Welcome to POEM 2010, Wuhan!

Note: The authors are supposed to have the access to the manuscript system from July 27, 2010. The Due Date for the submission is Aug. 31. Please submit your manuscript online: http://poem2010.edmgr.com.
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Note:
1) Registration online will open until Oct.25, 2010, after which only registration onsite is accepted.
2) We reserve several hotels of different room types for attendees at favorable price, including newly ordered Lake view Garden Hotel & Sunny Sky Hotel located near the venue.
3) Authors should print their posters in 90 cm x 120cm and set them up before the poster session on the 3rd floor. Authors or coauthors are required to stand by during the poster session.
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List of Best Student Papers

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The International Photonics and OptoElectronics Meetings (POEM) emerges with the worldwide rapid development of the optoelectronics, the leading technology in the 21st century which became the drive to push the technology revolution. The third POEM will be held on 3-5 November 2010, in conjunction with The 7th Optics Valley of China International Optoelectronic Exposition and Forum (OVC EXPO) and The 9th International Conference on Photonics and Imaging in Biology and Medicine (PIBM 2010).

POEM is one of the largest international conferences to be organized around the field of Photonics and Optoelectronics rather than a specific technology. By attracting world-famous experts, researchers, investors and entrepreneurs in the field of optoelectronics from more than 20 countries, POEM is to provide an international forum on exchange information on recent advances and future trends for researchers and to grow sales and boost brand for the enterprises.

POEM 2010 will extend its topics to Laser Technology and Appliacitions (LTA), Nano-enabled Energy Technologies and Materials (NETM), Optoelectronic Devices and Integration (OEDI), Optoelectronic Sensing And Imaging (OSI), Solar Cells, Solid State Lighting and Information Display Technologies (SSID) and Tera-Hertz Science and Technology (THST). A special workshop on Plasmonics Technology and Applications is also organized this year.

The city of Wuhan, as one of the major economic and industrial cities in China, is situated at the confluence of the Yangtze River with many unique sights scattered around its huge metropolis including East Lake, Yellow Crane Tower, Guiyuan Temple, Hubei Provincial Museum, Wudang Mountains and Three Gorges, etc.

Recently, Wuhan East Lake National Innovation Model Park, located in the Optics Valley of China in Wuhan, has been approved by the State Council to be the China's second National Innovation Model Park after Zhongguan Cun. This will certainly give a full play to its advantage of intensive intelligence and enhance the international competitiveness of China's optoelectronic industry.

Congratulations on the successful opening of POEM 2009!

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- 1. Gathering more than 1000 experts, entrepreneurs, governors and investors from both home and overseas in the "Wuhan Optics Valley of China"
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Thermoelectric Properties of Silicon Microchannel Plates

Structures

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Abstract. We have fabricated silicon microchannel plates (MCPs) by photo-assisted electrochemical etching (PAECE) and determined the thermoelectric properties by measuring the Seebeck coefficient of the samples. The samples are composed of regular arrayed lattices with a width of about 5 μm and spacing of about 1 μm. The Seebeck coefficient along the edge of the lattice is 466 μV/K. The silicon MCPs are potential materials for power generation and refrigeration. After oxidation from 30 minutes to 70 minutes and removing the silicon dioxide layer by buffered hydrofluoric acid, the samples show an improved coefficient as high as 1019 μV/K after repeating oxidation and etching 5 times. Our results show that the Seebeck coefficient increases when the wall of the silicon MCPs is thinned.

1. Introduction

There are needs to explore new energy sources with high efficiency and low pollution and thermoelectric materials have attracted increasing interest because they are able to convert heat into electricity directly and have simple structures without any moving parts [1]. Therefore, they are used to generate power in industrial heating and refrigeration products. Silicon is the most abundant and widely used semiconductor which also benefits from the well-developed microfabrication technology [2-4]. Silicon microchannel plates (MCPs) are one of the most hopeful silicon-based thermoelectric materials. Silicon MCPs offer good thermoelectric properties in initial measurements. In addition, silicon MCPs have a porosity (about 69%) similar to that of porous silicon (PS), and the thermal conductivity of PS can be as low as 0.7–1.3 Wm⁻¹K⁻¹ [5]. Thus, a low conductivity is expected from silicon MCPs.
Sun et al. [6] have reported different Seebeck coefficients along different orientations in the silicon MCPs. We are interested in the change in the Seebeck coefficient when the structure of the silicon MCPs is changed. This paper reports our study of the thermoelectric effect of silicon MCPs fabricated by photo-assisted electrochemical etching (PAECE). The Seebeck coefficients are measured in order to evaluate the thermoelectric properties. In order to clarify the relationship between the Seebeck coefficient and thickness of pore wall, oxidation and etching are performed to thin the pore wall before determining the Seebeck coefficient.

2. Experiment details
Silicon MCPs were fabricated by the PAECE process. A p-type <100> single-side polished silicon wafer 500 μm thick with a resistivity of 2-9 Ω·cm was used.

The process flow in electrochemical etching is illustrated in Figure 1. First of all, a silicon dioxide layer (3000 Å) was grown on the wafer by thermal oxidation at 1080°C and the oxide layer on the front side was patterned by a standard photolithographic process and wet etching in a buffered hydrofluoric acid which was used to open the etch windows. In order to fabricate the initial reaction interface, the pits with the shape of an inverted pyramid were formed by etching the samples in 25 wt% tetramethyl ammonium hydroxide (TMAH) at 85°C for a few minutes. The dimensions of the pore were designed to be 3 μm x 3 μm. The silicon dioxide layer was then removed and the PAECE process was performed at 20°C. The electrolyte was a solution of HF(40%):H₂O:DMF (Dimethylformamide: DMF) = 1:4:5. The etching current density was 15 mA/cm² and etching
voltage was 12 V. A halogen lamp (150 W, 15 V OSRAM) was used to provide backside illumination. A stable etching current was achieved by adjusting the illumination which provided the holes during etching. A computer was used to monitor the etching current and adjust the illumination automatically. After 8 hours, the silicon microchannel plate layer with square hole arrays was automatically broken away from the substrate [7]. The hole had dimensions of about 5 μm x 5μm, and the space between two holes nearby was about 1 μm. In addition, the thickness of the silicon MCPs was about 200 μm.

The samples were then divided into five groups. The first group underwent dry thermal oxidation for 30 minutes at 1080°C. The second group was oxidized for 40 minutes at 1080°C, including dry oxidation of 15 minutes, wet oxidation of 10 minutes, and dry oxidation of 15 minutes. To keep the time of dry oxidation the same and increase the time of wet oxidation to 20 minutes, 30 minutes and 40 minutes, the total oxidation time was increased to 50 minutes, 60 minutes, and 70 minutes, respectively. The oxidized samples were then dipped in a buffered hydrofluoric acid for a few minutes to remove the oxide layer. Using this procedure, pore walls with different thicknesses would be fabricated. The microstructure of the samples was characterized by scanning electron microscopy (SEM).

### 3. Results and discussion

Figure 2 shows SEM images of the surface and cross-section of the silicon MCPs fabricated by PAECE process.

![Figure 2](image)

**Figure 2.** SEM images of surface (a) and cross-section (b) of sample by PAECE.

The samples were first cut into pieces (2 cm long and 1 cm wide) by a laser beam for subsequent studies. In order to characterize the samples, they were placed on a thermally insulated substrate. The copper sheets serving as both the thermal and electrical conducting layers were spring loaded onto the sample by probes. This made the ohmic contact between the copper sheets and silicon MCPs. The schematic diagram is depicted in Figure 3.
Electrode I shown in Figure 3 was heated from room temperature (25 °C) to 60 °C in the heater while Electrode II was kept at room temperature. The electrodes were parallel to the edge of the square lattice.

The Seebeck coefficient can be determined from the thermoelectromotive force (∆V) and temperature difference (∆T) by $S=\frac{\Delta V}{\Delta T}$. In other words, the slope of the $\Delta T$-$\Delta V$ plots of samples is the Seebeck coefficient [8]. It must be emphasized that the distance between the electrodes has no influence on the data, and the key factor which affects the data is the temperature difference between the two electrodes.
Figure 4 shows a Seebeck coefficient of 466 μV/K along the edge of the lattice according to the slope. Meanwhile, the positive Seebeck coefficient reveals that the silicon MCPs fabricated by the PAECE process have exhausted the holes and behave like intrinsic semiconductor materials because a p-type semiconductor should have a negative Seebeck coefficient. The plot shows that the thermoelectromotive force (∆V) increase quickly when the temperature difference (∆T) (compared to room temperature) increases.

![Figure 4](image)

**Figure 5.** SEM images of (a) surface and (b) and cross-section of the sample after undergoing oxidation for 70 minutes.

To investigate the relationship between the thickness of the pore wall and Seebeck coefficient, oxidation is conducted to control the wall thickness. A different oxidation time can lead to various degree of silicon consumption. The longer the oxidation time, the smaller is the thickness of the silicon layer on the pore wall. The samples with small pore thickness can be obtained after the oxidation layer is etched by buffered hydrofluoric acid. The oxidation time is 30 minutes, 40 minutes, 50 minutes, 60 minutes, or 70 minutes. Figure 5 shows the SEM image of the surface and cross-section of sample after oxidation for 70 minutes. This sample has a silicon dioxide layer of about 500 nm. It can also be observed that the pore walls on both sides are oxidized and the silicon dioxide layer has different color. The difference is caused by dry oxidation and wet oxidation in terms of density.
The Seebeck coefficient is determined from the samples with thinned pore wall, and the curves which can be described by the $\Delta T$-$\Delta V$ plot are shown in Figure 6. The Seebeck coefficient can be determined from the slope of each curve. Based on the Seebeck coefficient and corresponding oxidation time, another curve is presented in Figure 7. The first thinning process has little influence on the Seebeck coefficient (472 $\mu$V/K), because dry oxidation for 30 minutes only consumes a thickness of about 30 nm of silicon which is negligible compared to the thickness of the pore wall. When wet oxidation is added to the oxidation process, the pore wall is thinned greatly, and

**Figure 6.** $\Delta T$-$\Delta V$ plots of sample with different oxidation time.

**Figure 7.** Relationship between the Seebeck coefficient and oxidation time.
subsequently an improved coefficient appears. After thinning for 5 times, the coefficient reaches a value of 1019 μV/K. Under this condition, the sample has a fragile structure which is no longer suitable practically. The enhancement in the Seebeck coefficient is due to the change in the energy band while the pore wall becomes thinner. Therefore, Figure 7 indicates that a smaller thickness of the pore wall will increase the Seebeck coefficient notably. It should be noted that all the samples have the same order of magnitude as intrinsic silicon in terms of resistivity. It is attributed to the exhaustion of holes in the PAECE process and is very disadvantageous to application as thermal materials. However, doping can reduce the resistivity and more work is underway in our laboratory.

4. Conclusion
We have investigated the Seebeck coefficient of silicon MCPs fabricated by PAECE. The results show remarkable thermoelectric characteristics with a Seebeck coefficient of 466 μV/K. An enhanced Seebeck coefficient is observed when the silicon MCPs are thinned by thermal oxidation and etching in buffered hydrofluoric acid. The Seebeck coefficient is proportional to the thickness of the pore wall. This phenomenon is believed to be related to the change in the energy band which affects the effective mass of carriers. In addition, the thermal conductivity of silicon MCPs which has the similar porosity to PS is very low. Owing to these advantages, silicon MCPs are potential thermoelectric materials in application such as power generation, refrigeration, and sensing.

Acknowledgments
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References
[7] Xiaoming Chen, Jilei Lin, Ding Yuan, Pengliang Ci, Peisheng Xin, Shaohui Xu and Lianwei Wang 2008 Obtaining a high area ratio free-standing silicon microchannel plate via a modified electrochemical procedure *J. Micromech. Microeng.*. **18** 037003