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Short Communication

# A gas management strategy for anode recirculation in a proton exchange membrane fuel cell

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ABSTRACT

The anode configuration and gas management strategy are two of factors that affect the energy efficiency of a proton exchange membrane fuel cell. In order to improve the hydrogen utilization, unused hydrogen can be recirculated to the inlet using a pump. However, impurities diffusing from the cathode to the anode may cause the dilution of hydrogen in the anode. As a result, a gas management strategy is required for the anode recirculation configuration. In this preliminary study, a novel configuration for anode recirculation and a gas management strategy are proposed and verified by experiments. Two valves are installed in the recirculation line. The anode is operated in four modes (dead-end, recirculation, compression, and purge), and the real-time local current density (LCD) is monitored for gas management purposes. The results show that the LCD distribution is uniform during the recirculation mode and nonuniform during the dead-end and compression modes. With this configuration and gas management strategy, the cycle duration is increased by a factor of 6.5.

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## Introduction

Proton exchange membrane fuel cells (PEMFCs) have many advantages over internal combustion engines, including a low operating temperature and noise, low pollutant emissions, high power density, and high energy efficiency. Some of the challenges for the commercialization of PEMFCs are hydrogen storage and production from renewable sources. At the current stage, hydrogen is more expensive than gasoline. To compete with internal combustion engines, hydrogen utilization is a key factor for the energy efficiency of a PEMFC system.

In a laboratory experiment, a PEMFC is always supplied with an excessive stoichiometric ratio of hydrogen to avoid fuel starvation and to remove the generated liquid water. However, unused hydrogen is usually purged to the environment, reducing the overall energy efficiency. To improve the energy efficiency, considerable efforts have been made to develop gas management strategies for an anode configuration with a dead-end or with recirculation. When a PEMFC is operated in the dead-ended anode mode, water and nitrogen gradually diffuse from the anode and accumulate within the anode [1], resulting in hydrogen dilution and a decrease in performance. Hydrogen dilution may cause carbon corrosion

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in the catalyst layer of the cathode [2]. The performance can be recovered by an anode purge to remove impurities. In published studies, anode purge strategies were developed on the basis of a voltage drop [3,4], a regular interval [5], nitrogen accumulation [6,7], current integration [8], or characteristic real-time current signals [9].

In an anodic recirculation configuration, the unused hydrogen is recirculated to the inlet via a mechanical pump, a compressor, or an ejector. An ejector is a passive device that draws hydrogen from the anode exhaust into the anode inlet [10,11]. The employment of ejectors for hydrogen recirculation has the advantages of no parasitic power, low noise, a simple control strategy, and easy maintenance compared with a recirculation pump [12]. However, the effectiveness of recirculation depends on proper design of the ejector [13–17]. Further, a recirculation pump is an active device that controls the recirculated flow rate according to the operating conditions of the PEMFC. Therefore, the control strategy for a

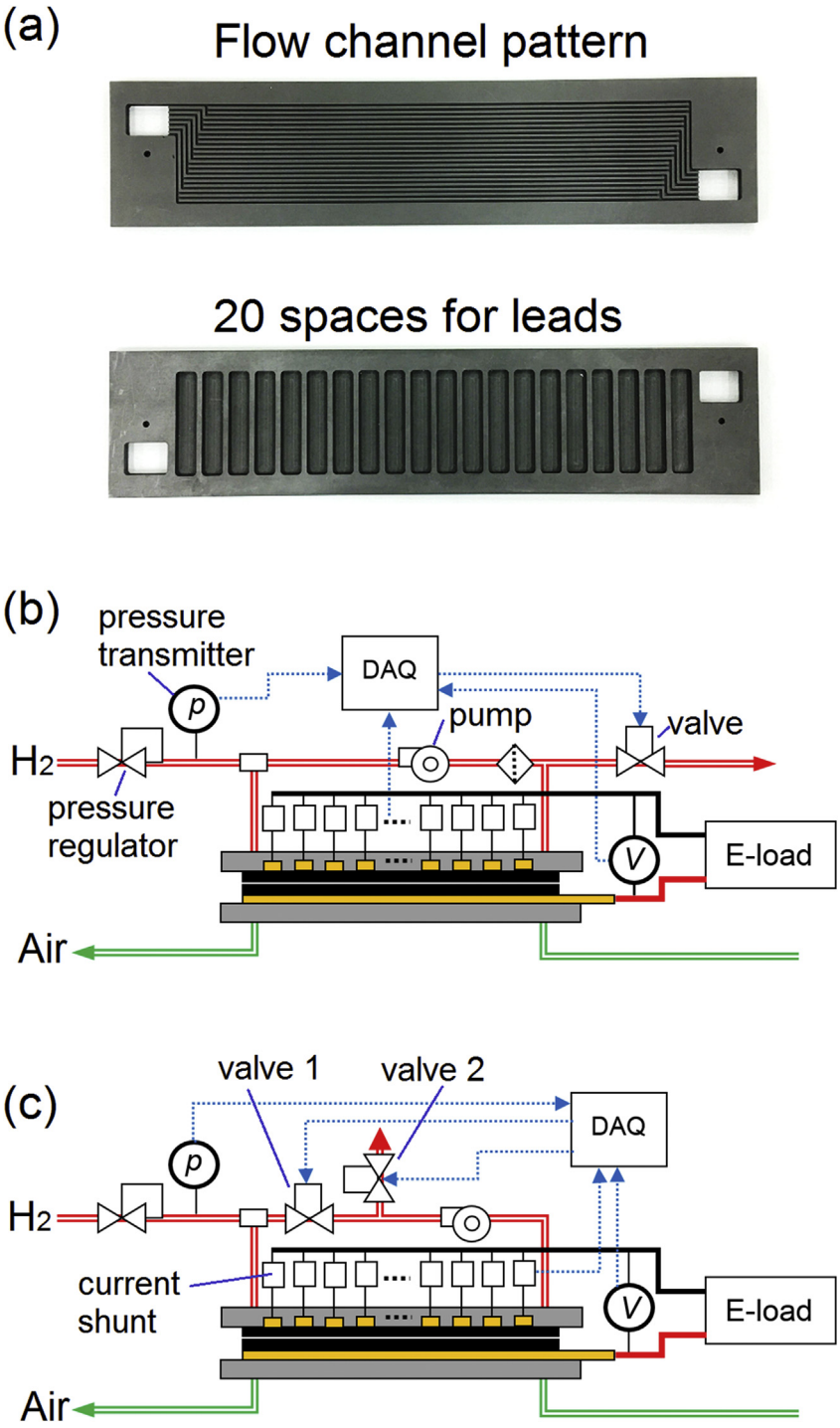


**Fig. 1 – (a) A picture of both sides of the anode graphite plates. (b) Traditional configuration for anode recirculation. (c) Novel configuration of the anode employing two valves.**

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