# Supporting Information

#### Kerf loss silicon as cost-effective, high-efficiency, and

## convenient energy carrier: additive-mediated rapid

## hydrogen production and integrated systems for electricity

#### generation and hydrogen storage.

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#### Calculation method for hydrogen production

Treat all gas as ideal gas and use the ideal gas law to estimate the amount of hydrogen produced. In a hydrogen generation experiment, increased pressure pushed the water level downward. But the pressure difference is very little compared to the ambient pressure, provided that 1 atm equals to 1033.6 cm-H<sub>2</sub>O. Hence, the calculation was simplified by neglecting the term of the pressure difference divided by the ambient pressure, which also insinuated that the gas volume was expanded due to the increase of gas molecules under constant pressure, resulting in that the number of hydrogen molecules in moles generated equals to the ambient pressure multiplied by the volumetric change and divided by the gas constant and temperature in specific units. The equations along with an illustration are shown as follows.

$$\begin{split} P_{i}V_{i} &= n_{i}RT \quad \& \quad P_{f}V_{f} = n_{f}RT \\ \Rightarrow (P_{i} + \Delta P)(V_{i} + \Delta V) &= (n_{i} + \Delta n)RT \\ \Rightarrow P_{i}\left(1 + \frac{\Delta P}{P_{i}}\right)(V_{i} + \Delta V) &= (n_{i} + \Delta n)RT \\ \Rightarrow P_{i}(V_{i} + \Delta V) &= (n_{i} + \Delta n)RT \\ \Rightarrow P_{i}V_{i} + P_{i}\Delta V &= n_{i}RT + \Delta nRT \\ \Rightarrow P_{i}\Delta V &= \Delta nRT \\ \Rightarrow n_{H_{2}} &= \Delta n = \frac{P_{i}\Delta V}{RT} = \frac{P_{i}A\Delta h}{RT} \qquad \Delta V = A\Delta h \end{split}$$

where P is the total pressure inside the system, V is the total gas volume inside the system, n is the number of total gas molecules in moles, R is the gas constant, T is the gas temperature, and A is the cross-sectional area of the inner tube, where i and f represent the initial and final state, respectively. The delta sign is used to express the change of a certain property. The yield was defined as the amount of hydrogen produced divided by the maximum amount of hydrogen theoretically generated, and the rate was defined as the mass of hydrogen generated per unit time per unit mass of silicon loaded, as in  $g(H_2)$  s<sup>-1</sup> g<sup>-1</sup>(Si).

In a large scale hydrogen generation experiment, the number of gas molecules in moles existed in the reactor right before the silicon-water reaction took place was estimated with ambient pressure, the inner volume of the reactor, and ambient temperature. Similarly, the number of gas molecules in moles existed in the reactor after the silicon-water reaction completed was estimated with system pressure, the inner gas volume inside the reactor, and the average temperature.



Fig. S1 Instruments of time-resolved small-scale hydrogen production



Fig. S2 Instruments of time-resolved large-scale hydrogen production



Fig. S3 HRTEM images and SAED patterns of single crystal kerf loss silicon observed from different zone axes.

$$S_{i} = S_{i} + 2 OH^{-} \longrightarrow S_{i} = S_{i} OH^{-} + 2 e^{-}$$
(1)

$$Si OH^{++} + 2 OH^{-} \longrightarrow Si(OH)_{4}$$
(3)

$$Si(OH)_4 \longrightarrow SiO_2(OH)_2^- + 2 H^+$$
 (4)

$$4 H_2 O + 4 e^- \longrightarrow 4 OH^- + 2H_2$$
 (5)

Overall reaction :  
Si + 2 OH + 2H<sub>2</sub>O 
$$\longrightarrow$$
 SiO<sub>2</sub>(OH)<sub>2</sub> + 2 H<sub>2</sub> (6)

Fig. S4 sub reactions of silicon etched in KOH aqueous solution

Element	Concentration. (ppb)
Si	1000000
Р	440
Ca	370
В	190

Table S1 ICP-MS analysis of kerf loss

Table S2	Summary	of additiv	ve tests	at 303K.
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Additives	Hydrogen production rate , g(H <sub>2</sub> ) s <sup>-1</sup> g <sup>-1</sup> (Si)	Yield (%)
K (0.57 M)	6.0E-05	73
$K (0.57 \text{ M}) + \text{S} (0.5 \text{ g dm}^{-3})$	6.3E-05	64
$K (0.57 M) + M (5 g dm^{-3})$	6.8E-05	71
K (0.57 M) + M (5 g dm <sup>-3</sup> ) + S (0.5 g dm <sup>-3</sup> )	7.4E-05	83
K (0.57 M) + M (5 g dm <sup>-3</sup> ) + S (0.5 g dm <sup>-3</sup> ) w/o kerf loss silicon	0	0

Table S3 Different composition of additives. KOH,  $Na_2SiO_3$  and  $H_2SiO_3$  are abbreviated as K, M and S respectively. All the results are based on reacting centrifugation treatment kerf loss with respective etching solution at 343K.

No. of experiment	<b>Composition of additives</b>	70% conversion rate , g(H <sub>2</sub> ) s <sup>-1</sup> g <sup>-1</sup> (Si)	Yield (%)
1	K (0.57 M) + M (5 g dm <sup>-3</sup> ) + S (0.5 g dm <sup>-3</sup> )	9.88E-04	79
2	$K (0.57 M) + M (40 g dm^{-3}) + S (0.5 g dm^{-3})$	1.61E-03	83
3	K (2.14 M) + M (5 g dm <sup>-3</sup> ) + S (0.5 g dm <sup>-3</sup> )	1.00E-03	81
4	K (2.14 M) + M (40 g dm <sup>-3</sup> ) + S (0.5 g dm <sup>-3</sup> )	4.72E-03	92
5	K (0.57 M) + M (5 g dm <sup>-3</sup> ) + S (4 g dm <sup>-3</sup> )	1.24E-03	84
6	$K (0.57 M) + M (40 g dm^{-3}) + S (4 g dm^{-3})$	9.99E-04	80
7	K (2.14 M) + M (5 g dm <sup>-3</sup> ) + S (4 g dm <sup>-3</sup> )	8.03E-04	82
8	K (2.14 M) + M (40 g dm <sup>-3</sup> ) + S (4 g dm <sup>-3</sup> )	1.24E-03	81

#### **Supporting Videos:**

Video. S1.

Real-time video of the operation of hydrogen production testing system using kerf loss silicion as a reactant. This video has been sped up by a factor of 6X

Video. S2.

Real-time video of the operation of a stainless steel reactor integrated with a fuel cell for electricity generation to turn on an electric model vehicle. This video has been sped up by a factor of 6X

Video. S3

Real-time video of the operation of a stainless steel reactor integrated with a high-pressure tank for hydrogen storage. This video has been sped up by a factor of 2X