Combinatorial Tools for Alloy-based Electrocatalyst Discovery

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To commercialize fuel cells powered vehicles, two issues have to be overcome, one is the fuel efficiency which has to be higher than that of the hybrid vehicles, and another is the cost that has to be comparable to the conventional ICE based vehicles. Among various material and engineering aspects, electrocatalysts are the key items having the potential of improving the fuel economy and reducing the cost. However, nowadays the commercial available electrocatalysts are precious metals based which are expensive and sluggish in the catalytic reaction, especially on the cathode side for oxygen reduction reaction (ORR). To discover much cheaper, yet more active electrocatalysts for PEM fuel cells, we have developed high throughput combinatorial research workflow and tools.

Figure 1 shows the general concept of a high throughput combinatorial electrocatalysis research workflow, whereby the different kind of combinations of materials can be synthesized by means of a Multi-source Physical Vapor Deposition (MPVD[1]) system, and the resulted materials are electrochemically screened by a Multi-channel Rotating Disk Electrode (MRDE[2]) system. Unlike some of the combinatorial systems, this system is able to offer not only high throughput research of electrocatalysts, but also very reliable data for analysis like the conventional single experimental equipment. From beginning on, we focus not only the ORR activity but also the chemical stability under the acid environment, which has been shown to be critical in the real application since the membranes so far used in PEM fuel cells are very acidic.

To get reliable data, it is necessary to understand what is measured and which the key parameter is in the discovery program. RDE is selected as standard screening method since it can offer intrinsic kinetic current for the catalytic reaction. Another reason is that the polarization curve measured from RDE is very close to that of the fuel cell test, yet it offers much easy experimental means, see figure 2. Table 1 shows the evaluation data by using Pt films. The error bar for $E_{1/2}$ is less than 1%, and the error bars for the kinetic currents at 0.7V and 0.8V are 10% and 12%, respectively. In addition to the evaluation data, the kinetic currents of Pt-based binary systems will be shown and the “leads” of ORR catalysts will be proposed for further evaluation.

[1)] & [2)] US patents are pending.

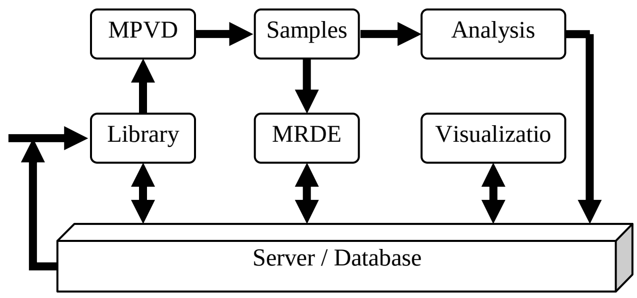

Fig. 1 Combinatorial workflow for electrocatalyst research.

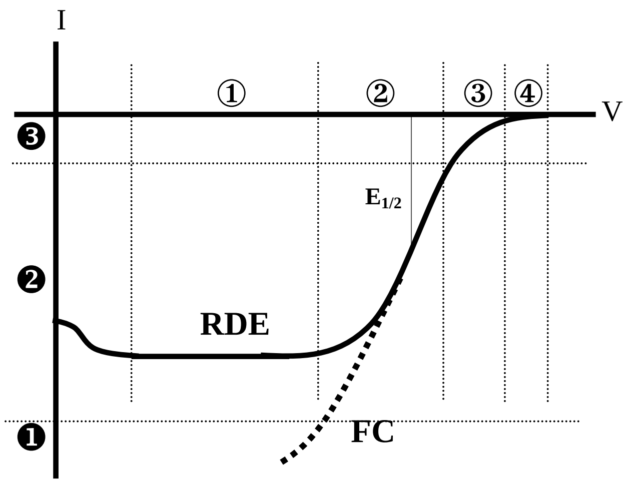

Fig. 2 A schematic RDE polarization curve at a given Rotating speed as well as a schematic comparison of polarization curves of RDE experiment and fuel cell test.

Channel	E(1/2) (mV)	I at 0.7V (mA)	I at 0.8V (mA)
1	738.8	2.228435149	0.345939378
2	727.1	1.790605854	0.273526873
3	730.1	1.879316817	0.284446111
4	735.2	2.094112456	0.311888958
5	735.1	2.11348904	0.324339617
6	735.4	1.974894209	0.331098941
7	729.2	1.931968317	0.279898132
8	735.5	1.972422736	0.331894458

Table 1 Comparing the activities of eight channels of sputtered Pt films of 100nm in thickness.