S7_O5_ICCF15

Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes

(I) Results of absorption experiments using Pd powders

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Aim

It has been reported in ref. [1] that charging of highly pure D2 gas into Pd nano-powders in the form of Pd/ZrO2 nano-composite contained in a stainless-steel vacuum vessel has induced significant excess heat.

we have constructed an experimental system to confirm the phenomenon of heat and ^{4}He generation by calorimetry and investigate the underlying physics.

[1] Y. Arata, et al.; The special report on research project for creation of new energy, J. High Temperature Society, No. 1. 2008.

Reduced view of the twin system A1A2

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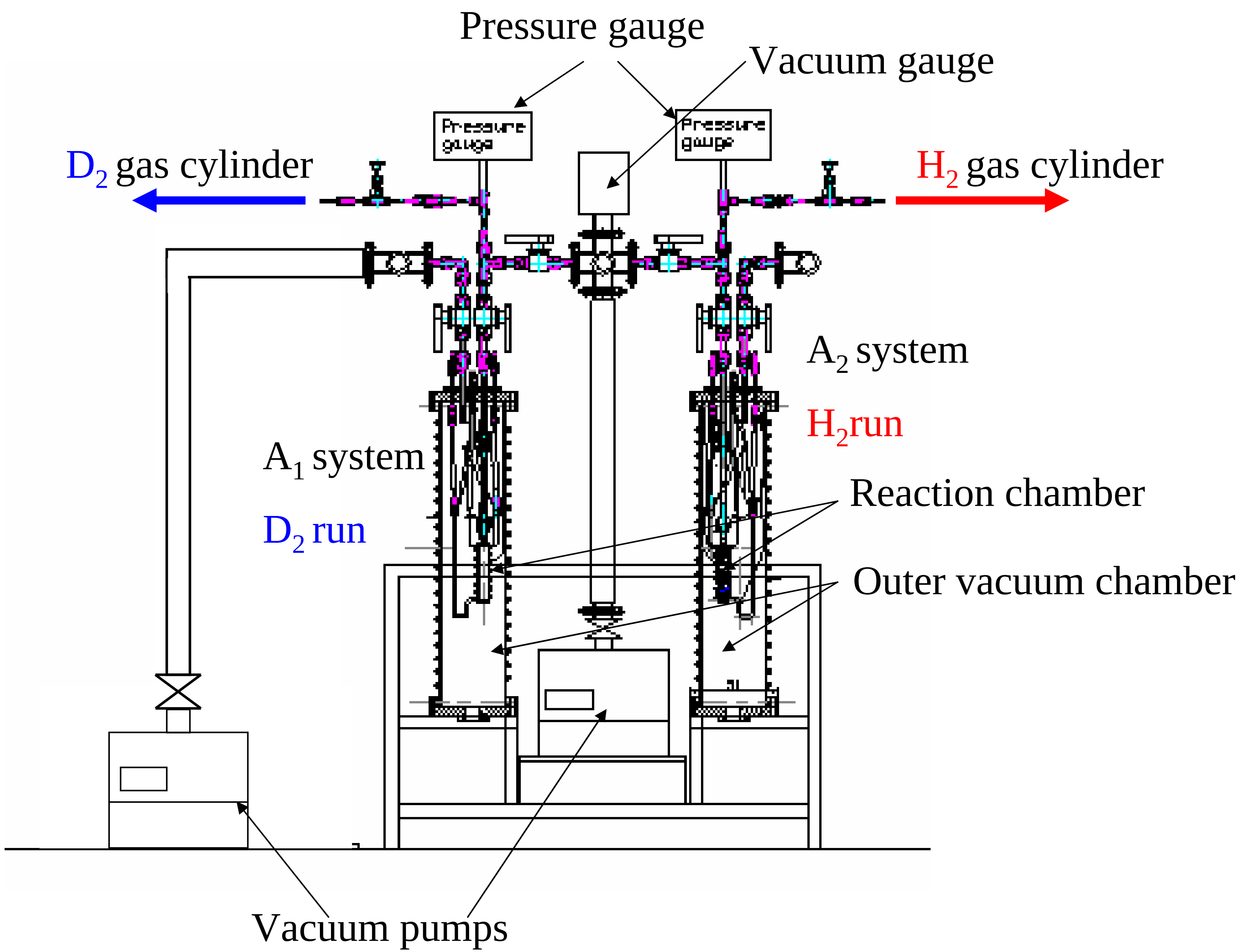
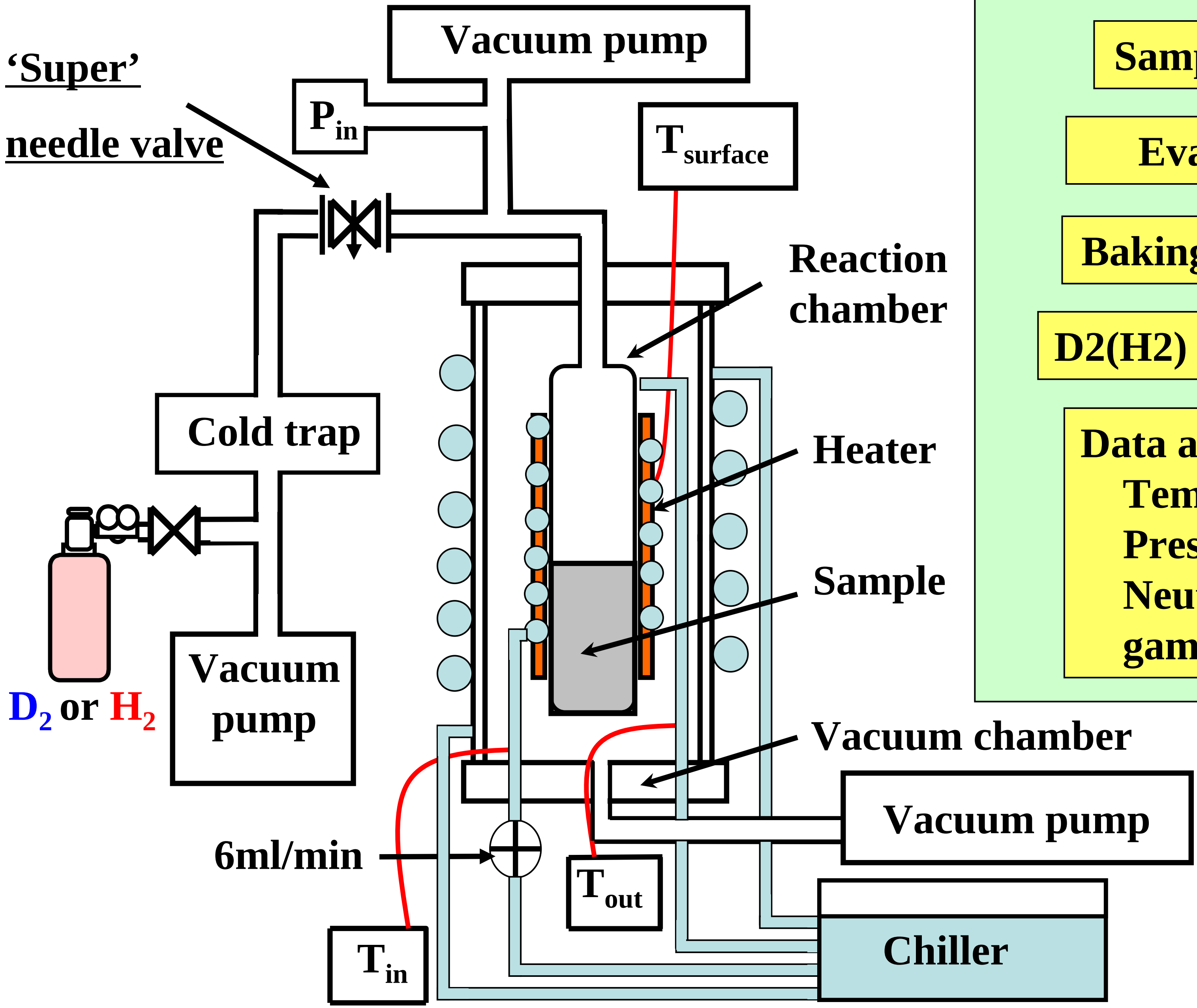
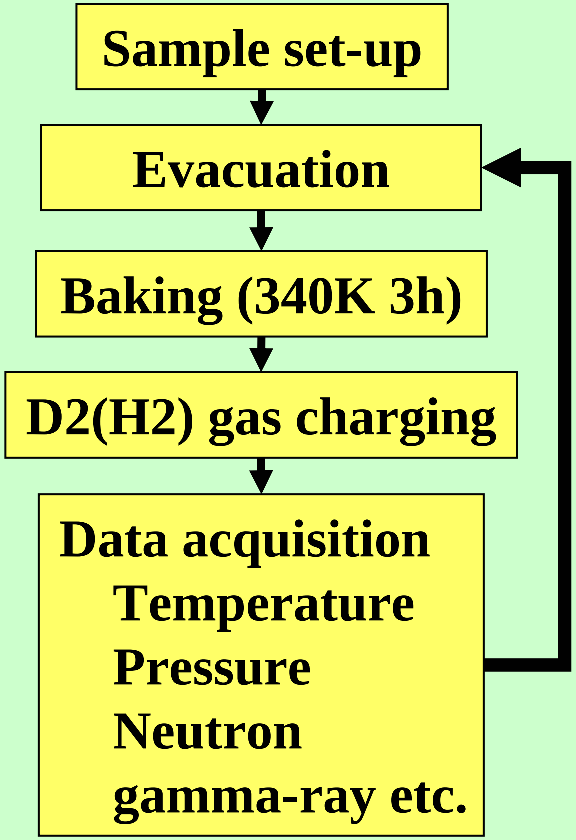


Functional view of the A_1 A_2system



Experimental procedure



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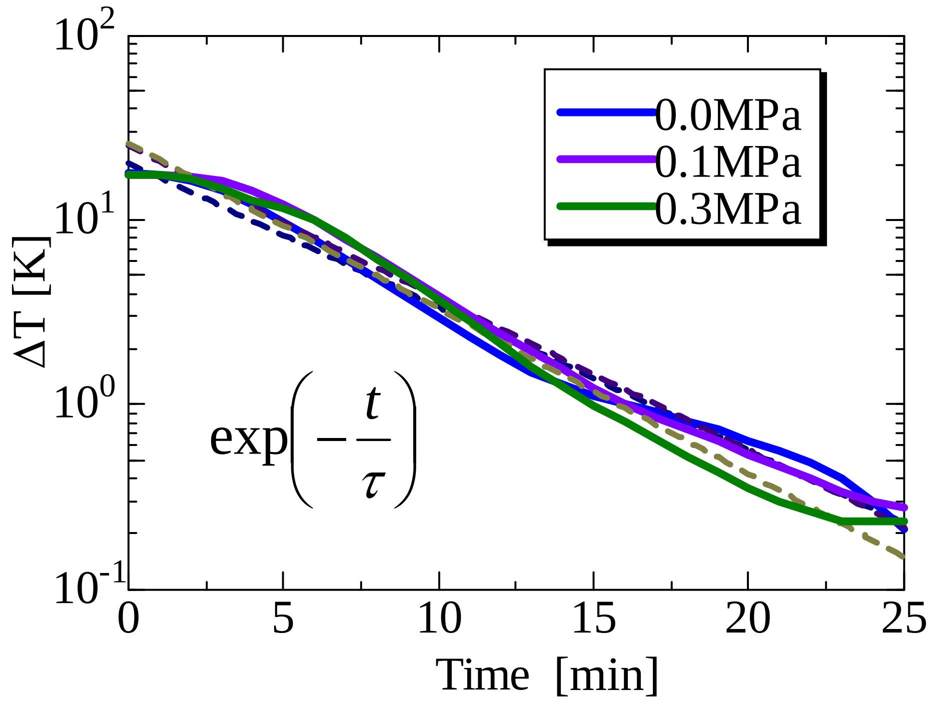
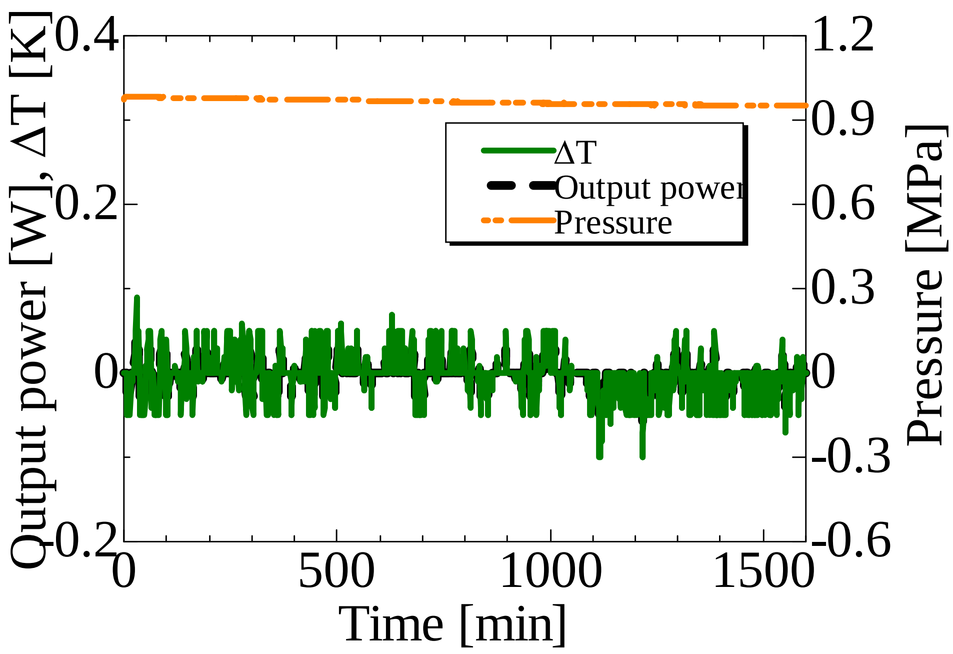
Performance of calorimetry

Time resolution : 5 min



Accuracy : ± 14 mW



Samples

- ϕ100 nm Pd (**PP**); This is a Pd powder diameter of particle is 100 nm, purity is 99.5%.

- Pd-black (**PB**); This is a 300 mesh powder and purity is 99.9%

- Santoku Pd (**PZ**); This is a nano-sized(**8 nm** and **10.5 nm**) powder of mixed-oxides of Pd and Zr (fabricated by Santoku Corporation)

TEM Image of Santoku Pd (10.5 nm)

(By courtesy of the Nuclear Science and Engineering Institute and Particulate Systems Research Center at the University of Missouri-Colombia; Prof. R. Duncan *et al.*)

TEM images of Palladium nanoparticles from Japan (sample # 2)

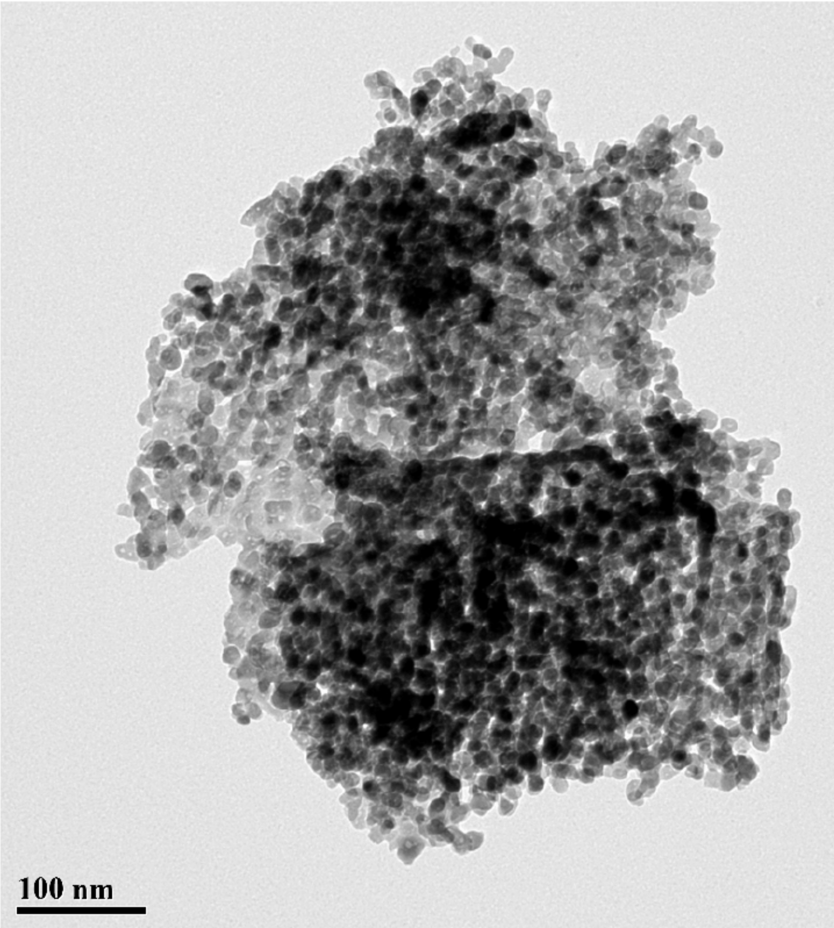
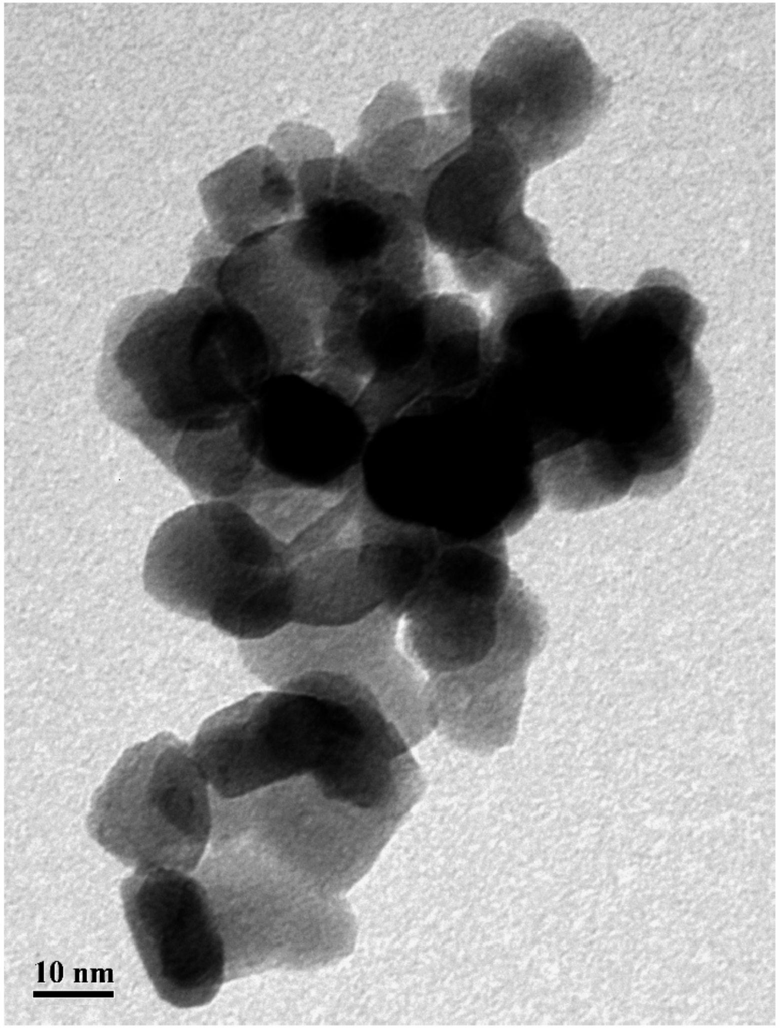
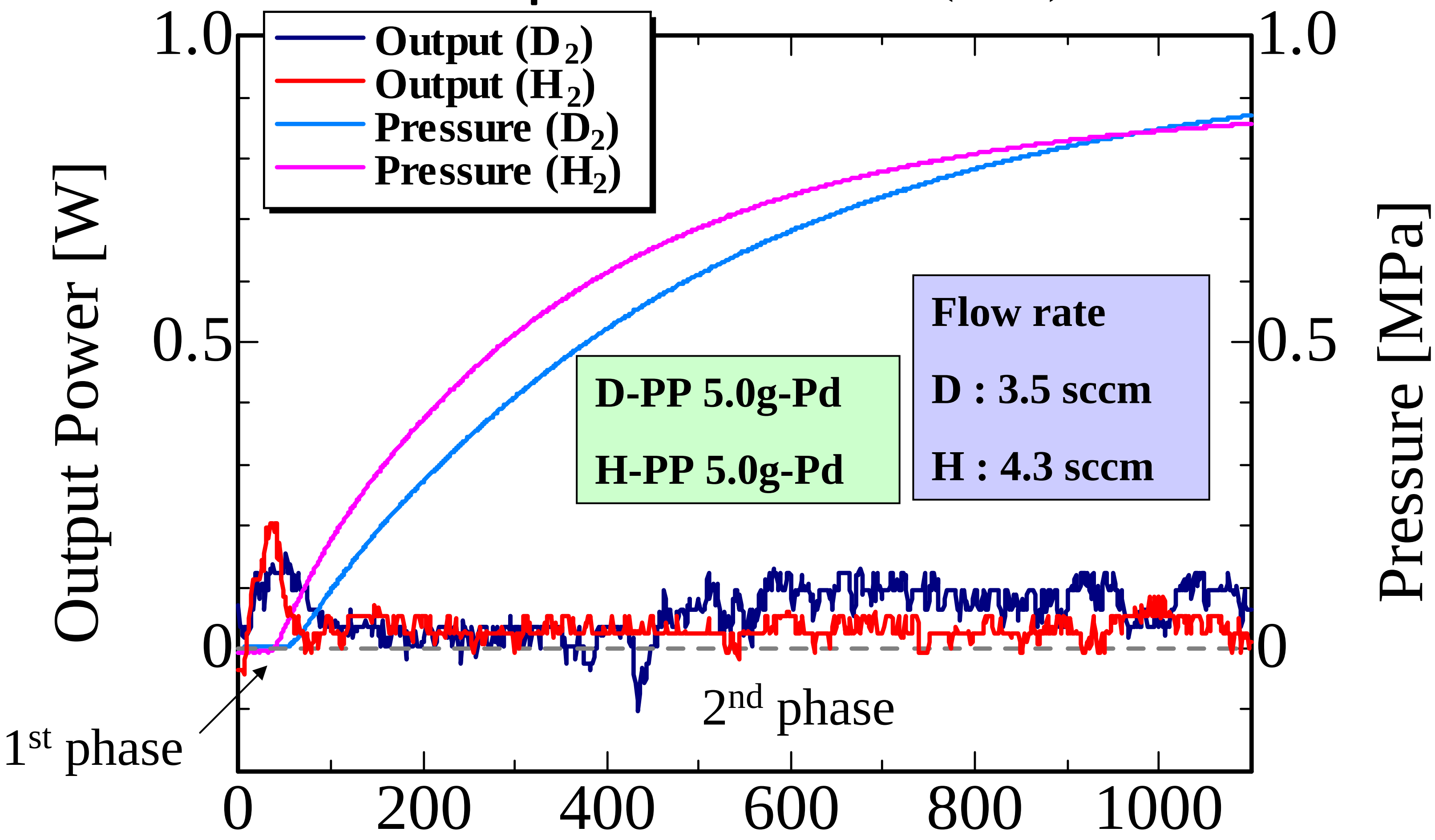


Image at 25000X magnification



ϕ100nm Pd (PP)



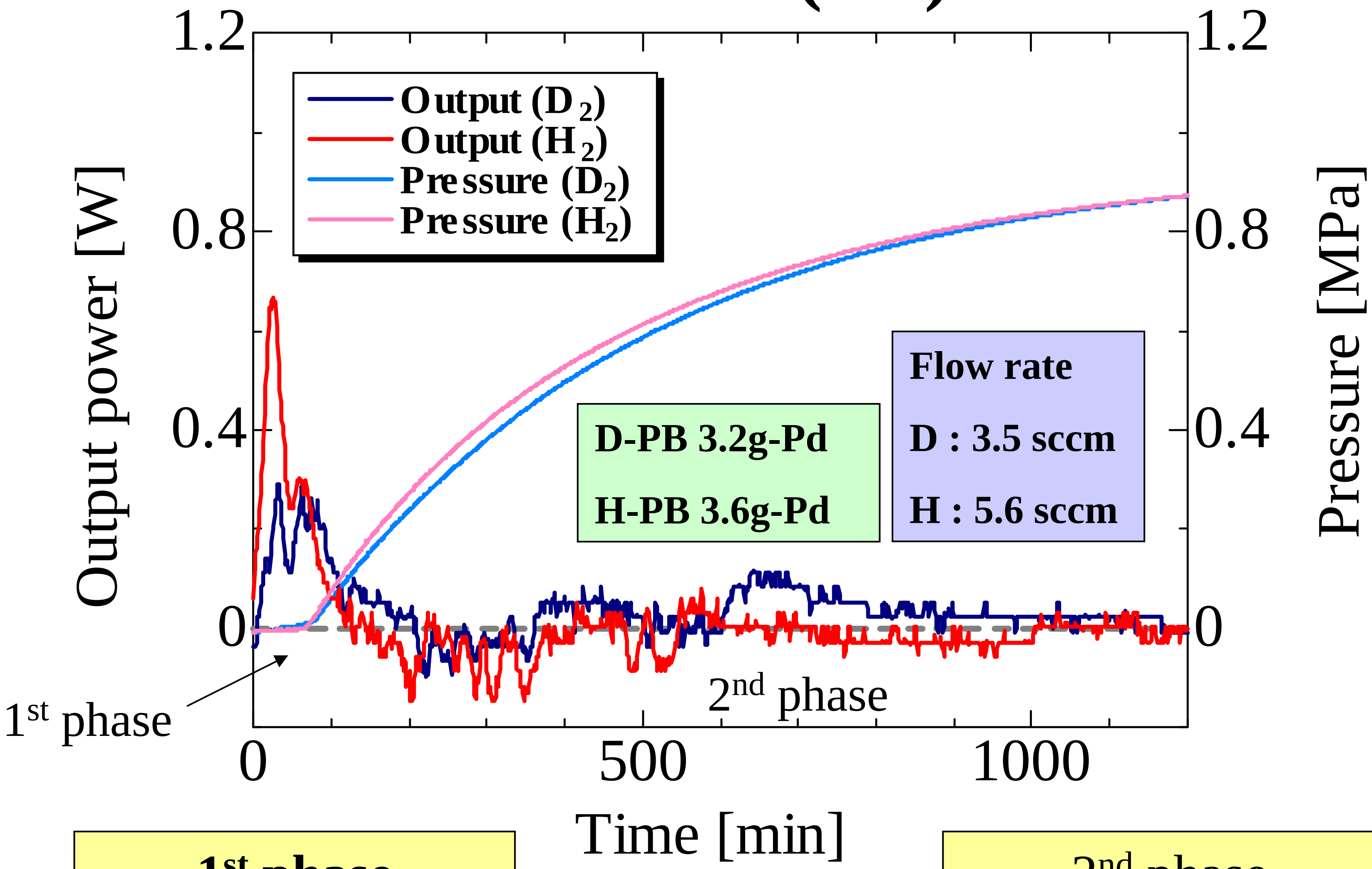
1st phase
D_2 : 0.10kJ/g-Pd
H_2 : 0.08kJ/g-Pd

D/Pd=0.43

H/Pd=0.45

2nd phase
D_2 : 0.79kJ/g-Pd
H_2 : 0.53kJ/g-Pd

Pd-black (PB)



1st phase
D_2 : 0. 54kJ/g-Pd
H_2 : 0.45kJ/g-Pd

D/Pd=0.85

H/Pd=0.78

2nd phase
D_2 : 0.65kJ/g-Pd
H_2 : -0.62kJ/g-Pd

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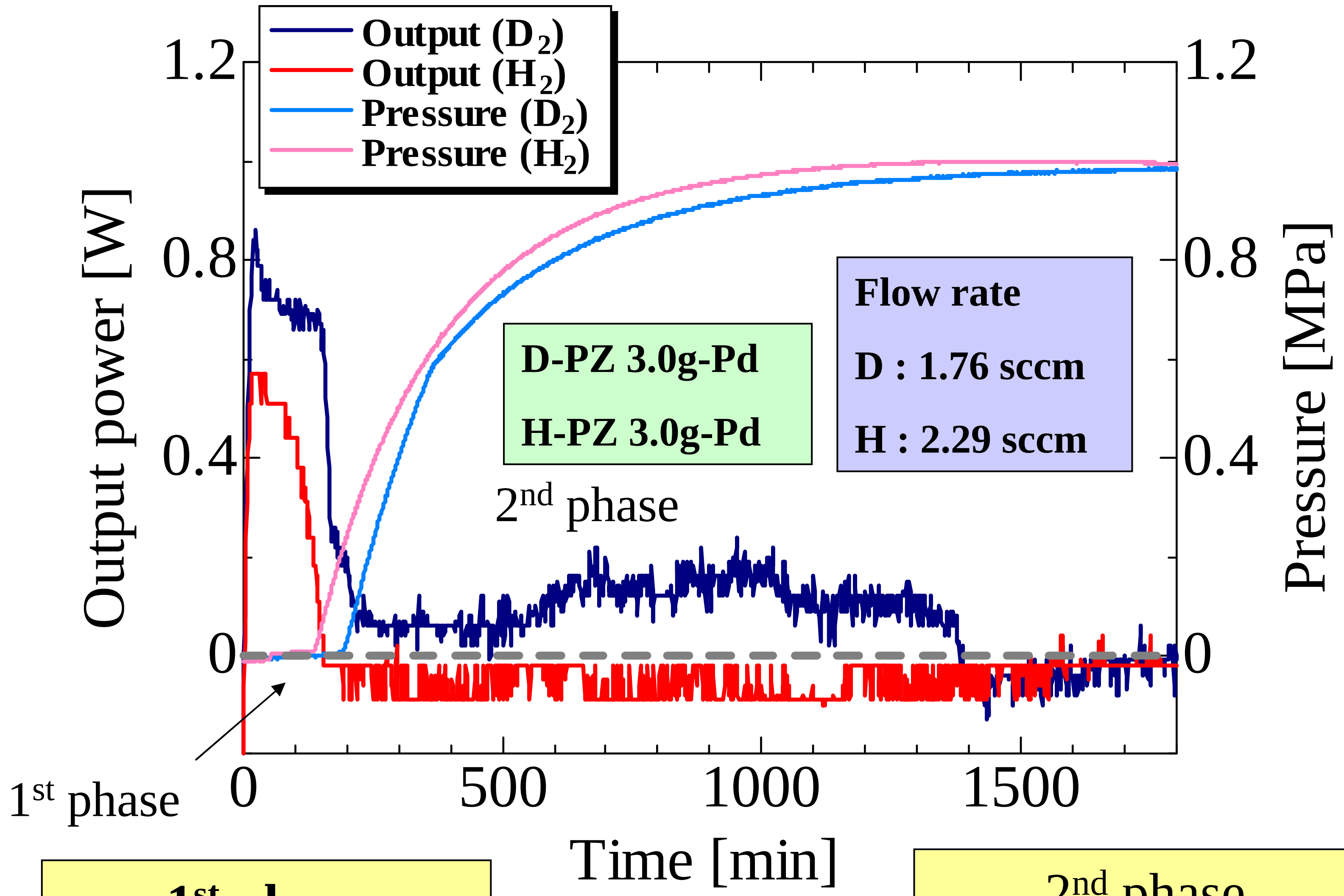
Santoku Pd (PZ1,2#1)



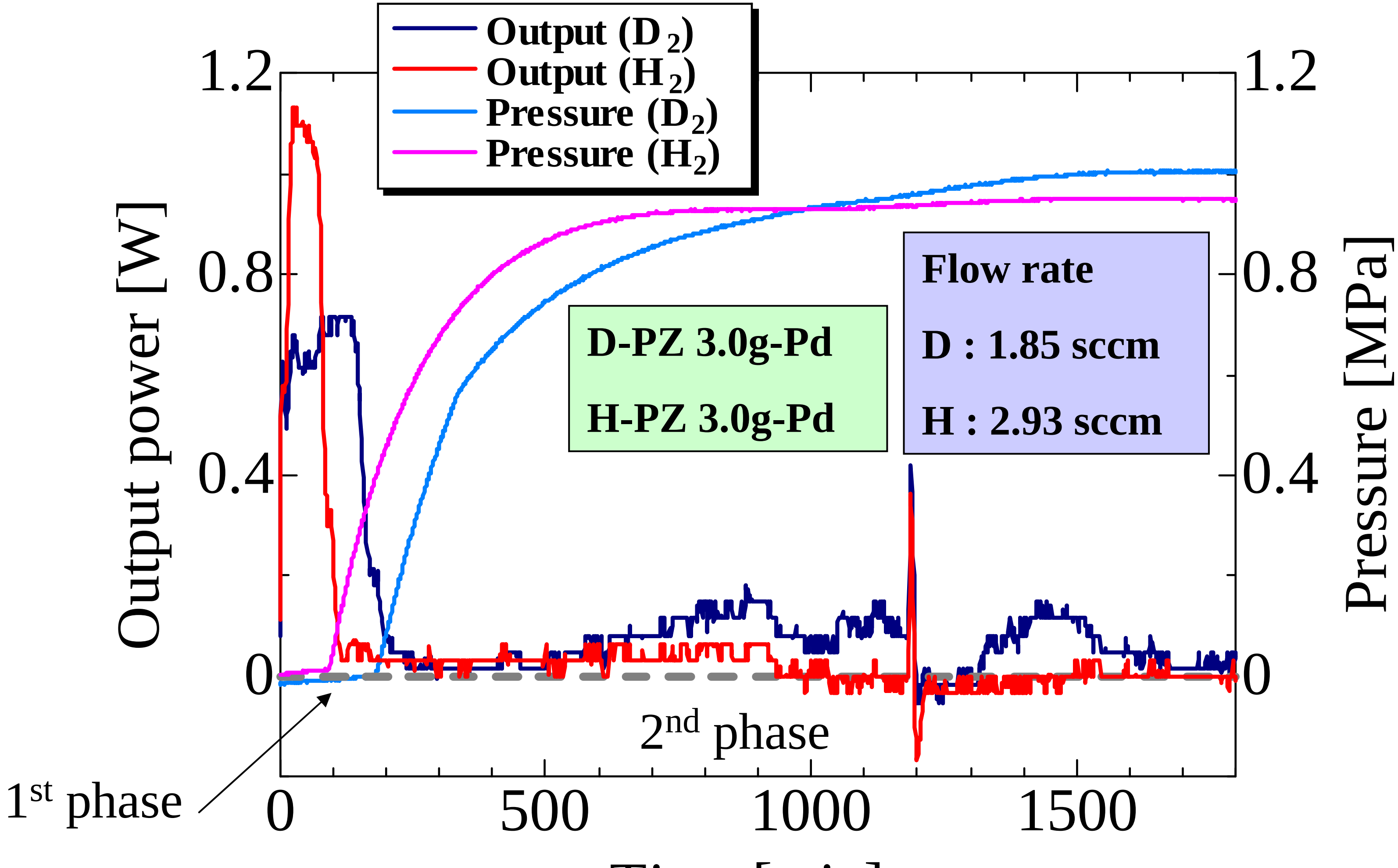
1st phase
D_2 : 1.3 kJ/g-Pd
H_2 : 1.0 kJ/g-Pd

D/Pd= 1.08

H/Pd= 1.00

2nd phase
D_2 : 1.9 kJ/g-Pd
H_2 : -1.3 kJ/g-Pd

Santoku Pd (PZ3,4#1)



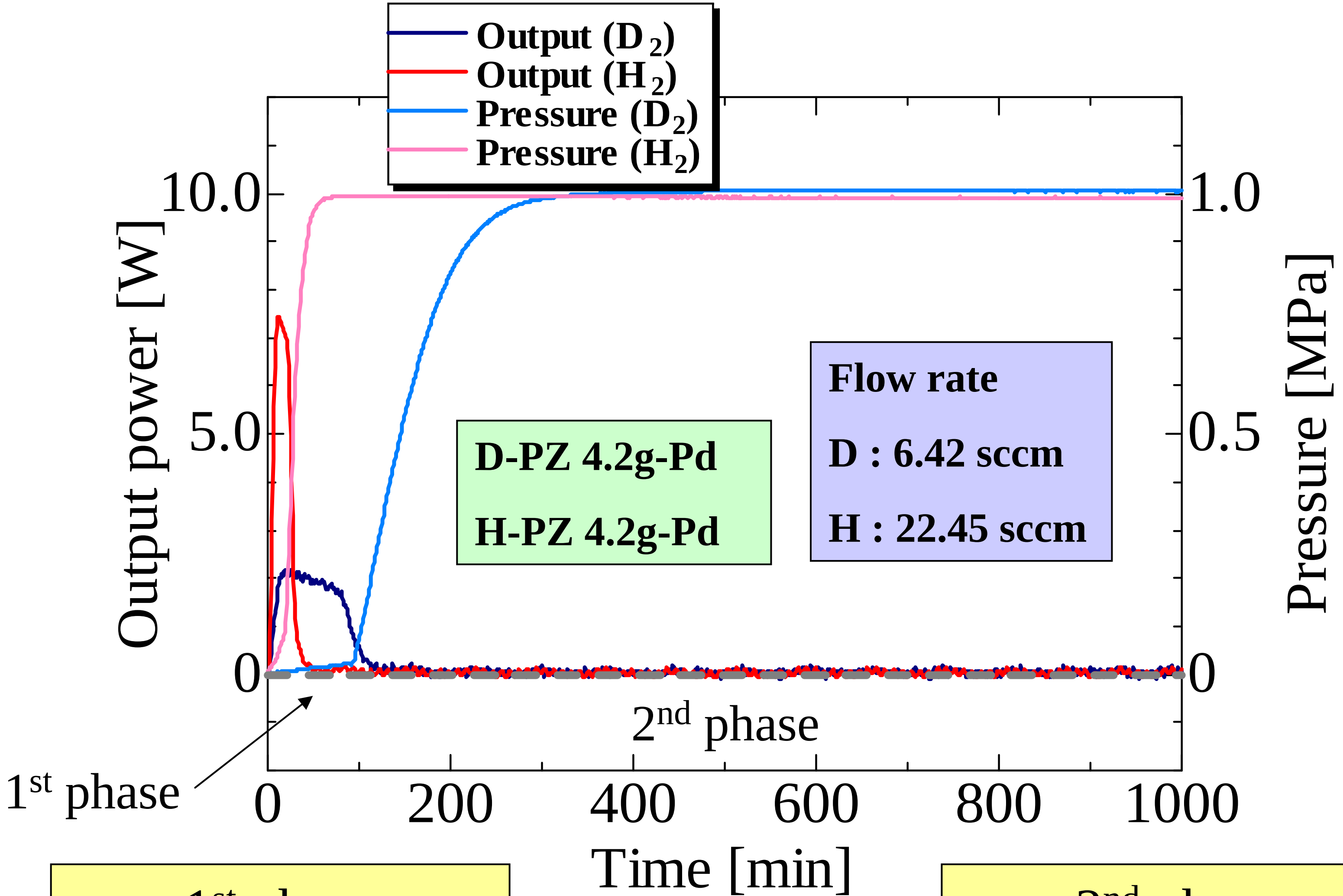
1st phase
D_2 : 2.13kJ/g-Pd
H_2 : 1.70kJ/g-Pd

D/Pd=1.07

H/Pd=0.86

2nd phase
D_2 : 1.28kJ/g-Pd
H_2 : 0.26kJ/g-Pd

Santoku Pd (PZ9,10#1)



1st phase
D_2 : 2.39kJ/g-Pd
H_2 : 2.27kJ/g-Pd

D/Pd= 1.41

H/Pd= 1.02

2nd phase
D_2 : 0.91 kJ/g-Pd
H_2 : 0.91kJ/g-Pd

run	weight	Gas	flow rate	Output energy[kJ]		Specific output energy[kJ/g]		D/Pd	*E* per D/H
	[g]		[sccm]	1st phase	2nd phase	1st phase	2nd phase	or H/Pd	atom
D-PP1#1	5	D_2	3.5	0.5±0.4	2.5±4.1	0.10±0.07	0.52±0.83	0.46	0.24
D-PP1#2	5	D_2	4.3	0.5±0.2	4.0±4.4	0.10±0.05	0.79±0.88	0.43	0.26
H-PP2#1	5	H_2	6.8	0.4±0.2	2.6±3.9	0.08±0.003	0.53±0.8	0.45	0.20
D-PB1#1	3.2	D_2	3.5	1.7±0.3	8.3±4.5	0.54±0.1	2.6±1.4	0.85	0.69
H-PB2#1	3.6	H_2	5.6	1.6±0.3	-2.2±4.6	0.45±0.08	-0.62±1.3	0.78	0.63
D-PB3#1	20	D_2	2.9	9.3±1.1	1.1±0.5	0.47±0.06	0.058±0.023	0.78	0.66
D-PB3#2	20	D_2	0.8	3.3±0.5	3.4±2.6	0.17±0.03	0.17±0.13	0.23	0.79
H-PB4#2	20	H_2	1.9	3.2±0.2	14±4.6	0.16±0.01	0.68±0.23	0.22	0.80
H-PB4#3	20	H_2	1.5	16±2.4	-4.8±8.1	0.79±0.01	-0.24±0.40	0.20	4.42
D-PB3#3	20	D_2	1.1	14±1.7	-2.2±1.1	0.68±0.01	-1.1±0.54	0.22	3.51
D-PB3#4	20	D_2	1.1	3.1±0.4	0.3±4.7	0.16±0.02	0.016±0.23	0.24	0.71
D-PZ1#1	10	D_2	1.76	7.0±0.2	6.8±1.3	1.3±0.04	1.9±0.31	1.08	2.39
H-PZ2#1	10	H_2	2.29	3.6±0.1	-5.1±1.4	1.0±0.03	-1.5±0.32	1.00	1.33
D-PZ3#1	10	D_2	1.85	6.4±0.2	5.5±0.8	2.13±0.0	1.2±0.2	1.07	2.20
H-PZ4#1	10	H_2	2.93	5.1±0.1	1.1±0.9	1.70±0.0	-1.3±0.2	0.86	2.18
D-PZ3#2	10	D_2	1.66	0.17±0.03	9.89±1.48	0.03±0.070	2.3±0.35	0.29	0.13
H-PZ4#2	10	H_2	2.79	0.58±0.05	1.68±1.46	0.17±0.011	0.39±0.34	0.31	0.59
D-PZ3#3	10	D_2	1.69	0.29±0.04	-3.47±0.34	0.07±0.092	-0.81±0.35	0.25	0.29
H-PZ4#3	10	H_2	2.99	0.37±0.02	0.75±0.35	0.01±0.006	0.17±0.34	0.26	0.42
D-PZ5#1	10	D_2	2.02	7.14±0.15	1.26±1.36	2.37±0.035	0.29±0.32	1.04	2.51
H-PZ6#1	10	H_2	6.23	7.07±0.07	-0.23±1.44	2.33±0.018	-0.05±0.33	1.41	1.82
D-PZ5#3	10	D_2	9.93	0.54±0.025	0.23±1.51	0.18±0.008	0.08±0.50	0.25	0.74
H-PZ6#3	10	H_2	10.69	0.92±0.025	4.18±1.51	0.31±0.008	1.39±0.50	0.30	1.10
D-PZ9#1	14	D_2	6.42	10.23±0.10	3.81±1.51	2.44±0.024	0.91±0.36	1.41	1.87
H-PZ10#1	14	H_2	22.55	9.56±0.034	3.82±1.51	2.28±0.008	0.91±0.36	1.02	2.46

1st phase results

run	D/Pd or H/Pd	*E* per D/H atom [eV]
D-PP	0.46	0.24
H-PP	0.45	0.20
D-PB	0.82±0.05	0.67±0.02
H-PB	0.78	0.63
D-PZ	1.15±0.17	2.24±0.28
H-PZ	1.07±0.24	1.95.±0.49

average

•PP ; Loading ratios are bulk values, and specific heats are also bulk values.

•PB ; Loading ratios are 2-fold of bulk values, and specific heats are 3-fold of bulk values

•PZ ; Loading ratios are 2.5-fold of bulk values, and specific heats are 10-fold of bulk values

Conclusion

- **The twin system of D(H) gas loading is a useful tool.**
- **Nano-Palladium Zirconium-oxide composite generates 10-fold larger specific heat by D(H)-absorption, compared to that of bulk palladium.**
- **Nano-Palladium Zirconium-oxide composite generates excess heat in the phase-2 for D_2 gas charging.**
- **We need further to study dependence on flow rate, nano-particle size, and cell temperature.**
- **We need also study of other material samples.**
- **Analyses of ^{4}He production and nuclear particle emission are expected.**