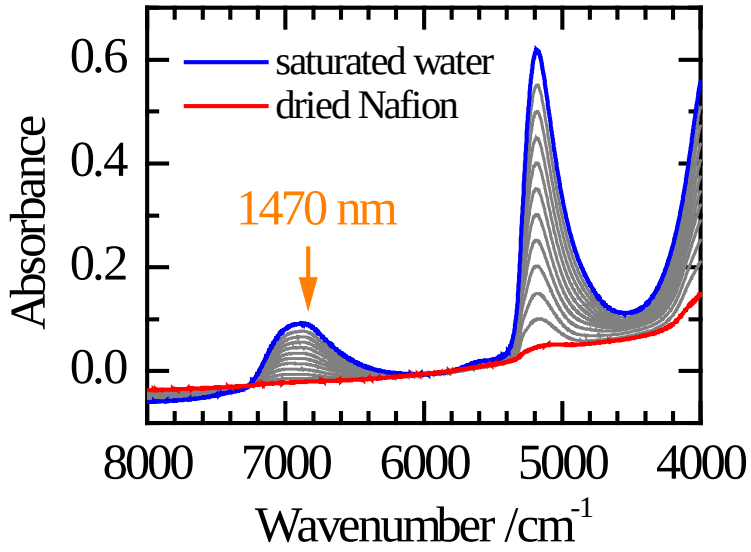




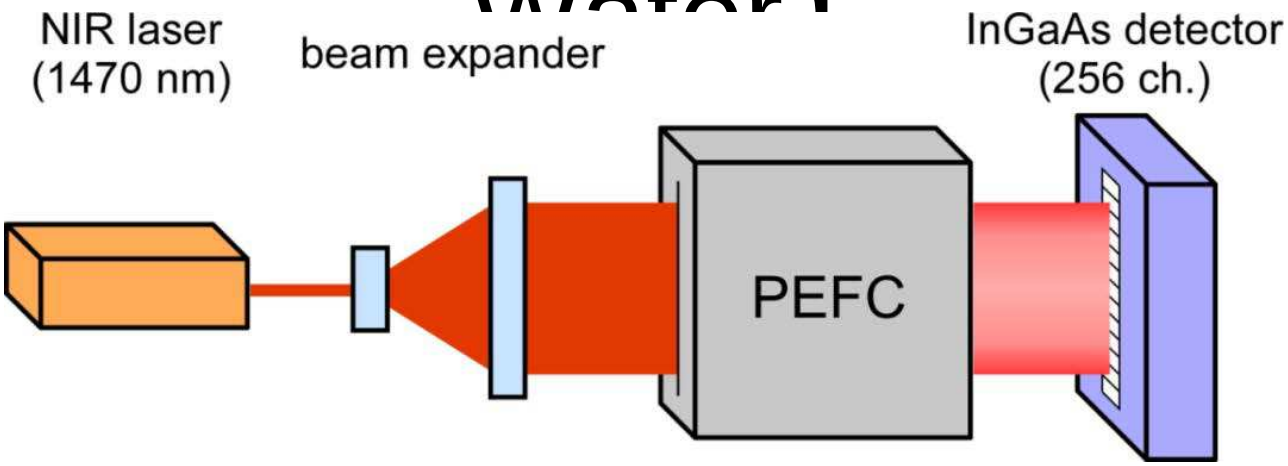
In situ monitoring of water in a proton exchange membrane (PEM) is important but difficult because the then membrane is sandwiched between two opaque electrodes. We have developed near-infrared (NIR) laser spectroscopy for the detection.

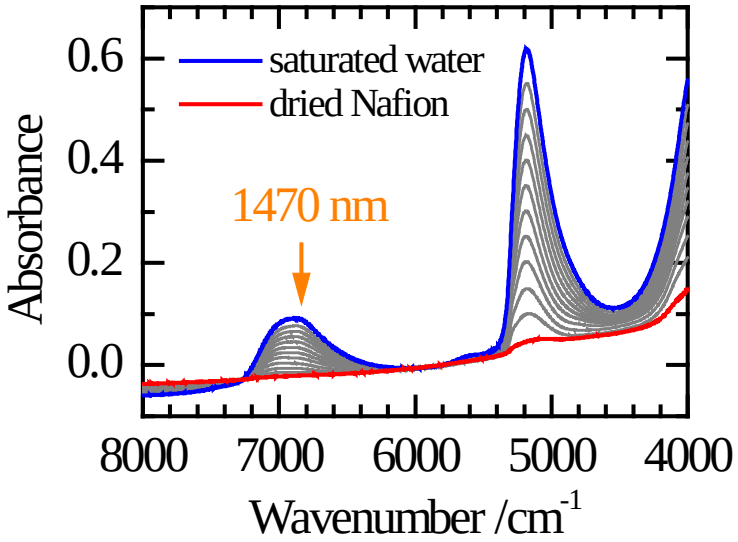
【Why NIR?】

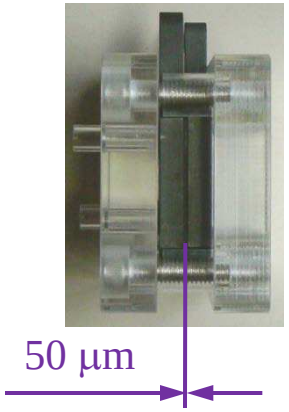

~ 8000 cm-1
ν1 + ν2 + ν3
~ 7000 cm-1
ν1 + ν3
~ 5000 cm-1
ν2 + ν3
~ 3400 cm-1
ν1, ν3
Absorbance
0.6
0.4
0.2
0.0
9000
8000
7000
6000
5000
4000
10000
9000
8000
7000
6000
5000
4000
3000
Wavenumber /cm-1
NIR
mid-IR

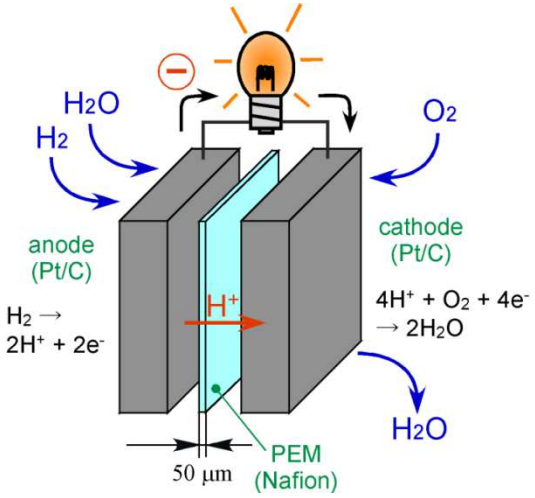

saturated water
dried Nafion
1470 nm
Absorbance
0.6
0.4
0.2
0.0
8000
7000
6000
5000
4000
Wavenumber /cm-1

Detection of Water

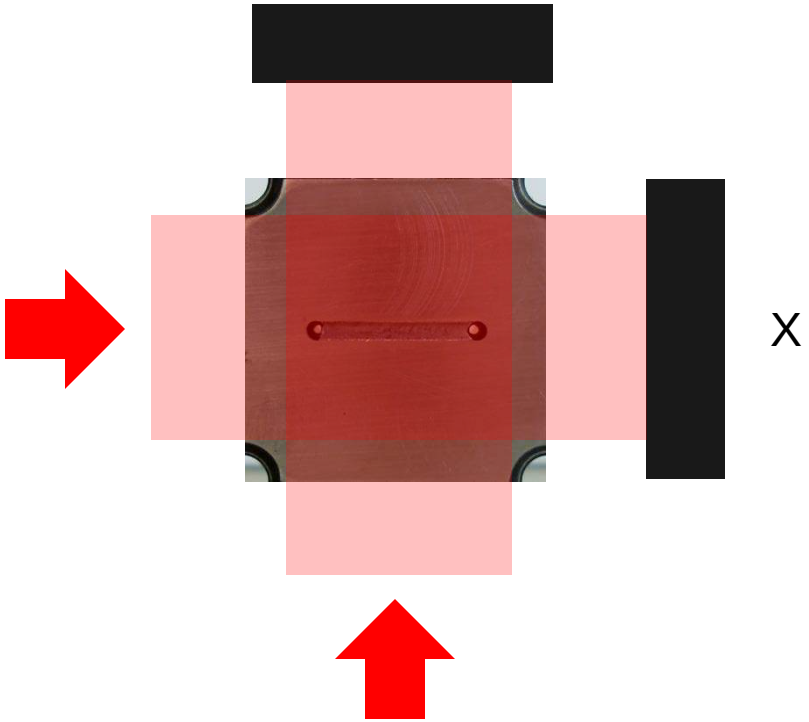


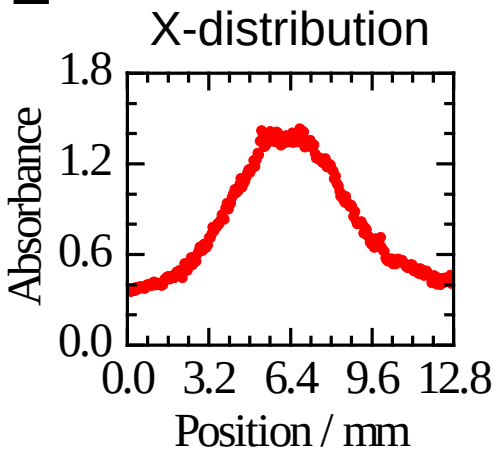




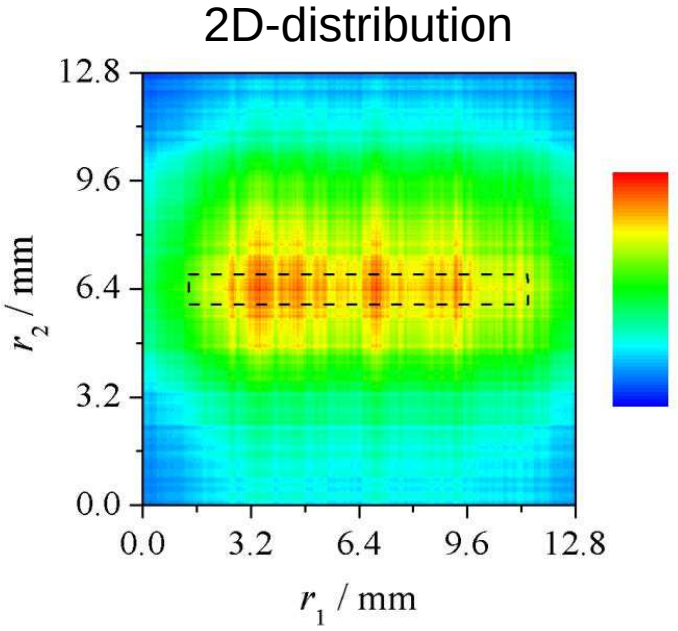


【2D Water Distribution】



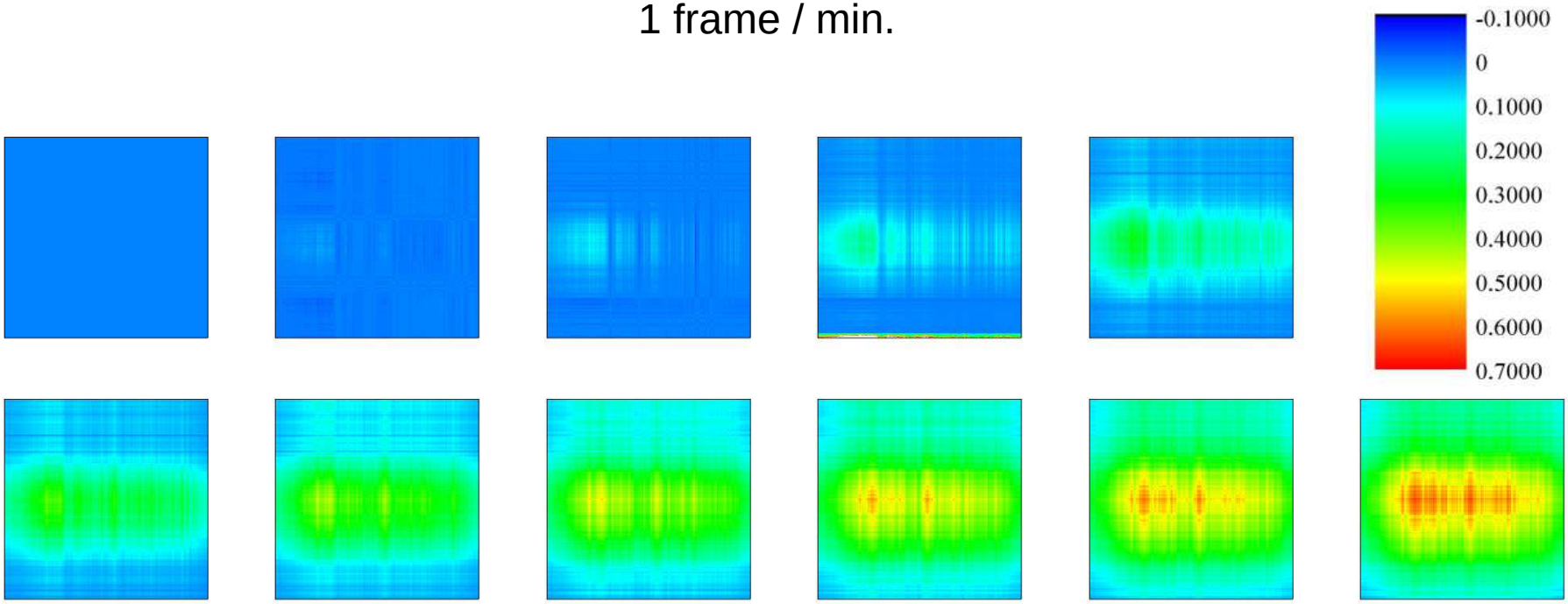


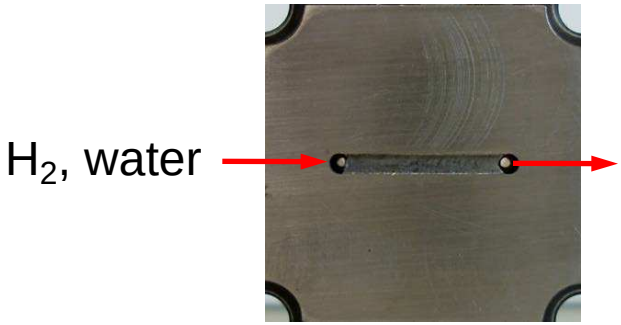
(X-distribution) × (Y-distribution) = 2D-distributiion



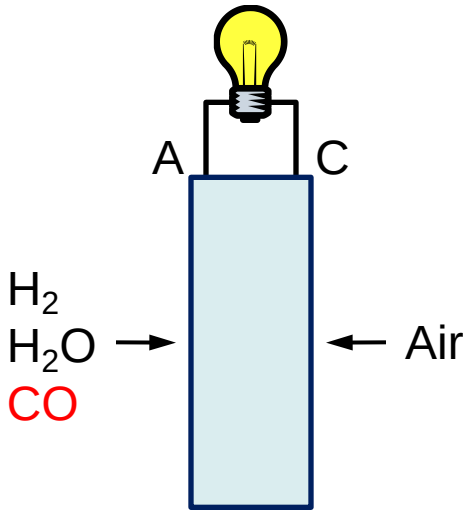
【2D imaging by NIR laser】

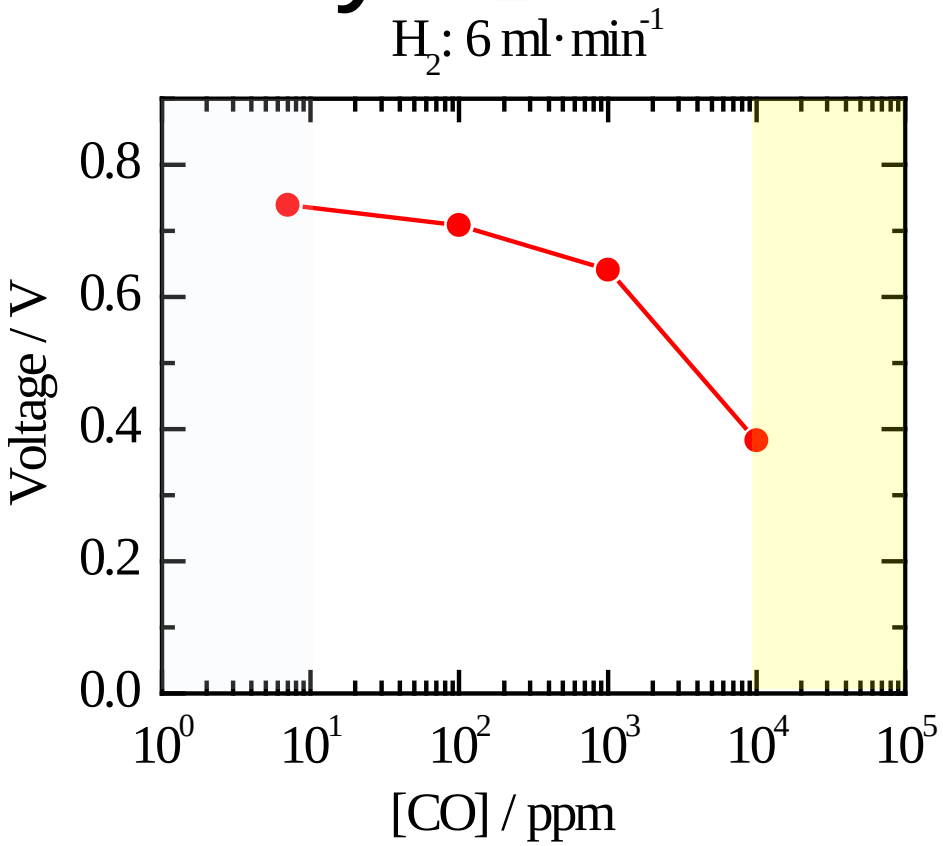
1 frame / min.





【CO poisoning onto a Pt catalyst】

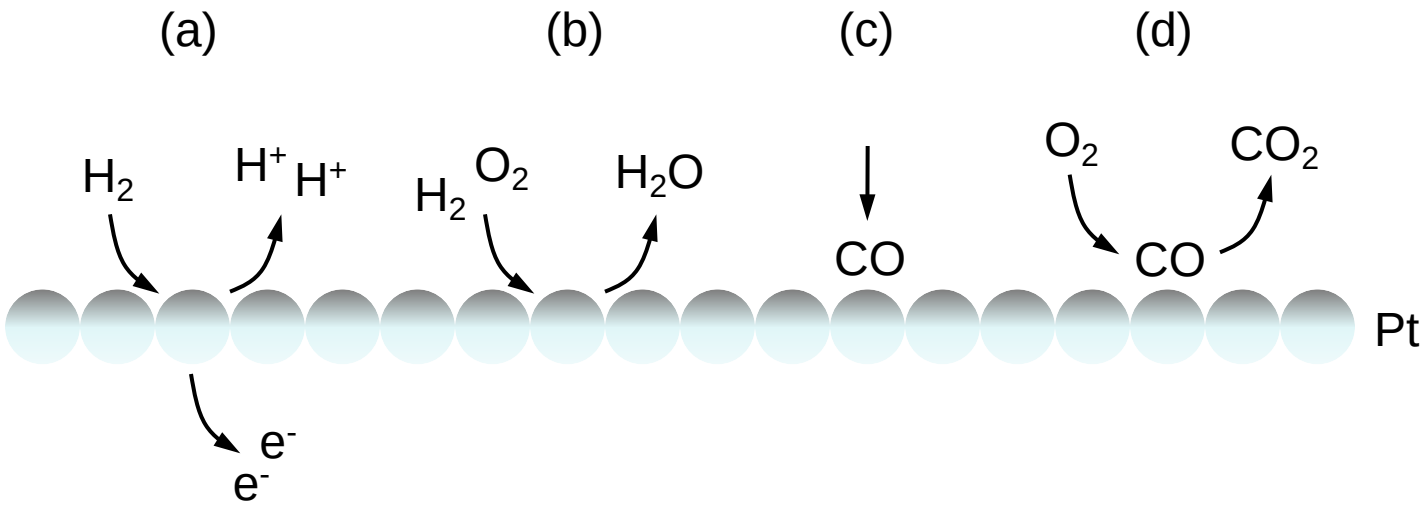




A hydrogen gas produced from hydrocarbons by steam reforming generally contains residual carbon monoxide (10^4 ~ 10^5 ppm). PEFC requests less than 10^1 ppm level of the residual CO.

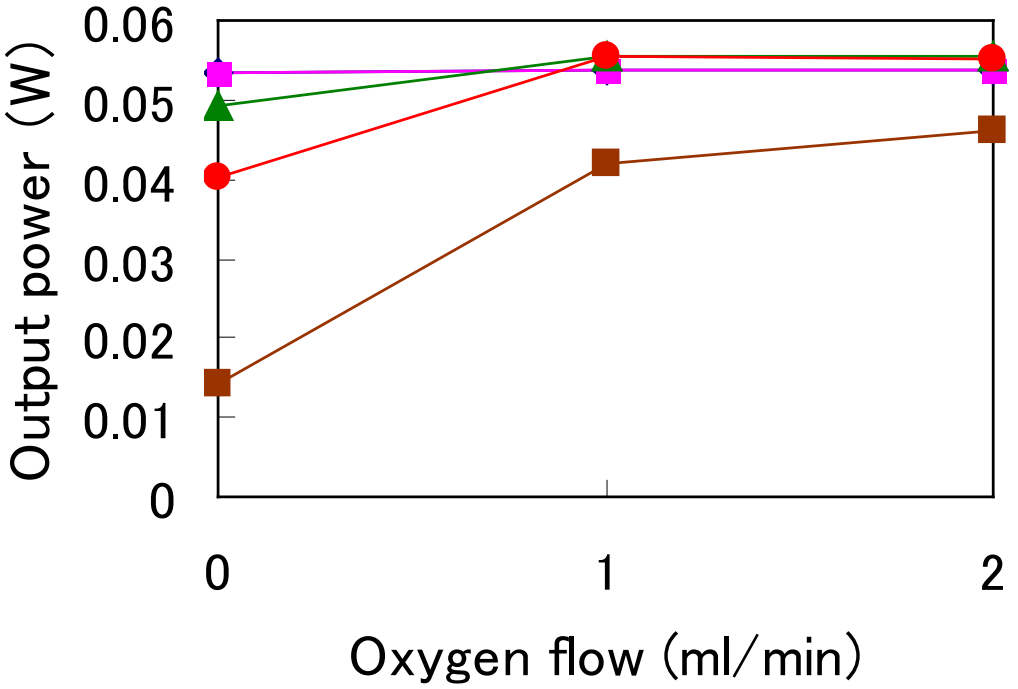
【Catalysis at the Pt surface】

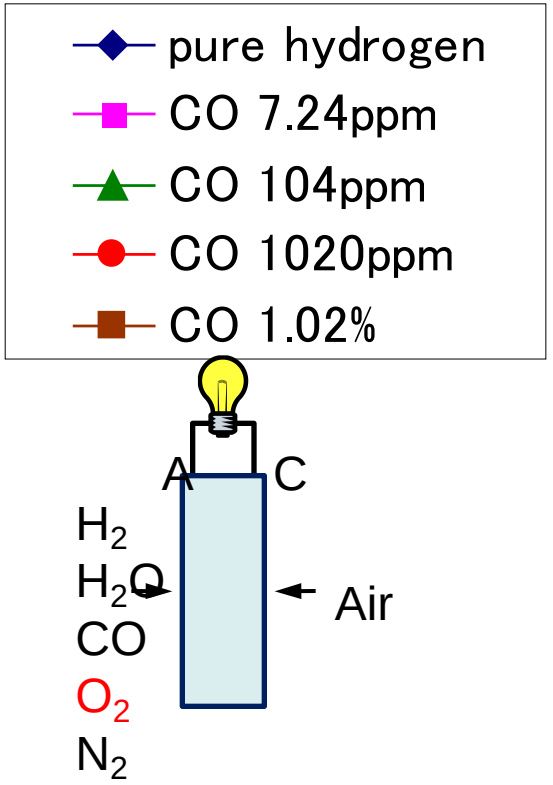
(a) Production of H^+
(b) Oxidation of H_2
(c) CO poisoning
(d) Oxidation of the adsorbed CO



Result

H_2+CO ca.6mL/min
N_2+O_2 ca.3mL/min





The deactivation by high concn. CO can successfully be suppressed.

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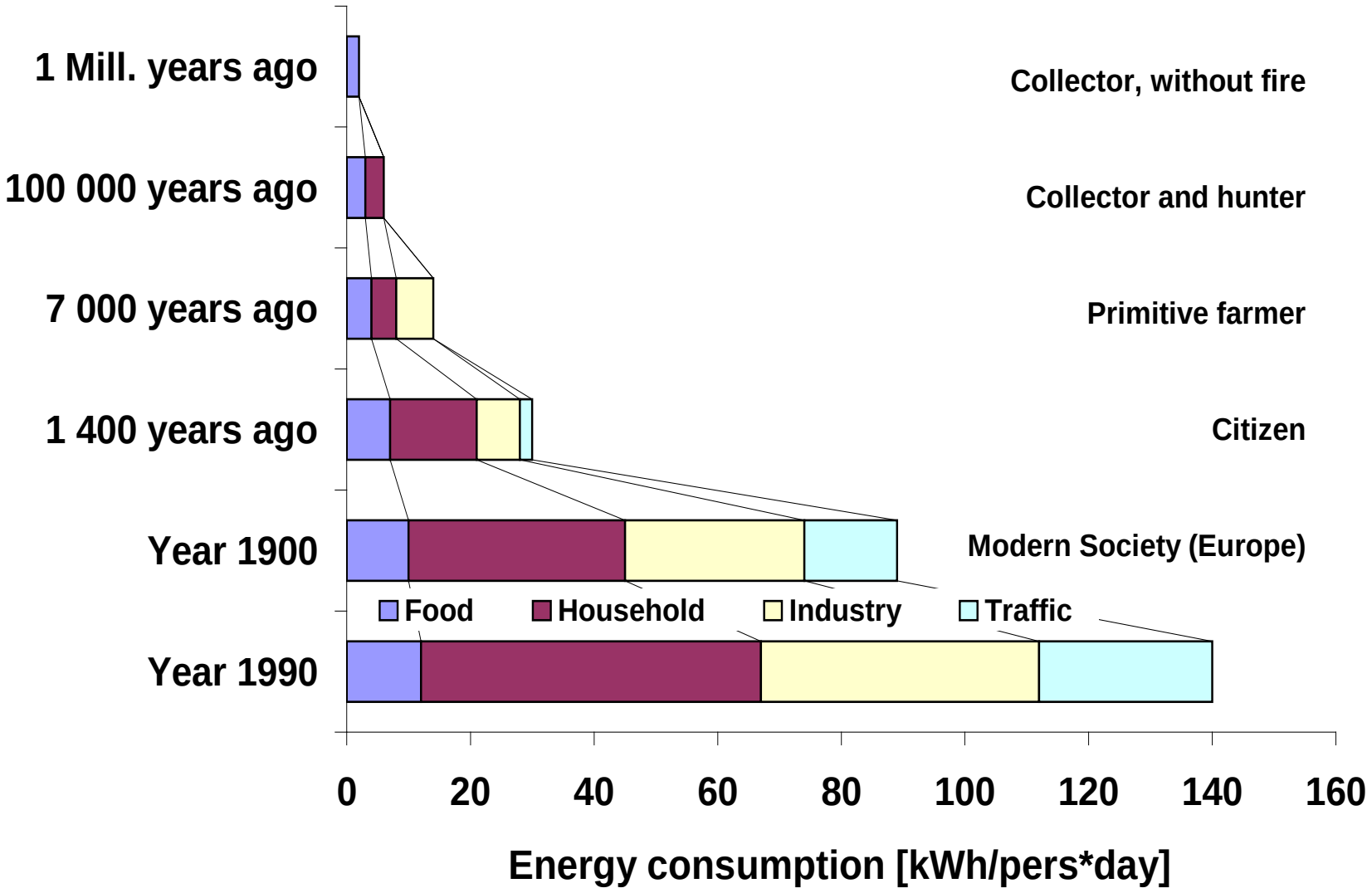
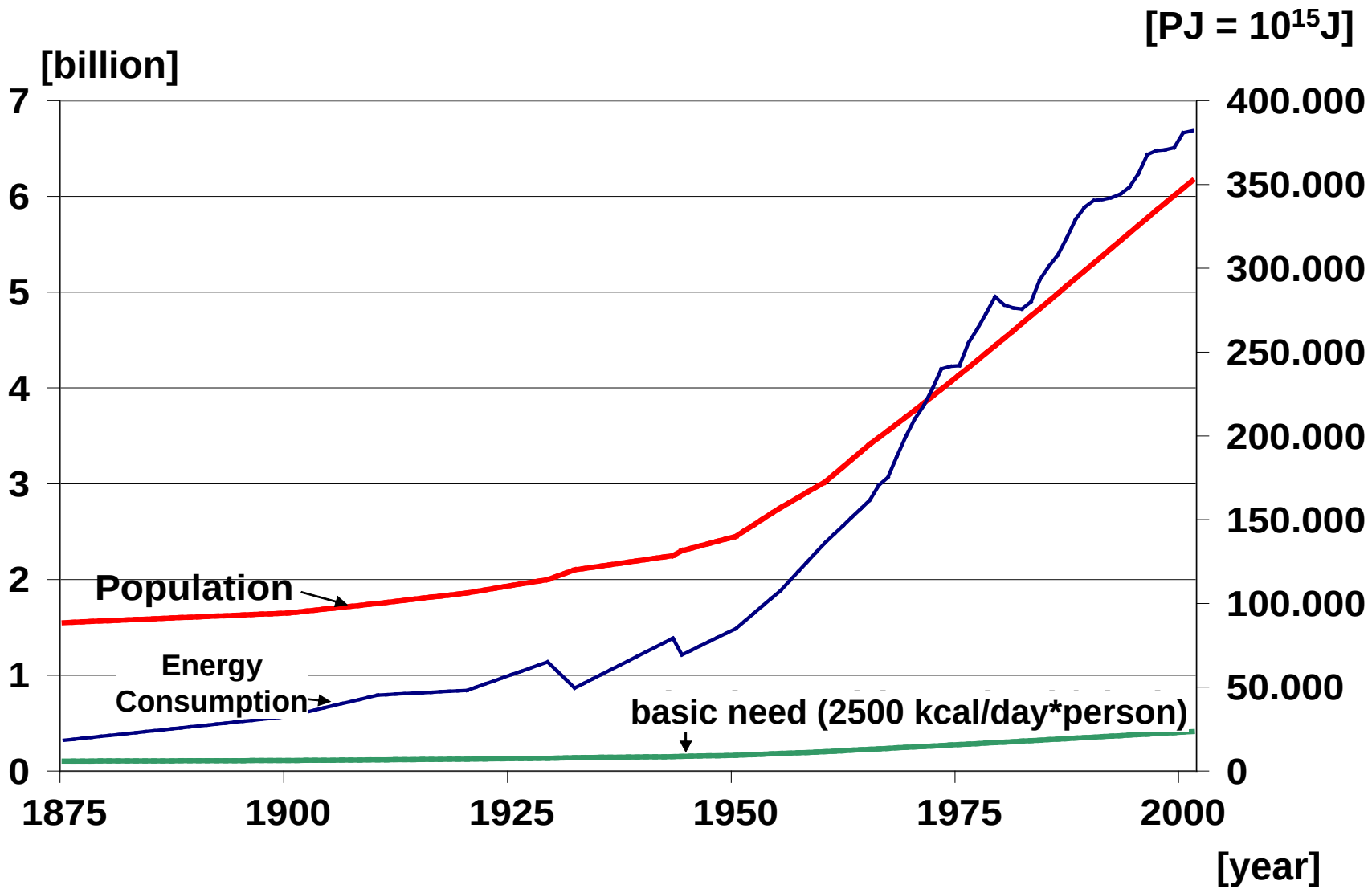
- ***Thank you for your attention.***

Development of Energy Consumption



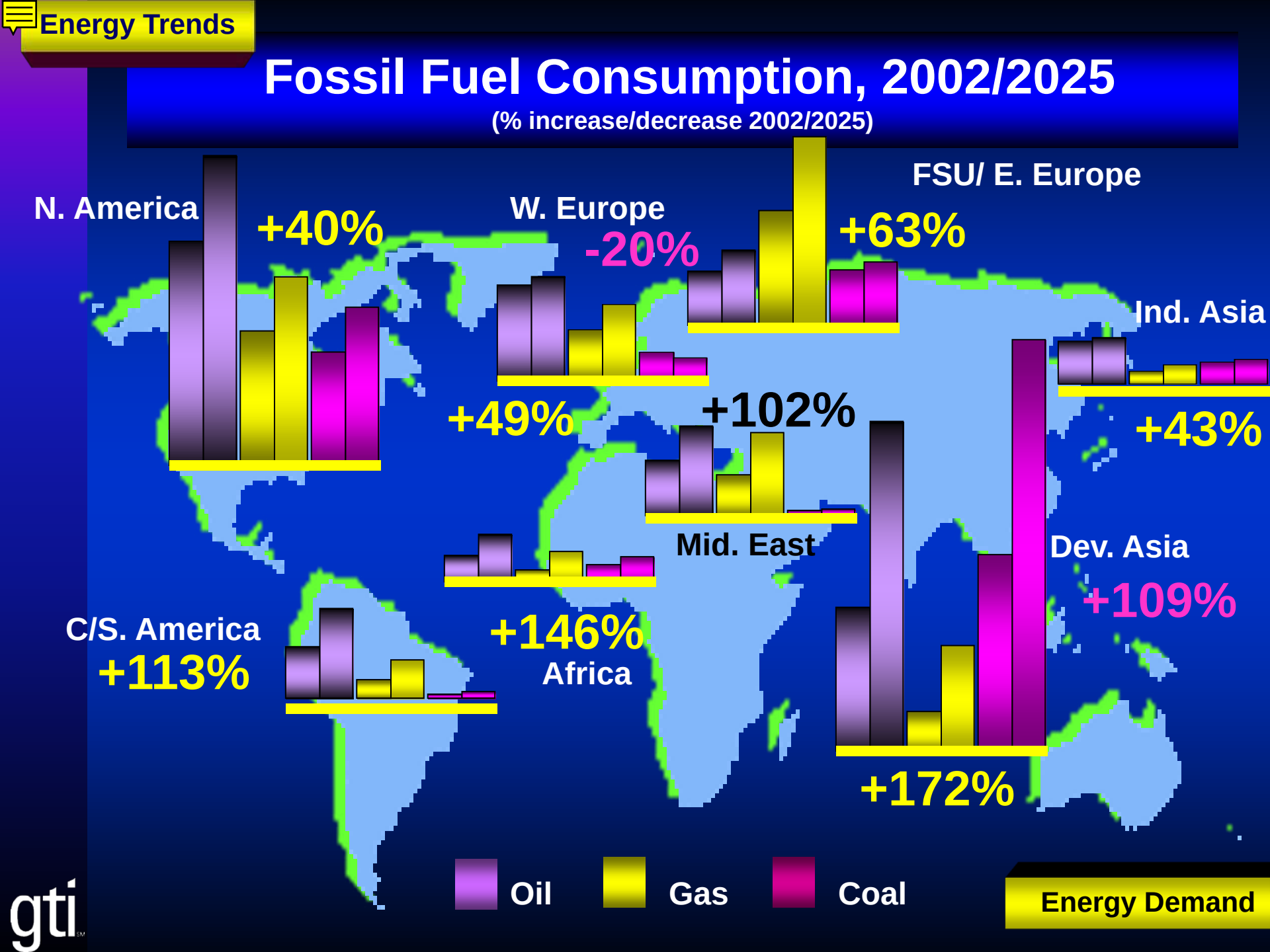
World Population and Energy Consumption



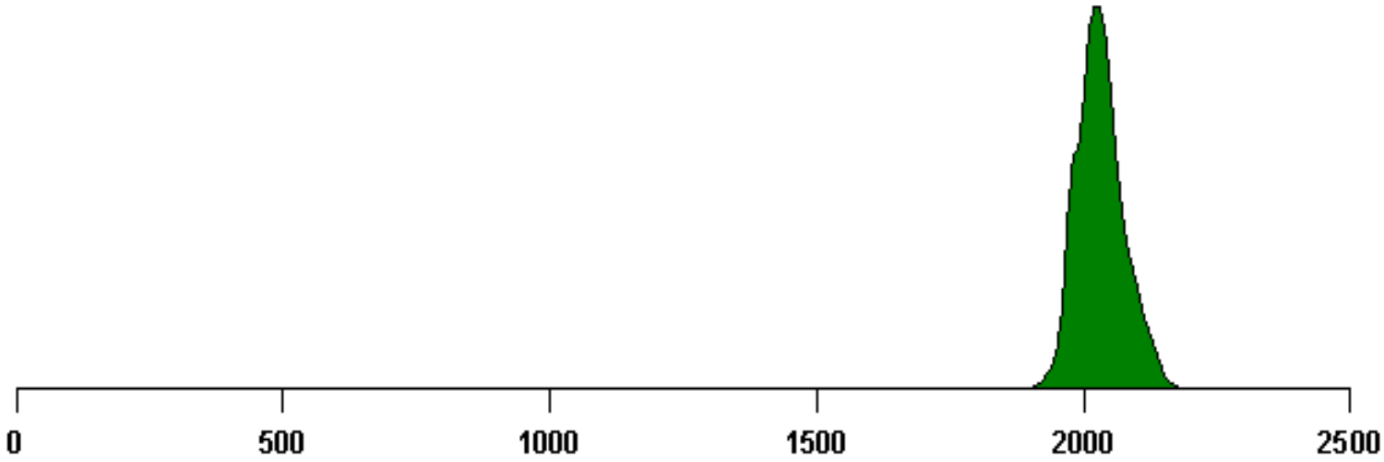
Source: BP 2002, US Census Bureau, own calculations

Fossil Fuel Consumption, 2002/2025

(% increase/decrease 2002/2025)



The Oil Era in the 2500 Years



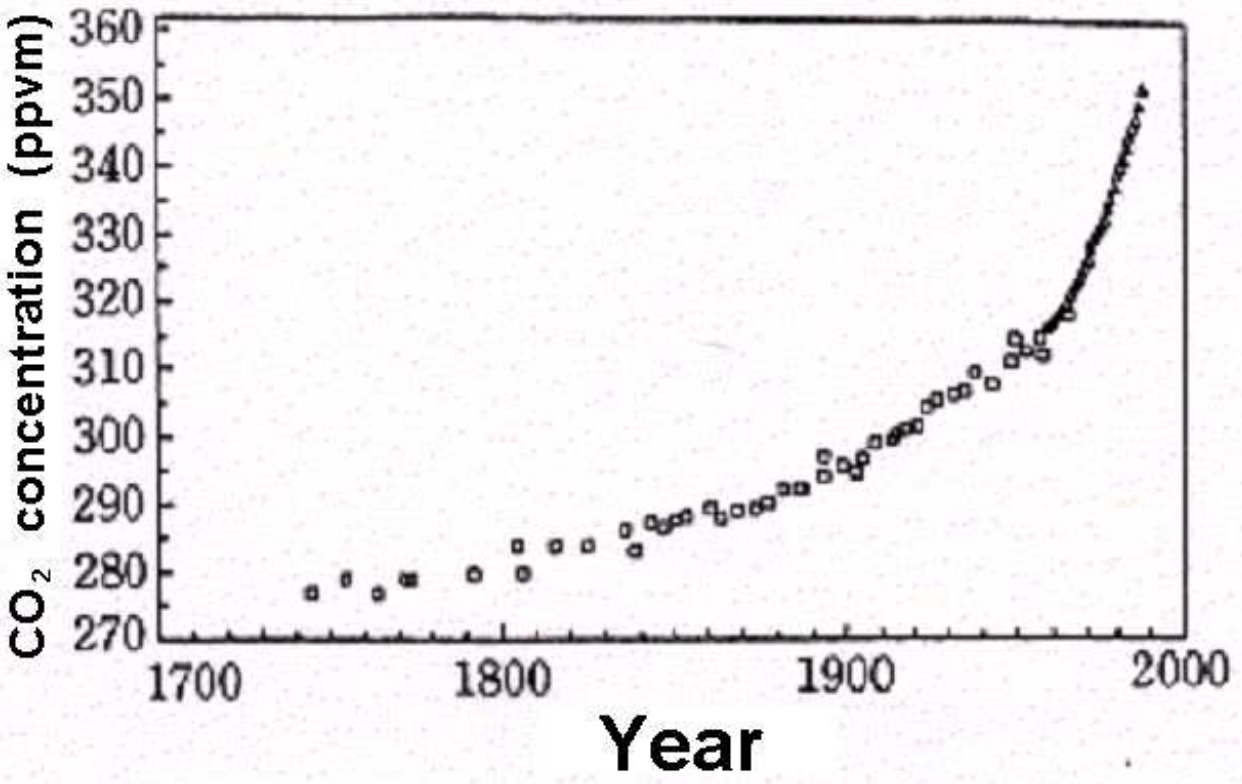


Fig 1.1.4 CO_2 concentration in the atmosphere