| 논문원고접수 |

2018년 12월 3일(월) ~ 12월 31일(월)

| 논문심사결과 통보일 |

2019년 2월 11일(월)까지 홈페이지 (http://www.micronanos.org)에 공지 및 책임저자에게 이메일로 통보

| 초록 및 논문접수처 |

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| 논문범위 |

1. Materials, Fabrication, and Packaging Technologies
2. Fundamentals in MEMS/NEMS
3. Micro/Nanofluidics and Lab-on-a-Chip
4. Bio/Medical Micro/Nano Devices
5. Micro/Nano Sensors and Actuators
6. RF/Optical Micro/Nano Devices
7. Micro/Nano Energy Devices
8. Flexible and Printed Devices
9. MEMS/NEMS Applications and Commercialization

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제21회 KMEMS 학술대회 POSTER SESSION

Poster Session 1 (TP-1)						4월 4일 목요일 16:50~ 18:00
논문 No.	발표장소	Journal Title	First Author	Corresponding Author	Presenting Author	Organization
TP-1-01	무궁화룸	Bio-oriented perm-selective structures for micro-nanofluidic applications	박성민	김성재	박성민	서울대학교
TP-1-02	무궁화룸	높은 감도와 극저농도 측정 능력을 가진 가스 센서의 제작을 위한 이황화몰리브덴의 안정적인 기능화 기술	김대기	김준협	김준협	고려대학교
TP-1-03	무궁화룸	웨어러블 응용을 위한 광 투과방식 유연 인장 센서 패키징	구지민	박인규	구지민	한국과학기술원
TP-1-04	무궁화룸	탄소나노튜브와 은나노와이어 복합체 기반 신축 직물 히터	안준성	박인규, 정준호	안준성	한국과학기술원
TP-1-05	무궁화룸	Electrochemical charge storage evaluation of nanostructured manganese sulfide thin film	Rahul B. Pujari	이동원	Rahul B. Pujari	전남대학교
TP-1-06	무궁화룸	프리즘기반의 비접촉 레이저 간섭 리소그래피를 통해 제작한 나노패턴 수치 시뮬레이션 및 AFM 측정	이성재	신보성	이성재	부산대학교
TP-1-07	무궁화룸	Hierarchical구조 기반의 신축성 투명 omniphobic PDMS 필름 제작	유채린	이동원	유채린	전남대학교
TP-1-08	무궁화룸	Dynamics of nanoelectrokinetic preconcentrated DNA leveraged by convection and diffusion	백성호	김성재	백성호	서울대학교
TP-1-09	무궁화룸	전극 위 절연층 에칭 윈도우 위치에 따른 유전영동 트랩 현상 비교	여강인	이상우	여강인	연세대학교
TP-1-10	무궁화룸	Electrode design for pH control in nano-electrokinetic device	오지환	김성재	오지환	서울대학교
TP-1-11	무궁화룸	제브라피쉬 정렬을 위한 유체 교환식 마이크로 유체 채널	이유현	김소희	이유현	대구경북과학기술원
TP-1-12	무궁화룸	확산 영동을 이용한 연속적 나노 입자 분리에서 pH의 효과 Effect of pH on Diffusiophoresis-based Continuous Nanoparticle Separation	서명진	김성재	서명진	서울대학교
TP-1-13	무궁화룸	Patternable particle microarray utilizing sequential particle delivery	이상현	김준원	이상현	포항공과대학교
TP-1-14	무궁화룸	강제적 정상 상태 달성을 통한 이온 선택적 전류에서의 옴의 전도도 제거.	권순현	김성재	권순현	서울대학교
TP-1-15	무궁화룸	Spontaneous Selective Preconcentration Leveraged by Convective Flow through Paper-based Micropores over Diffusiophoresis	이도근	김성재	이도근	서울대학교
TP-1-16	무궁화룸	마이크로 표면구조 및 전기전도성에 따른 심근세포의 성숙에 관한 연구	김종율	이동원	김종율	전남대학교
TP-1-17	무궁화룸	세포 자극 및 실시간 관찰을 위한 스테이지-탑 바이오리액터의 제작 및 평가	정윤진	이동원	정윤진	전남대학교
TP-1-18	무궁화룸	Microfluidic channel based stretchable pressure sensor for wireless health monitoring	Munirathinam Karthikeyan	이동원	Munirathinam Karthikeyan	전남대학교
TP-1-19	무궁화룸	Characterization of the membrane capacitance and permeability changes caused by cholesterol depletion based on Dielectrophoretic System	김채원	이상우	김채원	연세대학교 의공학부
TP-1-20	무궁화룸	A PDMS 기반의 유연한 피질뇌파측정용 전극 어레이	이경연	김소희	이경연	대구경북과학기술원
TP-1-21	로즈룸	Effect of wrinkled metallic thin film in cardiomyocyte growth and maturation	노민	이동원	노민	전남대학교
TP-1-22	로즈룸	고정된 PCR Assay를 이용한 와파린 약물 관련 SNP 검출	배서진	김상효	배서진	가천대학교
TP-1-23	로즈룸	폴리머 기반의 유연한 3 차원 전극의 장기간 사용적합성 평가	장재원	김소희	장재원	대구경북과학기술원
TP-1-24	로즈룸	Novel silicon cantilever integrated with surface-patterned polymer thin layer and strain sensor for biomedical applications	Mingming Dong	이동원	Mingming Dong	Chonnam National University

Novel silicon cantilever integrated with surface-patterned polymer thin layer and strain sensor for biomedical applications

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바이오메디컬 활용을 위해 표면구조를 갖는 폴리머 박막과 압저항형 센서가 통합된 새로운 실리콘 캔틸레버

[1]Dong Mingming, [1]O. Nomin-Erdene, [1]김동수, [1]정윤진, [1,2]이동원*,
[1]전남대학교 기계공학부, [2]전남대학교 차세대센서연구개발센터

Abstract

This paper describes a silicon cantilever integrated with a surface-patterned PDMS thin layer and a piezoresistive sensor for the study of cardiac cells treated with drugs. The contractile force and the beat frequency of the cardiac cells were measured in real time by the sensor-integrated cantilever, and the displacement at the free end of the cantilever was also confirmed using a laser sensor. The fabricated cantilever made by silicon greatly improved the stability in comparing with previous polymer cantilevers. Rectangular groove arrays formed on the polymer surface help the cardiac cells to grow in one direction. This greatly enhances the contractility of the cardiac cells. In addition, the surface-patterned PDMS thin film is chemically bonded to the silicon cantilever, which enables the cantilever to be operated stably for a long time in culture media. The proposed MEMS-based cantilever sensor is expected to be employed in various biomedical fields.

Keywords: ***Silicon cantilever(실리콘 캔틸레버), Etching(에칭), PDMS, Groove, Cardiac cells(심장세포).***

1. Introduction

The heart is an important organ for maintaining human life. Once the heart function fails, it will directly affect human life. According to the American Heart Association, cardiovascular disease is the number one cause of death worldwide, and the number of people dying from cardiovascular disease each year is more than any other reason. According to statistics, in 2016, approximately 17.9 million people died of cardiovascular disease, accounting for 31% of the global death toll [1]. Another article counts and predicts the number of congenital heart diseases in South Korea in recent years [2]. To control and reduce the number of patients, it is necessary to deeply study the reason that causes heart disease. As a first step in the research, it is necessary to obtain the physiological characteristics of cardiomyocytes. The contractility and beating frequency of cardiomyocytes are important indicators for measuring physiological characteristics. To measure the physiological characteristics of cardiomyocytes in vitro, researchers have proposed methods for measuring micro-post [3] and polymer cantilevers [4]. Compared with the cantilever, the displacement of the micro-post in the measurement of cardiomyocytes is small, and the structure of the cardiomyocytes is changed. At present, cantilevers made by polymer materials have drawbacks of low sensitivity, poor stability etc. In addition, current designs are very difficult to be practically applied. In this paper, we propose a novel design of a cantilever integrated with a surface-patterned polymer thin layer and a strain sensor. The strain sensors used here will be replaced by doped silicon to further improve sensitivity later.

2. Experimental Section

2.1 Design of Silicon cantilever

The structure of the proposed silicon cantilever is composed of a cantilever body, a metal sensor and a PDMS thin film as shown in Fig 1. The use of silicon as the cantilever material is based on the excellent physical properties of silicon and the silicon can be doped to replace the Au strain gauge sensor (high gauge factor and low environment noise) in further experiments. The designed four resistors constitute a Wheatstone bridge circuit to represent the resistance change in the form of output voltage. The reason why PDMS is used is that it is very convenient to make micro-grooves on the cantilever and the low Young's modulus of PDMS has little effect on the deformation of the cantilever.

2.2 Fabrication of Silicon cantilever

The process flow for the silicon cantilever fabrication is shown in Fig 2. The silicon cantilever is composed of two parts. One is cantilever part. The cantilever was fabricated using conventional MEMS processes. A thin metal is deposited on the cantilever surface and etched to form piezoresistive sensors as shown in the yellow part of Figure 2 (b). The sensor resistance on the body is fixed and the sensor resistance on the cantilever will be changed as a function of cantilever deformation. Another is the PDMS part, The PI used as a substrate due to the flexibility. Then, a thin PR (AZ-GXR601) layer was coated on the PI, and the PR was irradiated by the UV light through a photomask. The exposure time was optimized to obtain the desired depth of microgroove. Next, a desired thickness is obtained by spin-coating the PDMS on the grooved PR. An oxygen plasma was used to chemically bond the silicon cantilever with a strain sensor and the PDMS thin layer with rectangular -groove arrays. Finally, the fabricated cantilever was put into the ST-1023 solution to remove PR, thus the cantilever fabrication was completed.

3. Results & discussion

The fabricated silicon cantilever is shown in Fig 3. There are four cantilevers. This means that these cantilevers are made by the same conditions. This has an important impact on ensuring the reliability of subsequent controlled experiments. The PDMS thin layer was bonded with the cantilever after the oxygen plasma treatment as shown in Fig. 3c, and the structure of PDMS grooves is shown in Fig 3d. The dimensions of these micro-groove are 3 µm in groove width and space, and 1µm in height. The culture of cardiomyocytes is shown in Fig. 4. On the left side, the cells grow on the flat PDMS, and the cell growth direction is random, while the right cells grow in a specific direction under the influence of the microgrooves. The experimental data is shown in Fig 5, the resonance frequency of each cantilever is confirmed using the integrated sensor.

Acknowledgments

This study was supported by the NRF of Korea (NRF) grant funded by the Korean government (No. 2017R1E1A1A01074550).

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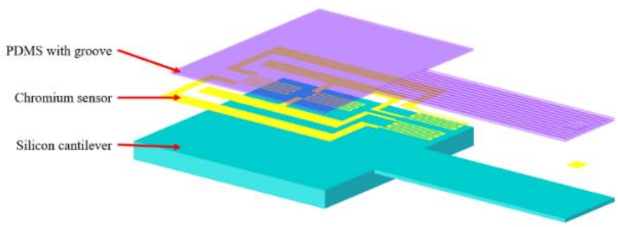

Fig. 1. Schematic of the proposed silicon cantilever device

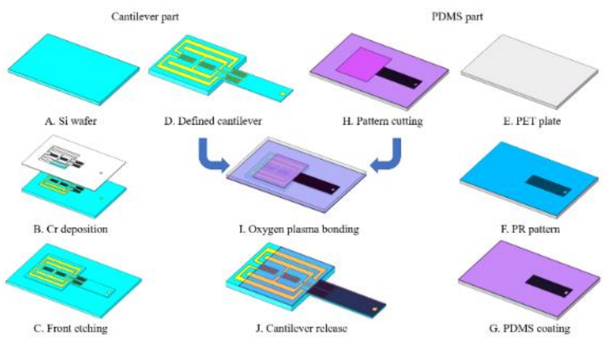

Fig. 2. Process flow for the cantilever fabrication

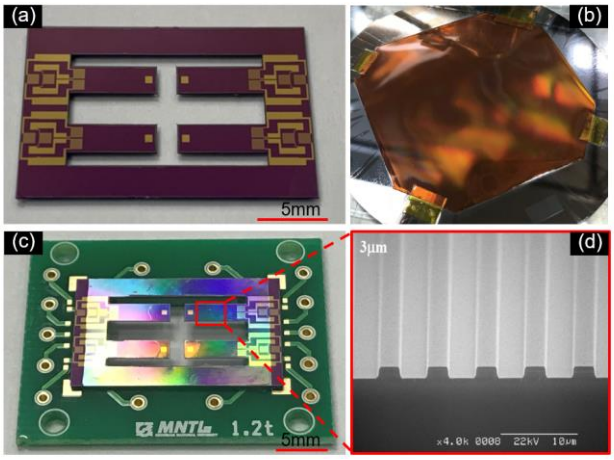

Fig. 3. Optical and SEM images of (a) silicon cantilever integrated with an Cr strain sensor body, (b) surface-patterned PDMS thin film form on the polyimide (c) plasma bonding between PDMS thin film and silicon cantilever and (d) micro-groove patterns on the PDMS thin film.

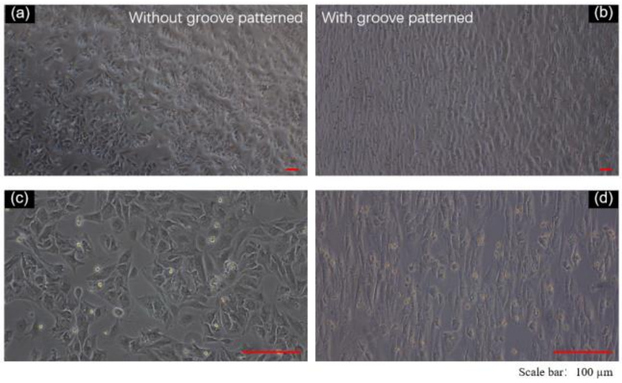

Fig. 4. Optical microscope images of cardiac cells culture, (a, c) cardiac cells grown on the unpattern surface and (b, d) cardiac cells grown on the micro-groove patterned surface.

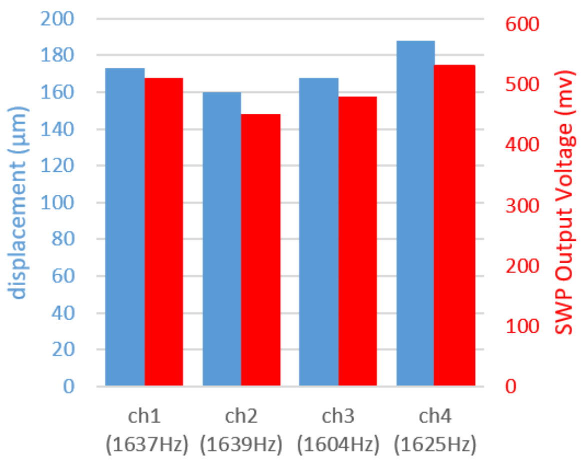

Fig. 5. Cantilever displacement and output voltage obtained from the integrated sensor at resonance frequency.

The 21st Korean MEMS Conference
April 04-06, 2019 JEJU, SOUTH KOREA

NOVEL SILICON CANTILEVER INTEGRATED WITH SURFACE-PATTERNED POLYMER THIN LAYER AND STRAIN SENSOR FOR BIOMEDICAL APPLICATIONS

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ABSTRACT

This paper describes a silicon cantilever integrated with a surface-patterned PDMS thin layer and a piezoresistive sensor for the study of cardiac cells treated with drugs. The contractile force and the beat frequency of the cardiac cells were measured in real time by the sensor-integrated cantilever, and the displacement at the free end of the cantilever was also confirmed using a laser sensor. The fabricated cantilever made by silicon greatly improved the stability in comparing with previous polymer cantilevers. Rectangular groove arrays formed on the polymer surface help the cardiac cells to grow in one direction. This greatly enhances the contractility of the cardiac cells. In addition, the surface-patterned PDMS thin film is chemically bonded to the silicon cantilever, which enables the cantilever to be operated stably for a long time in culture media. The proposed MEMS-based cantilever sensor is expected to be employed in various biomedical fields.

◆Keywords : Silicon cantilever, Etching, PDMS, Groove pattern, Cardiac cells

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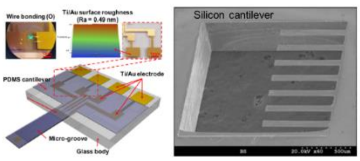
MEMS & Nanotechnology Laboratory

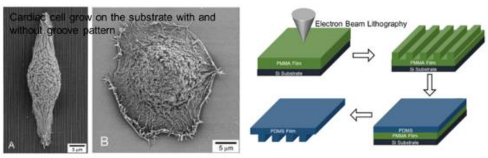
MNTL

INTRODUCTION

Cantilever material selection



Micro-groove pattern for induce anisotropic growth



- Silicon as the material of cantilever has high stability and can increase the sensitivity of cantilever by doping. Silicon is less susceptible to culture media and other environmental factors than other materials.
- Micro-groove structure can enhance contraction force of cardiac cells, to allow the cells to grow in a particular direction, the silicon cantilever was coated with micro-groove patterned PDMS thin film.
- Both silicon cantilever and PDMS grooves are based on MEMS processes and are fabricated by photolithography.
- The deformation of silicon cantilever is measured by high resolution laser vibrometer system and Wheatstone circuit.

DESIGN CONCEPT

Design concept of cantilever device

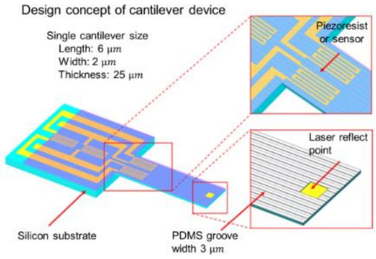


Fig. 1. Design concept of silicon cantilever with PDMS groove and Au sensor

DEVICE FABRICATION

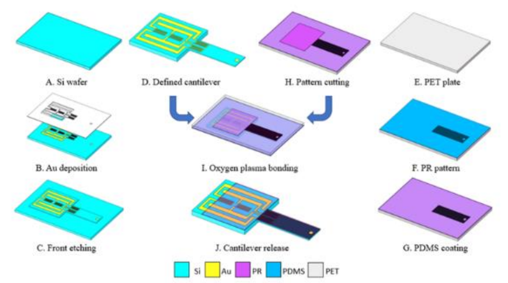


Fig. 2. Device fabrication process flow (a) Si substrate; (b) 100 nm thin Au sensor pattern; (c) Cantilever pattern; (d) Cantilever body define; (e) PET substrate; (f) PR micro groove pattern; (g) PDMS layer coating; (h) PDMS pattern cutting; (i) Bonding cantilever and PDMS; (j) Cantilever release.

FABRICATED DEVICE

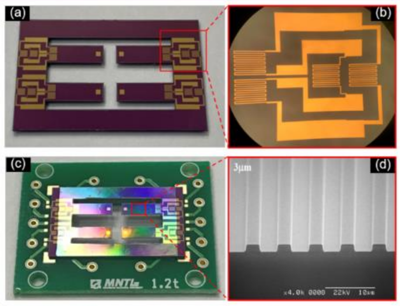


Fig. 3. Optical and SEM images of (a) silicon cantilever integrated with an Au strain sensor, (b) Au strain sensor with Wheatstone bridge, (c) plasma bonding between PDMS thin film and silicon cantilever and (d) SEM image of micro-groove patterns on the PDMS thin film.

CARDIAC CELL MORPHOLOGY

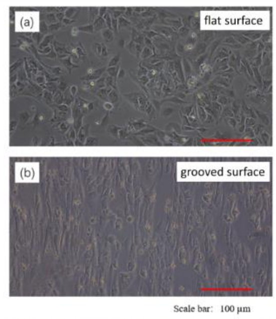


Fig. 4. Optical microscope images of cardiac cells culture, (a) cardiac cells grown on the flat surface and (b) cardiac cells grown on the micro-grooved surface.

MEASUREMENT RESULT

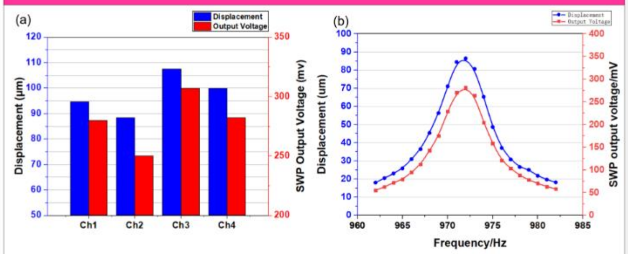


Fig. 5. Silicon cantilever displacement and SWP output voltage obtained from laser vibrometer and the integrated sensor at resonance frequency. Ch1 resonance frequency: 972Hz; Ch2 resonance frequency: 915Hz; Ch3 resonance frequency: 924Hz; Ch4 resonance frequency: 1014Hz; (b) Detect resonance frequency of Ch1 cantilever .

CONSLUSION

The fabricated silicon cantilever is shown in Fig 3. There are four cantilevers. This means that these cantilevers are made by the same conditions. This has an important impact on ensuring the reliability of subsequent controlled experiments. The PDMS thin layer was bonded with the cantilever after the oxygen plasma treatment as shown in Fig. 3c, and the structure of PDMS grooves is shown in Fig 3d. The dimensions of these micro-groove are 3 μm in groove width and space, and 1 μm in height. The culture of cardiomyocytes is shown in Fig. 4. On the left side, the cells grow on the flat PDMS, and the cell growth direction is random, while the right cells grow in a specific direction under the influence of the microgrooves. The experimental data is shown in Fig 5, the resonance frequency of each cantilever is confirmed using the integrated sensor.

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ACKNOWLEDGMENT

This study was supported by the NRF of Korea (NRF) grant funded by the Korean government (No. 2017R1E1A1A01074550).