The 22nd Korean MEMS Conference

제22회 한국 MEMS 학술대회

2020.8.19(수) ~ 8.21(금) | 휘닉스 평창 |

Plenary & Invited Speakers

Plenary talk

8.20(목) 10:00~10:50(50") _ 삼성 전자 주혁 상무

Invited talk

8.20(목) 09:15~09:45(30") _ 광운대 박재영 교수

8.20(목) 13:30~14:00(30") _ 서울대학교 김호영 교수

8.21(금) 13:30~14:00(30") _ 울산과학기술원 고현협 교수

Tutorial Session

Smart Wearables for The 4th Industrial Revolution

Organizer: 박재영교수 (광운대), 전자MEMS 분과위원회

- 최정일교수 (국민대) Microfluidic Wearables 50분 강연
- 정재웅교수 (KAIST) Bio Wearables 50분 강연
- 김정현교수 (광운대) Wireless Wearables 50분 강연

Conference Topics

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

Pre-registration

★ 온라인 사전등록 기간 : ~2020년 8월 10일(월)

★ 등록처 : 학회 홈페이지 : micronanos.org

Program

8.19 (수요일)

13:30~17:00	등록
14:00~16:50(170")	Tutorial Session (Smart Wearables for the 4th Industrial Revolution)
16:50~17:30(40")	휴식
17:30~19:00(90")	리셉션

8.20 (목요일)

08:00~09:00(60")	구두 발표 TO-1 Physical and Mechanical Micro/Nano Sensors
09:00~09:15(15")	휴식
09:15~09:45(30")	학술상 초청강연1 (Invited talk 1) 광운대 박재영 교수
09:45~10:00(15")	개회식
10:00~10:50(50")	기조강연 (Plenary talk) 삼성전자 주혁 상무
10:50~12:00(70")	포스터 발표 TP-1
12:00~13:30(90")	후원기관 소개 및 점심
13:30~14:00(30")	초청강연 2 (Invited talk 2) 서울대 김호영 교수
14:00~15:00(60")	구두 발표 TO-2 Nature-Inspired Microsystems
15:00~15:20(20")	휴식
15:20~16:20(60")	구두 발표 TO-3 Physics and Chemistry of Micro/Nanofluidics
16:20~17:30(70")	포스터 발표 TP-2
17:30~19:30(120")	만찬

8.21 (금요일)

08:00~09:00(60")	구두발표 FO-4 Bio/Medical Micro/Nano Devices
09:00~10:10(70")	포스터 발표 FP-3
10:10~11:10(60")	구두발표 FO-5 Lab-on-a-Chip
11:10~12:20(70")	포스터 발표 FP-4
12:20~13:30(70")	후원기관 소개 및 점심
13:30~14:00(30")	초청강연 3 (Invited talk 3) UNIST 고현협 교수
14:00~15:00(60")	구두 발표 FO-6 Fabrication, and Packaging Technologies
15:00~15:20(20")	우수논문 시상 및 폐회

주최: (사)마이크로나노시스템학회 (E-mail : master@micronanos.org, 전화 : 02-749-6482)

논문 No.	Journal Title	First Author	Corresponding Author	Presenting Author	Organization
FP-3-09	An Electrolysis Micro Pump Created for Ocular Treatment	동조위	박우태	동조위	서울과학기술대학교
FP-3-10	신축성과 유연성을 갖는 마이크로니들 기반 연속혈당 모니터링 패치센서	김현식	박재영	김현식	광운대학교
FP-3-11	Strain sensor integrated with polymer cantilever: new device system for characterization of cardiac muscle cell	노민	이동원	노민	전남대학교
FP-3-12	Cardiac Troponin I (cTnI) Sensor Study with reusable Extended Gate Field Effect Transistor (EGFET)	김강현	이정훈	김강현	광운대학교
FP-3-13	Development of Pt Strain Gauge for Application to Smart Catheter for Simultaneous Diagnosis and Treatment of Blood Vessel Disease	김윤호	김용대	김윤호	경일대학교
FP-3-14	Rollable strain sensor	이건희	강대식	안기현	아주대학교
FP-3-15	망막하 자극을 위한 고해상도 3차원 전극	서희원	김소희	서희원	대구경북과학기술원
FP-3-16	Fabrication of pH-responsive Microneedles with Porous Polymer Coatings	Asad Ullah	김규만	Asad Ullah	경북대학교
FP-3-17	유체 주입에 의해 형상이 제어되는선택적 접착 기술 기반의 3차원 구조물 제작	문현민	김소희	문현민	대구경북과학기술원
FP-3-18	Development of electrochemical immunosensor for detection of PHB 2 protein as blood cancer marker	윤영란	양성	윤영란	광주과학기술원
FP-3-19	표면발현 기술 기반의 재생가능한 분자인지막	강동혁	박민	강동혁	한림대학교
FP-3-20	휴대형 유체 요소 바이오센서	김지영	박민	김지영	한림대학교
FP-3-21	Development of electrochemical immune sensor for apolipoprotein a1 as a potential bladder cancer biomarker in urine	김영주	성우경	김영주	전자부품연구원
FP-3-22	Tau transfer enhancement in neuron on a chip stimulated by KCl and nocodazole	박재영	이수현	박재영	한국과학기술연구원
FP-3-23	IMPLEMENTATION OF MICROFLUIDIC CHANNEL ON A HIGHLY SENSITIVE BEAD-BASED ELECTROCHEMICAL IMPEDENCE SPECTROSOCPY (BEIS) BIOSENSOR WITH FIELD FOCOUSING MICROWELLS FOR THE DETECTION OF ALZHEIMER'S DISEASE	쇼우미로이	강지윤	쇼우미로이	한국과학기술연구원
FP-3-24	왁스 인쇄된 종이-디스크 원심광학기기에서 다중 물질 검출	김세진	김상효	김상효	가천대학교
FP-3-25	외력에 의한 미세유체소자 내 생체 외 3차원 교세포 흉터 형성	방석영	김홍남	방석영	한국과학기술연구원
FP-3-26	Detecting tau proteins in 3D in vitro traumatic brain injury model using nano-gap electrochemical impedance sensor.	강준호	이수현	강준호	한국과학기술연구원
FP-3-27	CNT-PDMS 커프형 인장센서 기반 실시간 혈류 모니터링	류채현	김회준	류채현	대구경북과학기술원
FP-3-28	Au hierarchical nanostructure deposition on microelectrode for improved neural signal recording	우현수	임근배	우현수	포항공과대학교
FP-3-29	Drug treatment and embolization of cancer-associated blood vessel on a microchip with transformable liquid metal particles	김다솜	김홍남	김다솜	한국과학기술연구원
FP-3-30	Development of multichannel cartridges for multi-detectable lateral flow diagnosis kits integrated with a whole blood treatment module.	최요한	최요한	최요한	한국전자통신연구원
FP-3-31	말초신경 재생을 돕기 위한 공극률을 높인 시브형 신경 전극	최원석	김진석	최원석	한국과학기술연구원
FP-3-32	Enhanced lateral flow assay sensitivity with paper-based ion concentration polarization preconcentrating devices	김천중	이정훈	김천중	광운대학교
FP-3-33	The Effect of Enzyme—Electrode Interfaces of Electrochemical Cholesterol Sensor on its Performance	이민교	이수현	이민교	한국과학기술연구원
FP-3-34	Miniaturized Urine Odor Analysis Platform for Diagnosis of Bladder Cancer	이장현	임시형	이영석	국민대학교
FP-3-35	Pillar Strip for myogenic differentiation toxicity study	안경환	이동우	안경환	건양대학교

Strain sensor integrated with polymer cantilever: new device system for characterization of cardiac muscle cell

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Abstract

Herein, we developed a biosensor based on photosensitive polymer cantilever to characterize cardiomyocytes (CMs) characteristics. The complex cantilever can sense both of mechanical and electrical properties of cardiac primary muscle cell. The cantilever device consists of couple parallel microelectrode, biomimetic micro pattern and thin metal strain sensor. All functional sub parts are unique benefit for measuring electrical and mechanical behavior of cardiac cell. The parallel micro electrode and biomimetic micro patterns are used for synchronize beating of individual cell and aligning cell like a real tissue respectively. Both of electrical stimulation and micro groove patterns are greatly enhance the contraction force of cardiomyocytes which is resulted in enhancing the sensitivity of the sensor. Also the cantilever system is much more effective for sensing the behaviour of cardiac cell.

Keywords: Polymer cantilever, Strain sensor, Electrical stimulation, Cardiomyocyte

1. Introduction

Cell growing, or generation of contractile force, is a key component for both development and general cardiac function. Especially, cardiac muscle cell growing activity and beating frequency could indicate that cell basic characteristic. Over the years several research have been devoted to develop the various sensor and cell culturing platform to deeply understand biological and mechanical properties of the cardiomyocytes [1].

In other case, cardiac toxicity is also urgent problem in world wide. To detect the influence of drug toxicity, researchers are focused on a functional groove patterned surface cantilever devices [2]. However, the functionalized cantilever system only provides an information of mechanical properties of the cardiomyocytes but not an electrical. The carbon electrode is mainly utilized for the electrical stimulation to synchronizing beating frequency of the cardiomyocytes, however this method is invasive and lacks of spatial resolution. Novel smart sensor still desirable, that could be sensing simultaneously both of electromechanical properties of the cardiomyocytes. Strain sensor materials could create a coupling link between mechanical and electric domains.

In this study we have developed polymer cantilever, which can sense mechanical as well as electrical properties simultaneously. Polymer cantilever system provides several key advances in screening technology, including the ability to measure contraction force as a function of time and intracellular architecture.

2. Material and methods

2.1 Design and fabrication of culture constructs

The cantilever was designed to be compatible with well-established 3D cell culturing technique, such as biomimetic micro patterned surface for supporting directional grooving [3].

The Fig. 1 shows the schematic view of the fabricated cantilever system. The couple electrode array and metal strain sensors are designed to produce an electric field and sensor response signal during cantilever displacement. The 3D functional groove surface is used not only directional growing of cardiac cell but also to enhance the contraction force of the cardiomyocytes.

2.2. Measurement system

Displacement of the cantilever is monitored at free end of the cantilever through the laser sensing device. The cantilevers displacement occurring as a result of contraction and relaxation of the cardiomyocytes are measured through the change in resistance (R) of the strain sensor. The change in sensor resistance is determined through the current-voltage (I vs V) characteristics of the strain sensor (KEITHLEY source-meter- 2410).

3. Result

Fig. 2 shows the optical images of the fabricated strain sensor-integrated with polymer cantilever. Fig. 2a shows the top view of the strain sensor-integrated polymer cantilever with grooves, and Fig. 2b shows the side view of the fixed polymer cantilever. The Fig. 2c shown cantilever in the working solution (medium).

In this proposed work, the strain sensor-integrated polymer cantilever designed to show the large response of strain sensor even with the small contraction force of cardiomyocytes. The length, width, and thickness of the cantilever are kept at 6000 µm × 2,000 µm × 14 µm respectively. The calculated spring constant of the strain sensor-integrated polymer cantilever is found to be ~0.012 N/m. The aspect ratio of the cantilever is set 3:1.

After culturing neonatal rat ventricular myocyte (NRVM) on the cantilever surface, the electrical stimulation using square monophasic pulses was applied from day 4, (Fig. 3a). As seen from Fig. 3b, the cantilever displacement increased when we applied 0.5 Hz. To optimize appropriate frequency, range of electrical stimulation, various stimulation voltages, frequencies and pulse durations were tested. As observed from Fig. 3c-f the displacement of the cantilever decreases with increasing the frequency ranged from 0.5 Hz to 2 Hz. When the applied frequency increased above 2 Hz, the cantilever unable to restore its initial position. In this regard, the frequency of 0.5 Hz was selected for the electrical stimulation. The optimal parameters for the electrical stimulation were determined as electric field of 1.66 V/mm, frequency of 0.5 Hz and duration time of 2 ms.

Under these conditions, the stable electrical stimulation inside the cell culture medium could be obtained. The working solution has been changed every 3 days to avoid any contamination. During the electrical stimulation, we simultaneously measure the displacement of the cantilever using a laser vibrometer. Through the measured displacement, the contraction force of CMs cultivated on the cantilever could be evaluated. The used measurement system also included the function generator to modulate the amplitude and frequency of the input signal and electrical circuit to capture the output signal from the device.

As shown in Fig. 4 the displacement of the cantilever increases (up to day 10) as a function of culture time. The maximum displacement of cantilever observed at day 10. The real-time measurement of resistance changes strain sensor is performed with beating cardiac cell. Fig. 4b shows sensor response (ΔR) and beating frequency of cantilever displacement. The mechanical deformations of the polymer cantilever increases until day 10 and then decreases. The maximum bending and the corresponding sensor response of the patterned polymer cantilever on day 10 is measured to be 0.109 ± 01.689 Ω and its displacement is 40 ± 0.8 μm.

Acknowledgments

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References

1. W.L. Stoppel, D.C. Kaplan and L.D. Black, Electrical and mechanical stimulation of cardiac cells and tissue constructs, *Adv. Drug Deliv Rev.* 96 (Jan 2016).
2. J.Y. Kim, N.E Oyunbaata, and D.W. Lee, Fully automated high-throughput cardiac toxicity screening platform using interlocking -structured 192 SU-8 cantilever arrays, *Sens. Actuators B Chem*. 285 (April. 2017)
3. N.E. Oyunbaatar, A. Shanmugasundaram, Y.J. Jeong, B.K. Lee, E.S. Kim and D.W. Lee, Micro-patterned SU-8 cantilever integrated with metal electrode for enhanced electromechanical stimulation of cardiac cells, *Colloids Surf B Biointerfaces*, 186 (Nov. 2019)

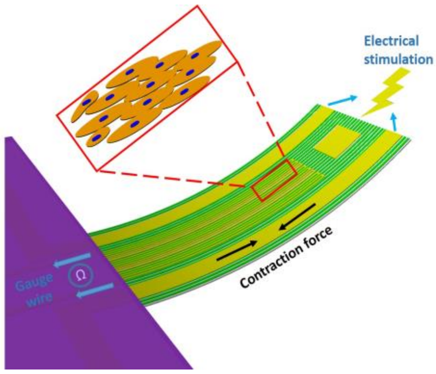

Fig. 1. Cantilever system based on photo sensitive biocompatible polymer.

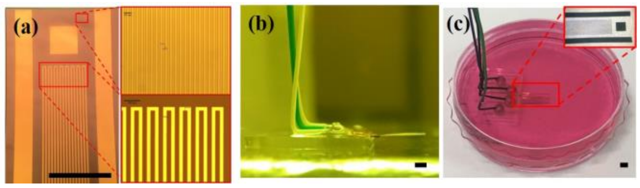

Fig. 2. (a) Optical images of fabrication of s strain sensor including 3D surface modification, (b) side view of fixed cantilever, (c) cantilever in working solution (scale bar 1μm).

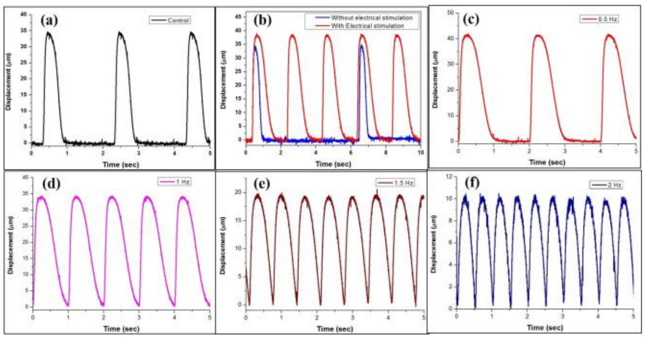

Fig. 3. Cantilever bending displacement depending on frequency changes of electrical stimulation (a) control, before electrical stimulation, (b) cantilever displacement increases after electrical stimulation with 0.5 Hz frequency, from (c) to (f) optimization of electrical stimulation frequency changes from 0.5 Hz to 2 Hz respectively.

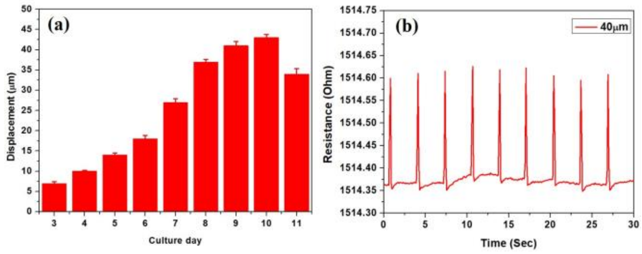

Fig. 4. Cantilever displacement changes depending on culture time, (b) real-time measurement of beating cardiac cell using the strain sensor integrated with cantilever system.