PEM fuel cell with very low Pt loading

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The first PEM fuel cells used loadings of several mg/cm^2 of colloidal Pt at their electrodes. These initial loadings were drastically reduced to 0.4 mg/cm^2 by supporting Pt on carbon black [1,2].

None of the standard methods, using Pt supported on carbon black, can easily be incorporated in micro machining process or in integrated circuit technology used to produce micro fuel cells. Sputtering is without any doubt a more appropriate deposition method for the production of these miniature fuel cells. This Pt deposition technique was used more than 10 years ago by Srinivassan et al. [3,4] to study the effect of the localization of Pt on fuel cell performance. According to Hirano et al. [5], a cathode made from a sputtered layer of 0.1 mg Pt / cm^2 can produce results similar to an E-TEK electrode with a loading of 0.4 mg/cm^2. This result demonstrated that an alternative procedure, not based on Pt supported on carbon black, was viable and can be used to lower Pt loading in PEM fuel cells without lowering their performance.

The present work will show that, besides sputtering, Pulse Laser Deposition (PLD) is also an interesting technique to obtain low Pt loadings in PEM fuel cells. Pt deposition with PLD was performed on uncatalyzed (carbon only, no metal) double-sided V2 ELAT gas diffusion electrode (GDE) from E-TEK. PLD was conducted using an excimer laser (KrF, λ = 248 nm) with a pulse width of 17 ns, at a repetition rate of 100 Hz. Electrodes made using the PLD method were tested on the cathode or anode sides of a single cell fuel cell. Since only one side of the fuel cell was tested at a time, the other electrode was a standard E-TEK electrode (20 wt% Pt/C, 0.4 mg Pt/cm^2). The results obtained using the Pt PLD method were compared to different fuel cell set-ups using supported platinum on carbon as shown in Tables 1 and 2.

Table 1: Current densities during the **anode** tests at 0.6V for various Pt electrodes and comparison with the E-TEK electrode.

Catalyst	Pt loading (mg/cm^2)	i (A/cm^2)	i ratio vs E-TEK
E-TEK	**0.4**	**0.78**	**1**
2wt% Pt/C	0.015	0.48	0.62
Pt PLD	0.135	0.78	1
	0.017	**0.78**	**1**
	0.007	0.59	0.75
	0.002	0.29	0.37

When tested at the anode side, the electrodes produced using PLD may contain as little as 0.017 mg/cm^2 Pt but perform as well as standard E-TEK electrodes (0.4 mg/cm^2 Pt).

Table 2: Current densities during the **cathode** tests at 0.6V for various Pt PLD electrodes and comparison with the E-TEK electrode.

Catalyst	Pt loading (mg/cm^2)	i (A/cm^2)	i ratio vs E-TEK
E-TEK	**0.4**	**0.78**	**1**
Pt PLD	**0.135**	**0.66**	**0.85**
	0.034	0.58	0.74
	0.017	0.53	0.68

The results on the cathode side are not so impressive. Here, a Pt loading of 0.135 mg/cm^2 obtained by PLD reached 85% of the current density measured at 0.6V for the reference electrode containing 0.4 mg/cm^2.

Using scanning electron microscopy (SEM), we were able to observe that the PLD deposited Pt layer coats the surface of the GDE with platinum without changing the initial morphology of the carbon backing. XRD studies of the PLD deposited Pt electrodes show that the average crystallite size of the platinum particles is about 10 nm.

Further studies will focus on using PLD to deposit binary alloys such as Pt-Ru.

References:

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