CHAPTER III
EXPERIMENTAL

The experiment was performed at the National Metal and Materials Technology Center (MTEC). The overview of the experimental setup is illustrated in Fig. 3.1 consisting of four main sections:

i. Electrochemical cell and one-cell stack
ii. Gas controlling system
iii. Furnace and temperature controling system
iv. Electrical loading and measurement system

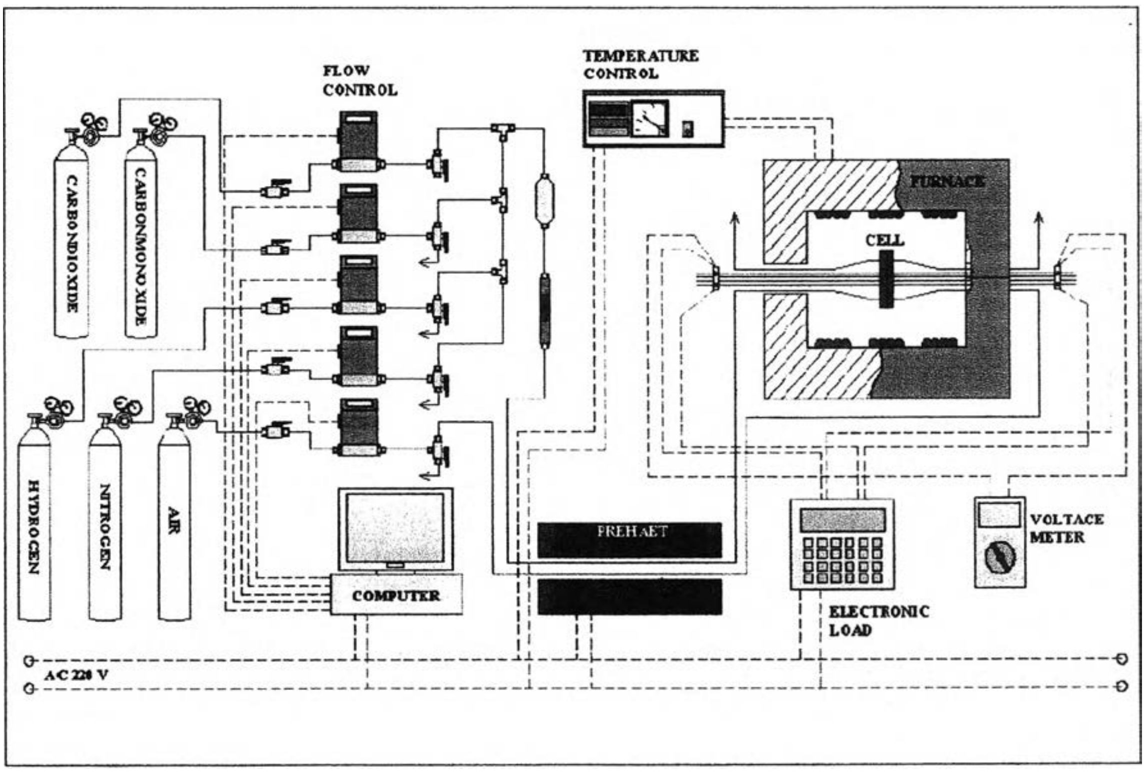
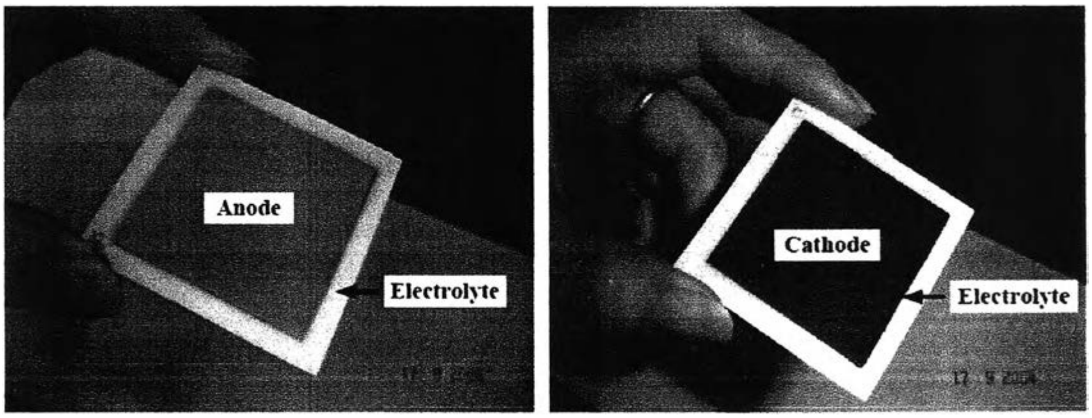


Figure 3.1 Schematic of experimental setup.

3.1 Electrochemical Cell and One-cell Stack

3.1.1 Electrochemical Cell

Electrochemical cells used in this experiment are Electrolyte-Supported Cells (ESCs) supplied by Innovative Dutch Electro Ceramics (In DEC B.V.) CO., Ltd., as shown in Fig. 3.2. The ESC consists of a TZ3Y electrolyte (3 mol% yttria-stabilized zirconia) that is approximately 150 μm thick and is fabricated by tape casting. Then, a 160 μm thick Ni-CeO_2-YSZ anode and a 50 μm thick $La_{0.7}Sr_{0.2}MnO3_{-\varsigma}$ cathode are screen printed on each side of the electrolyte. The areas of the electrolyte and each electrode are 25 cm^2 (5x5) and 16 cm^2 (4x4), respectively.



(a) (b)

Figure 3.2 Electrolyte-Supported Cell: (a) anode and (b) cathode.

3.1.2 One-cell Stack

To study and test the performance of a PSOFC, a one-cell stack has to be fabricated, as illustrated in Fig. 3.3. A one-cell stack consists of PSOFC sandwiched between two plates. Each plate contains several small gas flow channels and ribs to distribute the fuel, and the oxidant flows over the fuel cell surface while collecting current from the cell.

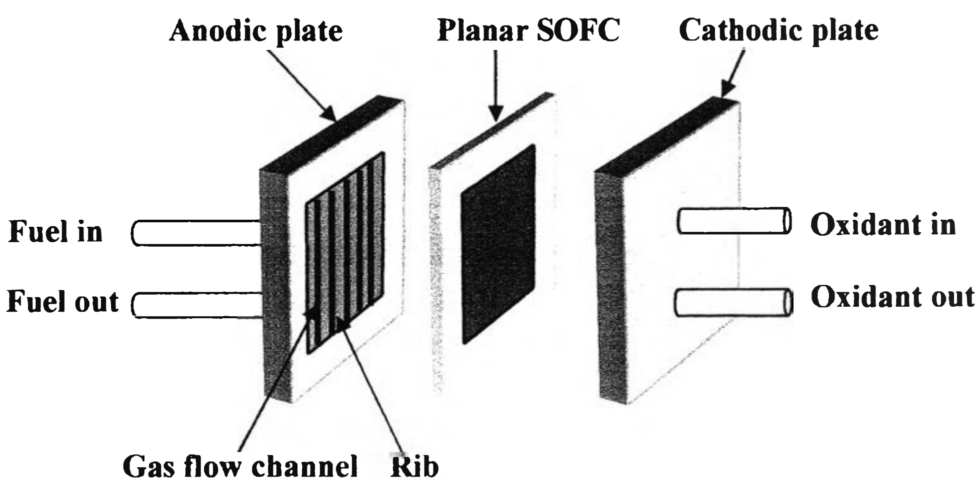
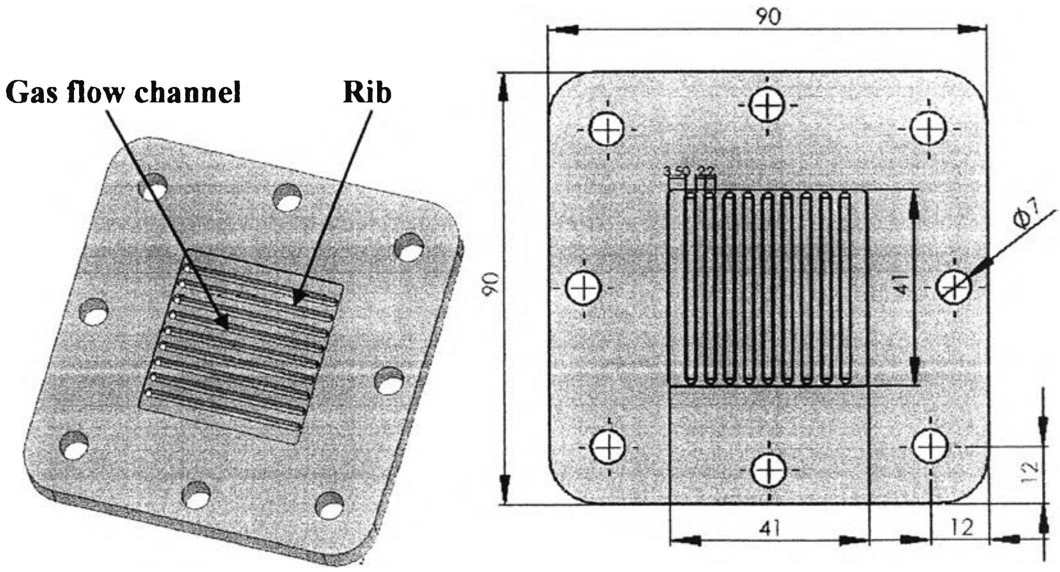


Figure 3.3 A simple schematic of a PSOFC one-cell stack.

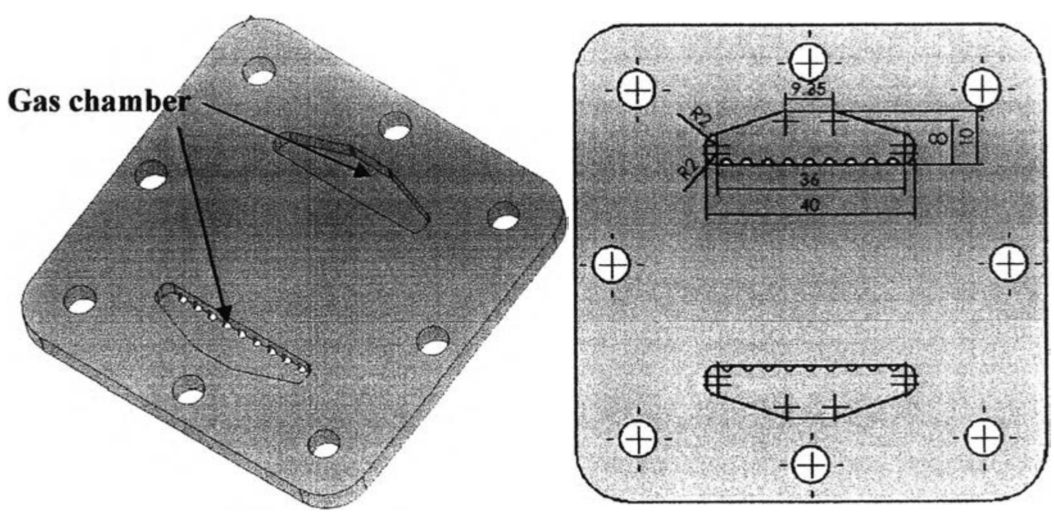
3.1.2.1 Plate Design and Fabrication

To fabricate a high performance one-cell stack, the plate has to provide even gas distribution to the PSOFC surface and also has to prevent gas leakage. Therefore, the plate design becomes very important. Front and the back views of the plate are illustrated in Figs. 3.4 and 3.5, respectively.



(a) (b)

Figure 3.4 Front view of (a) the plate and (b) its dimensions.



(a) (b)

Figure 3.5 Back view of (a) the plate and (b) its dimensions.

The plate has a square geometry with 6 mm thickness. For the front side, there are nine small flow channels and ten ribs. Each channel is 2 mm wide and 2 mm deep. For the back side, there are two gas chambers to make the gas flow into every channel equally. Each gas chamber is 5 mm depth. Eight holes along the edge of the plate are available for screws and nuts. To provide gas flow in/out of the plate, two stainless steel tubes are welded to each plate. Front and the back views of the completed plate are shown in Figs. 3.6 and 3.7, respectively.

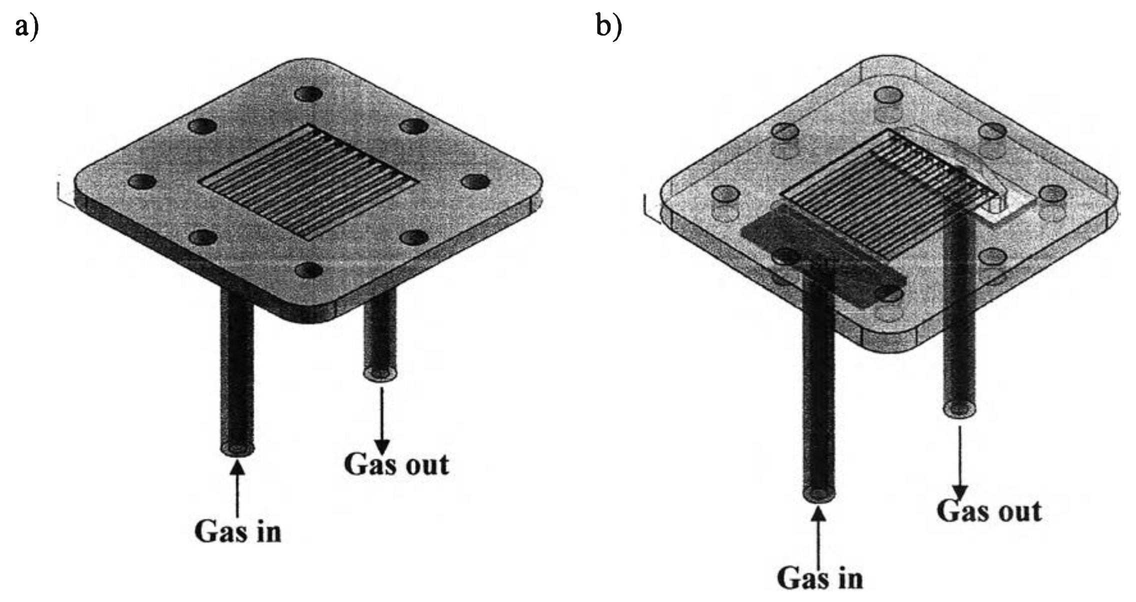


Figure 3.6 Front view of the completed (a) opaque and (b) transparent plates.

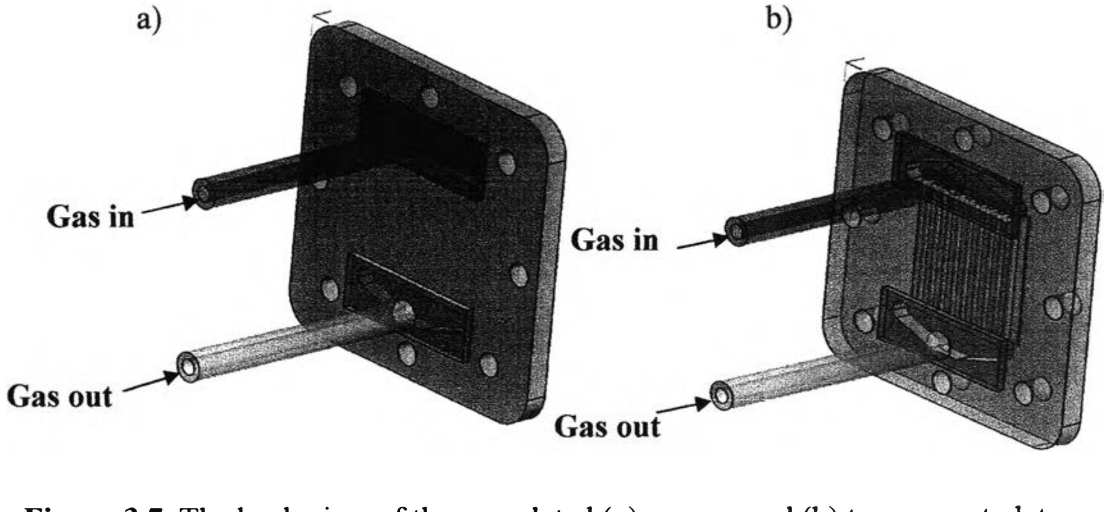
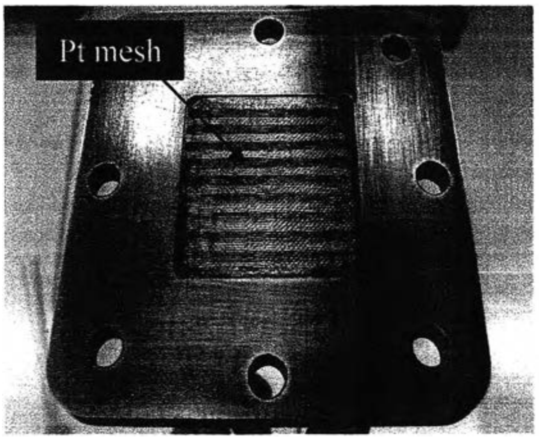


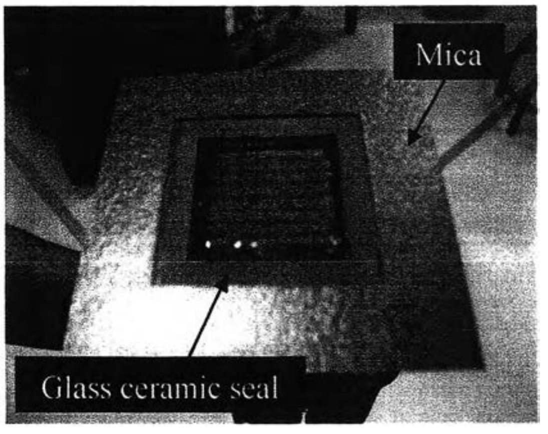
Figure 3.7 The back view of the completed (a) opaque and (b) transparent plates.

3.1.2.2 One-cell Stack Fabrication Steps

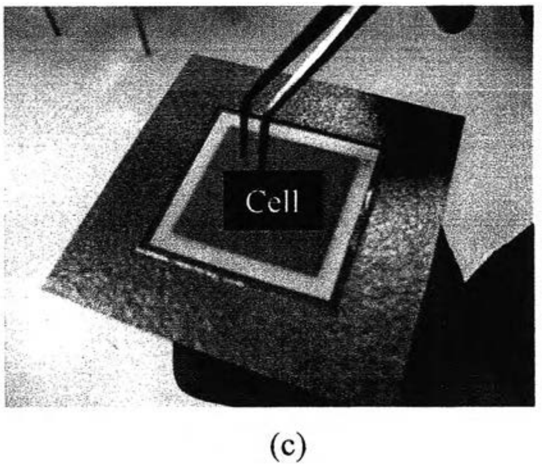
The fabrication steps of a one-cell stack are illustrated in Fig 3.8. Firstly, a Pt mesh (99.9%, Alfa Aesar GmbH & Co KG) is placed on the plate ribs to act as a current collector, (a). Mica (SUAN LUANG ENGINEERING LTD. PART.) and a glass seal (Sealing Glass Tape 500, fuelcellstore.com) are applied to the plate to prevent short-circuiting and gas leakage, respectively, (b). A PSOFC is then placed on the Pt mesh, (c). A seal again is applied to the white electrolyte layer, (d), followed by joining both plates together, (e). Screws and nuts are used for tightness. Two c-clamps are used to provide compression force to the stack (f). Finally, the completed PSOFC one-cell stack is put in the furnace, (f) and (g).



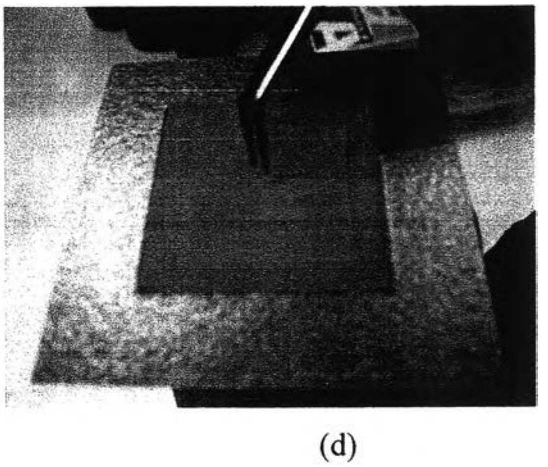
(a)



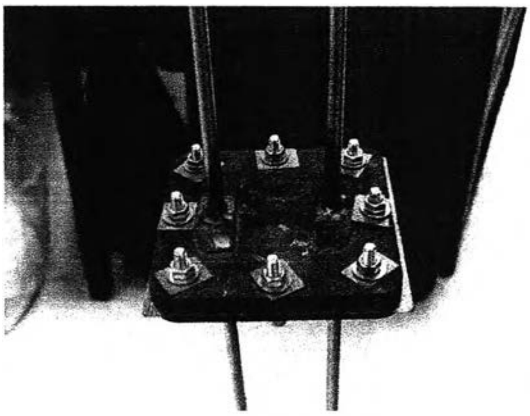
(b)



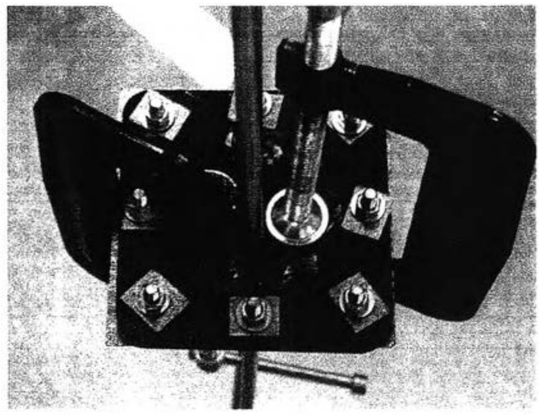
(c)



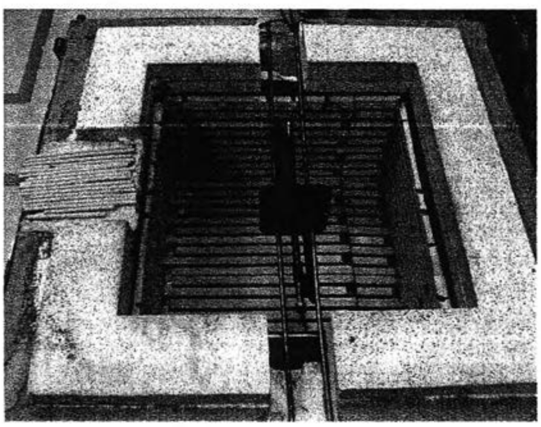
(d)



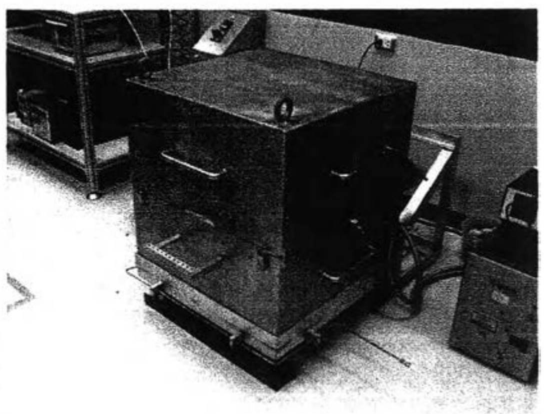
(e)



(f)



(f)



(g)

Figure 3.8 One-cell stack fabrication steps.

3.2 Gas Controlling System

Fuel stream (H_2, CO, CO_2 and N_2) and an oxidant (Air) are controlled and delivered to the one-cell stack and PSOFC by a set of OMEGA mass flow control model FMA-A2400 (OMEGA ENGINEERING, INC.). Flow rates of gas are measured and calibrated by a mass flow meter (ADM 2000, Agilent Technologies)

3.3 Furnace and Temperature Control System

Furnace is 700x700x700 mm outside volume and 400x400x400 inside volume (SUAN LUANG ENGINEERING LTD. PART.) and its maximum temperature is 1100°C. A k type thermocouple (inconel) is used to measured temperature inside the furnace. Temperature is controlled by a PDI controller (DB 5090, JIUH DONG CO., LTD.).

3.4 Electrical Loading and Measurement System

To obtain a performance curve of the one-cell stack, an adjustable resistance electronic load (Chroma 6301, Chroma ATE INC.) is used to drawn current from the one-cell stack. While voltage of the one-cell stack is measured by a multimeter (Fluke 189, Fluke Corporation)

3.5 Operation and Testing

Operating the PSOFC one-cell stack at 800°C, it is heated in a furnace at a rate of 1°C/min to avoid cell cracking. N_2 is used in the anodic side to purge air from the flow channels. The temperature is held at 550°C for 3 hrs to remove the organic in the glass seal. At 800°C, H_2 is used for 4 hrs to reduce the nickel oxide in the anode to nickel metal, the active catalyst. For performance testing, the current-voltage (I-V curve) is obtained using an electronic load by mean of resistance varying from 4000 to 1 ohm.