Semiconductor and Nano Application Lab.

Surface Bio – Fouling / Non-fouling control

Department of Physics
Sungkyunkwan University

Homepage: http://snal.co.kr

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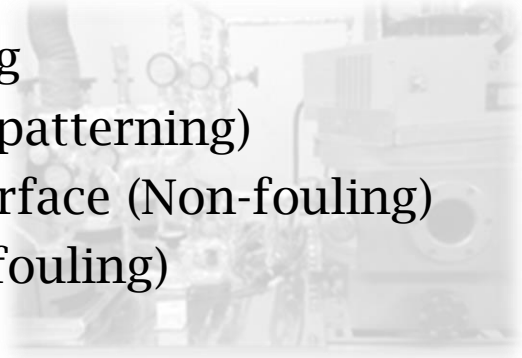
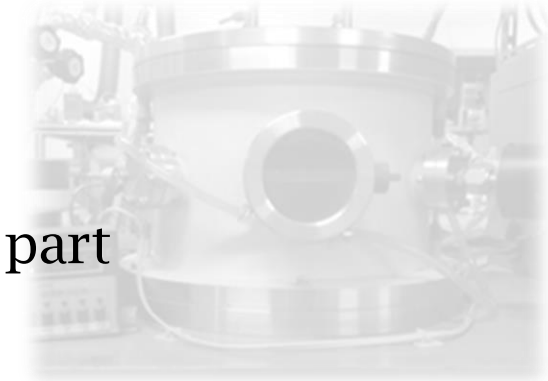




Members/Alumni

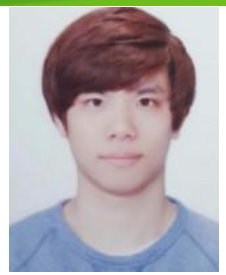
Members

Prof. Donggeun Jung

Ph. D. Candidate
Jungyoung Jang

Ph. D. candidate
Namwuk Baek

Ph. D. student
Chanyong Seo



Master's course
Gihun Park

Ph.D. student
Changsoo Lee

Ph. D. student
Hyewon Han

Master's course
Kyubeom Bae

Master's course
Jeongbeom Choi

Alumni

UNIVERCITY

東京大学 THE UNIVERSITY OF TOKYO, UNIVERSITY OF LOUISIANA Lafayette, GIST, SUNG KYUN KWAN UNIVERSITY (2 people), POSTECH POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY, KOREA UNIVERSITY, UST

SEMICONDUCTOR COMAPNY

SAMSUNG (20 people), LG (12 people), SK hynix (3 people), Hanwha, Woongjin, KOLON, ORION

Lam RESEARCH (4 people), APPLIED MATERIALS, ASM (5 people), JUSUNG ENGINEERING, WONIK IPS (3 people), TES (3 people), DB HiTek (2 people), ON Semiconductor, ICD, D&C

NATIONAL ORGANIGATIONS

NFRI 국가핵융합연구소 National Fusion Research Institute, KITECH 한국생산기술연구원, KETI, 전자부품연구원 Korea Electronics Technology Institute (2 people), KRISS 한국표준과학연구원 Korea Research Institute of Standards and Science, 기상청 Korea Meteorological Administration

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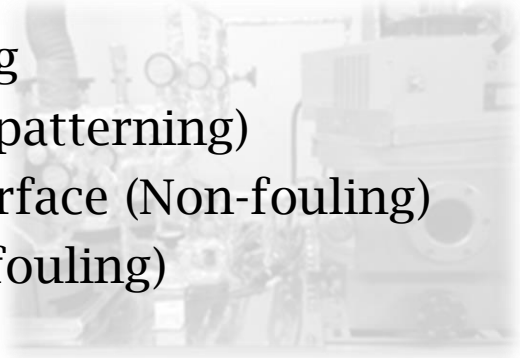
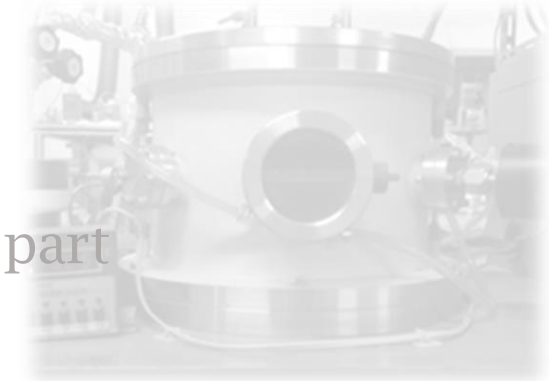
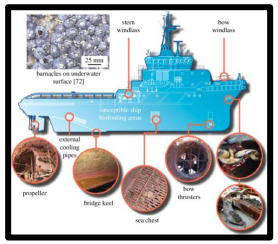
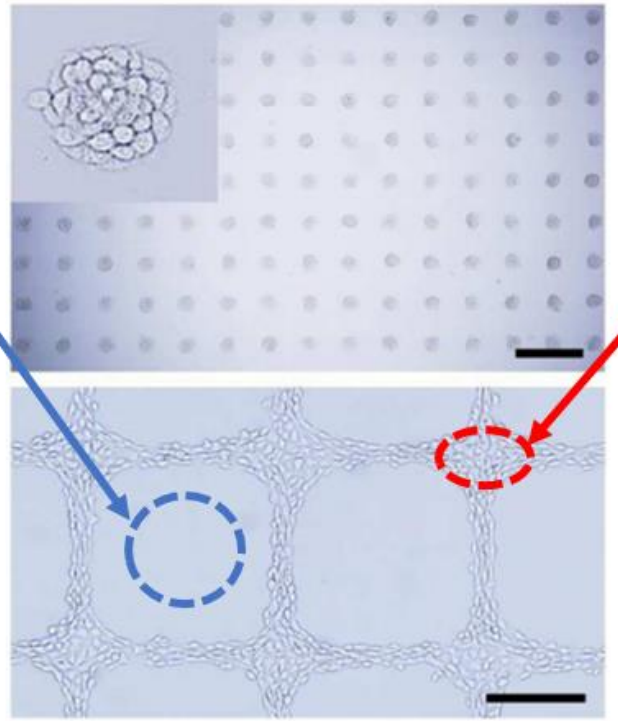




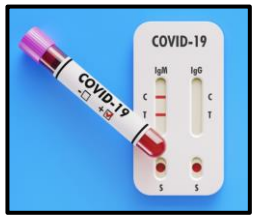
What is the Bio Fouling / Non-fouling ??



Bio Non-fouling coating



Bio Fouling coating



◆ Bio Non-fouling (hydrophobic)

- ➢ 표면처리를 통한 이물질 부착 방지
- ➢ 응용분야
  - ✓ 의료용품 살균 코팅
  - ✓ 선박 따개비등 부착 방지 코팅
  - ✓ 기뢰, 부표 유리창 투명성 유지 코팅

(장기간 혈액, 바닷물 등에 노출에도 이물질 부착방지가 필요한 표면)

◆ Bio Fouling (hydrophilic)

- ➢ 표면처리를 통한 이물질 부착력 향상
- ➢ 응용분야
  - ✓ 세포 거동연구 (암세포, 줄기세포...)
  - ✓ 전염병 진단 검사기 (민감도향상)

(원하는 목표 물질 부착력 향상이 필요한 표면)

그림 1 (위). Bio Fouling / Non-fouling patterning

+ Bio Non-fouling - - Bio Fouling +

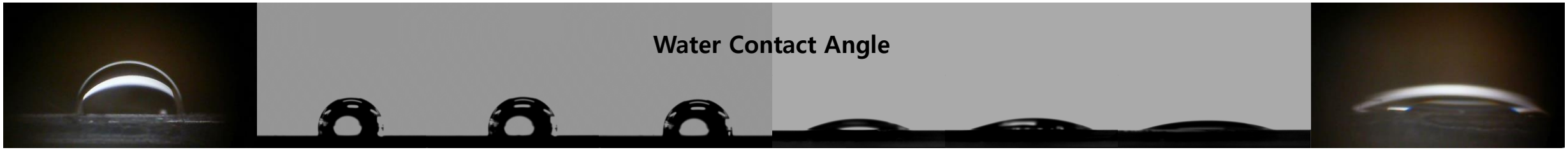
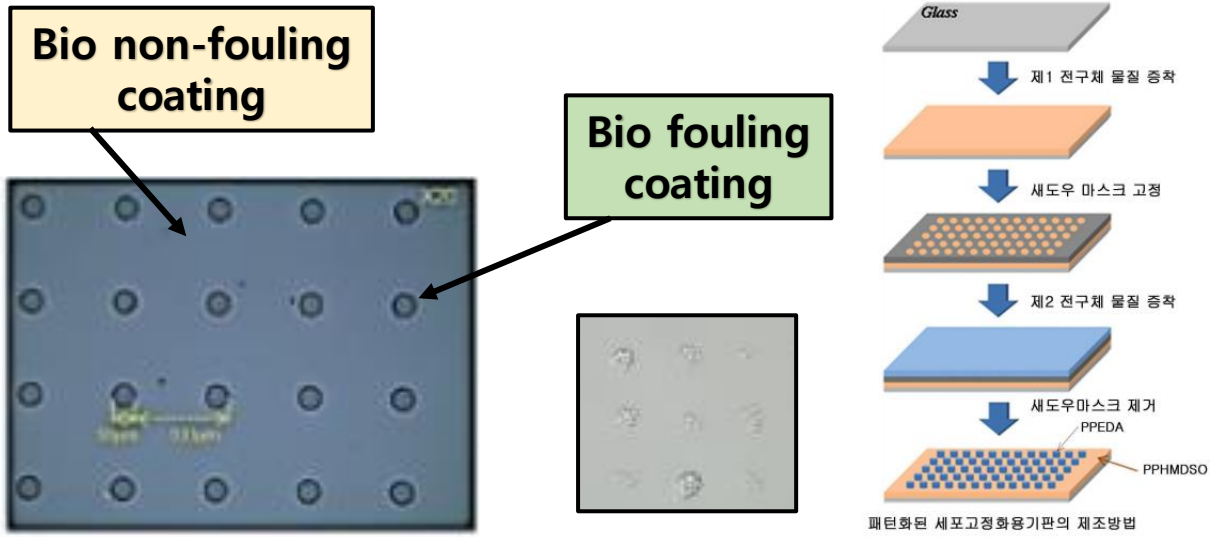


그림 2 (위). Bio Fouling / Non-fouling 코팅 종류별 Water contact angle

Research : Bio chip (Fouling / Non-fouling)

Surface Bio-(non)fouling patterning control



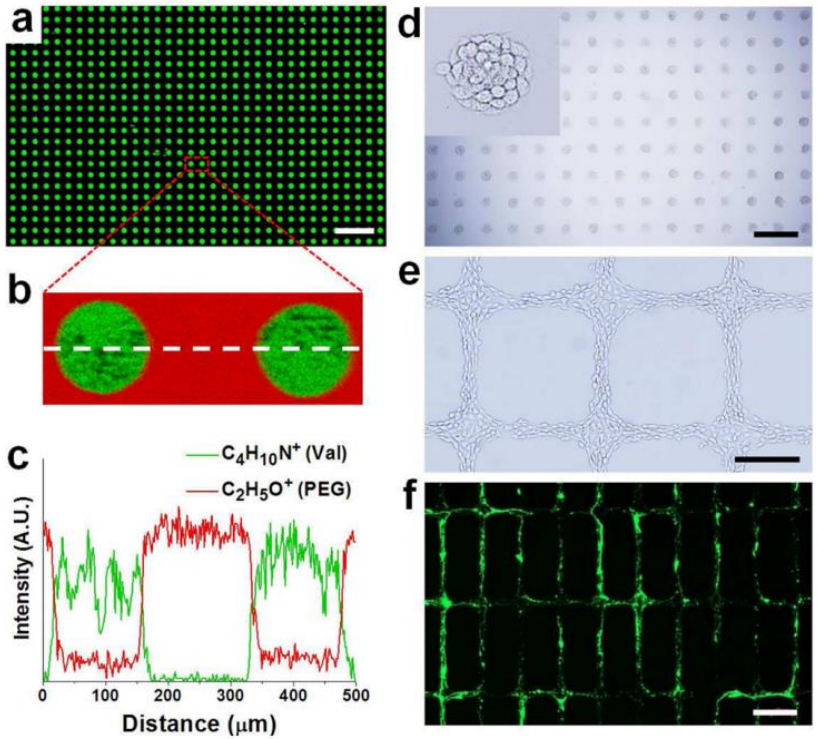
특허청

Bio fouling / non-fouling surface control 관련 특허

대한민국, 미국, 일본, 중국 4개국 외
PCT 포함 관련특허 12개 보유 (등록기준)

(+출원 중 특허 국내1건, 미국1건)

Bio patterning chip application

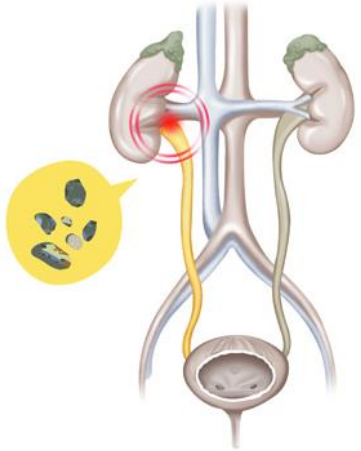


Cell culture and protein adsorption demonstrate the uniformity of CCP-CVD of PP-PEG and PP-amine

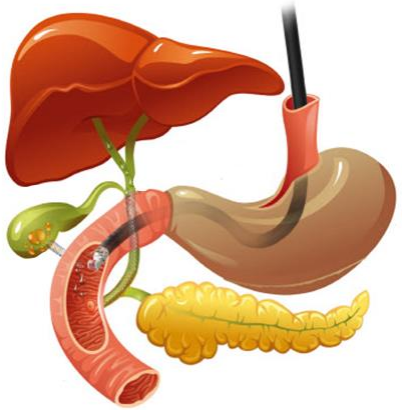
A newly fabricated plasma-polymerized poly(ethylene glycol) (PP-PEG) film shows extremely low toxicity, low fouling, good durability, and chemical similarity to typical PEG polymers, enabling live cell patterning as well as various bioapplications using bioincompatible materials.

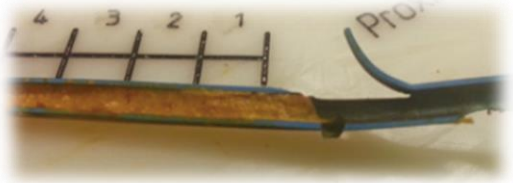
Research : Thin tube (medical stent) inner surface (Non-fouling)

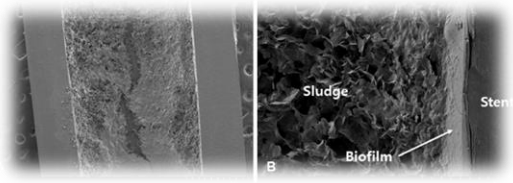
Encrustation in Human body



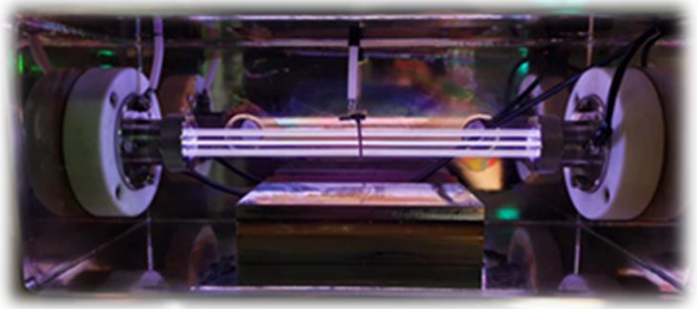
Encrustation in Stent inner surface



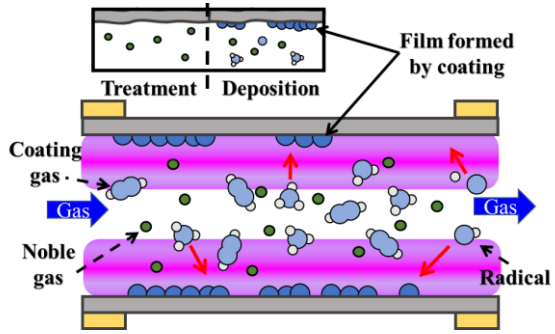




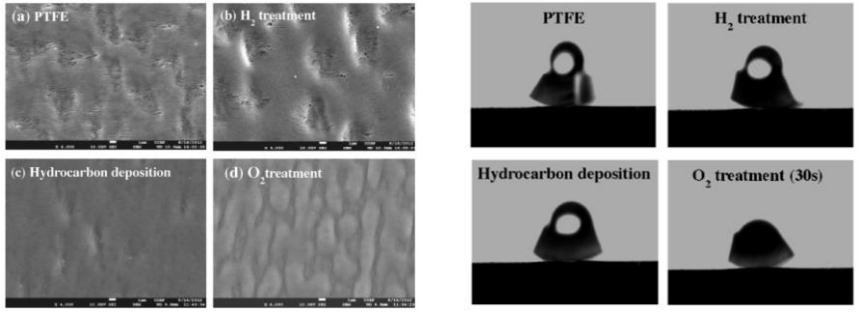
Bio active surface modification on inner wall of tube



Specialized plasma enhanced chemical vapor deposition system



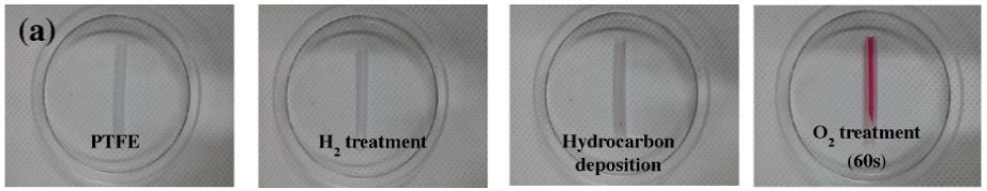
Plasma surface modification by dielectric barrier discharge(DBD)



SEM surface morphologies and Water contact angle of various treatment conditions

Research : Thin tube (medical stent) inner surface (Non-fouling)

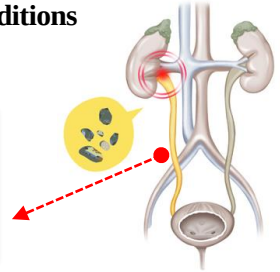
Bio fouling coating

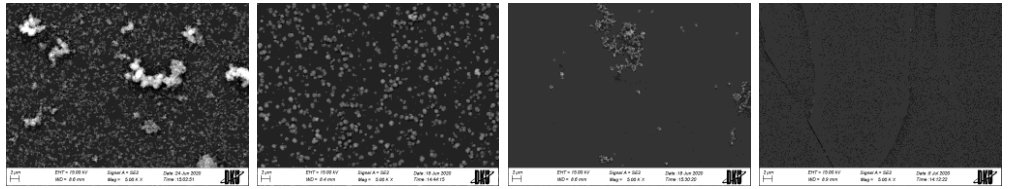


\- Surface reactivity +

Smooth muscle cell(SMC) attachment of various treatment conditions

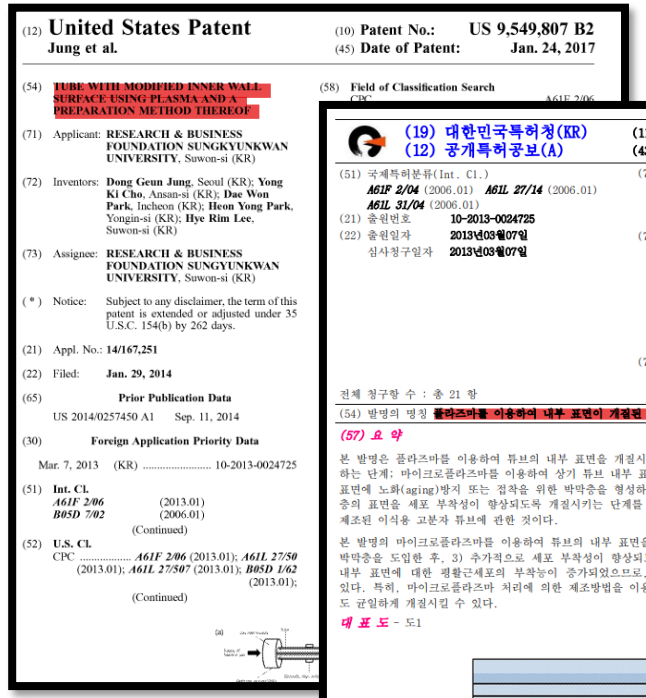
Bio non-fouling coating





\+ Surface reactivity -

Urine immersion test for urolithiasis patients SEM image



(12) **United States Patent**
Jung et al.

(10) Patent No.: US 9,549,807 B2
(45) Date of Patent: Jan. 24, 2017

(54) TUBE WITH MODIFIED INNER WALL SURFACE USING PLASMA AND A PREPARATION METHOD THEREOF

(71) Applicant: RESEARCH & BUSINESS FOUNDATION SUNGKYUNKWAN UNIVERSITY, Suwon-si (KR)

(72) Inventors: Dong Geun Jung, Seoul (KR); Yong Ki Cho, Ansan-si (KR); Dae Won Park, Incheon (KR); Heon Yong Park, Yongin-si (KR); Hye Rim Lee, Suwon-si (KR)

(73) Assignee: RESEARCH & BUSINESS FOUNDATION SUNGYUNKWAN UNIVERSITY, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 262 days.

(21) Appl. No.: 14/167,251

(22) Filed: Jan. 29, 2014

(65) Prior Publication Data
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(30) Foreign Application Priority Data
Mar. 7, 2013 (KR) 10-2013-0024725

(51) Int. Cl.
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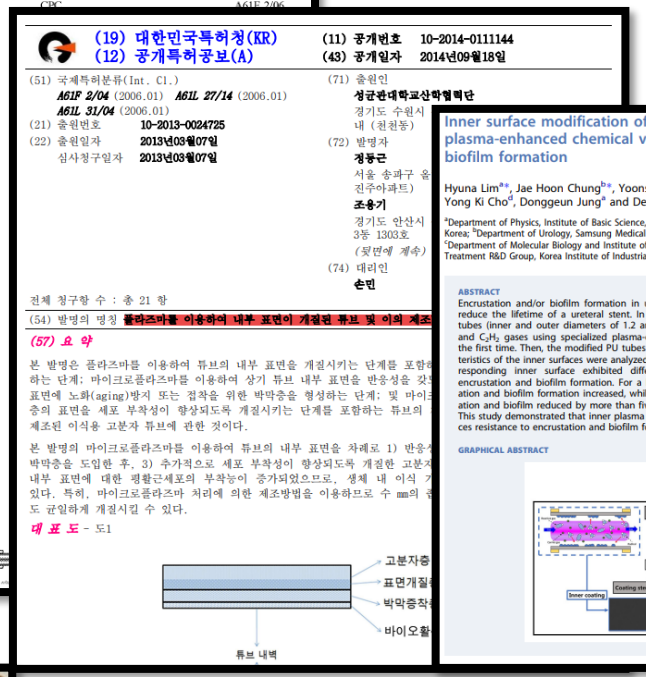
B05D 7/02 (2006.01)
(Continued)

(52) U.S. Cl.
CPC *A61F 2/06* (2013.01); *A61L 27/50* (2013.01); *A61L 27/507* (2013.01); *B05D 1/62* (2013.01);
(Continued)

(58) Field of Classification Search
CPC A61F 2/06



(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

(11) 공개번호 10-2014-0111144
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(51) 국제특허분류(Int. Cl.)
A61F 2/04 (2006.01) *A61L 27/14* (2006.01)
A61L 31/04 (2006.01)
(21) 출원번호 10-2013-0024725
(22) 출원일자 2013년03월07일
심사청구일자 2013년03월07일

(71) 출원인
성균관대학교산학협력단
경기도 수원시
내 (천천동)

(72) 발명자
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진주아파트)
조용기
경기도 안산시
3동 1303호
(뒷면에 계속)

(74) 대리인
손민

전체 청구항 수 : 총 21 항

(54) 발명의 명칭 플라즈마를 이용하여 내부 표면이 개질된 튜브 및 이의 제조

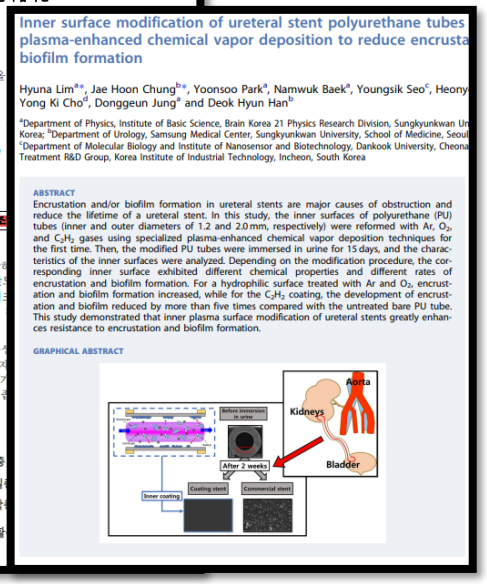
(57) 요 약

본 발명은 플라즈마를 이용하여 튜브의 내부 표면을 개질시키는 단계를 포함하는 단계; 마이크로플라즈마를 이용하여 상기 튜브 내부 표면을 반응성을 갖는 표면에 노화(aging)방지 또는 접착을 위한 박막층을 형성하는 단계; 및 마이크로층의 표면을 세포 부착성이 향상되도록 개질시키는 단계를 포함하는 튜브의 제조된 이식용 고분자 튜브에 관한 것이다.

본 발명의 마이크로플라즈마를 이용하여 튜브의 내부 표면을 차례로 1) 반응성 박막층을 도입한 후, 3) 추가적으로 세포 부착성이 향상되도록 개질한 고분자 내부 표면에 대한 평활근세포의 부착능이 증가되었으므로, 생체 내 이식 가능하다. 특히, 마이크로플라즈마 처리에 의한 제조방법을 이용하므로 수 mm의 도 균일하게 개질시킬 수 있다.

대 표 도 - 도1

고분자층
표면개질
박막층착
바이오활
튜브 내벽



Inner surface modification of ureteral stent polyurethane tubes plasma-enhanced chemical vapor deposition to reduce encrusta biofilm formation

Hyuna Lim[a*], Jae Hoon Chung[b*], Yoonsoo Park[a], Namwuk Baek[a], Youngsik Seo[c], Heony Yong Ki Cho[d], Donggeun Jung[a] and Deok Hyun Han[b]

[a]Department of Physics, Institute of Basic Science, Brain Korea 21 Physics Research Division, Sungkyunkwan Un Korea; [b]Department of Urology, Samsung Medical Center, Sungkyunkwan University, School of Medicine, Seoul [c]Department of Molecular Biology and Institute of Nanosensor and Biotechnology, Dankook University, Cheona Treatment R&D Group, Korea Institute of Industrial Technology, Incheon, South Korea

ABSTRACT

Encrustation and/or biofilm formation in ureteral stents are major causes of obstruction and reduce the lifetime of a ureteral stent. In this study, the inner surfaces of polyurethane (PU) tubes (inner and outer diameters of 1.2 and 2.0 mm, respectively) were reformed with Ar, O_2, and C_2H_2 gases using specialized plasma-enhanced chemical vapor deposition techniques for the first time. Then, the modified PU tubes were immersed in urine for 15 days, and the characteristics of the inner surfaces were analyzed. Depending on the modification procedure, the corresponding inner surface exhibited different chemical properties and different rates of encrustation and biofilm formation. For a hydrophilic surface treated with Ar and O_2, encrustation and biofilm formation increased, while for the C_2H_2 coating, the development of encrustation and biofilm reduced by more than five times compared with the untreated bare PU tube. This study demonstrated that inner plasma surface modification of ureteral stents greatly enhances resistance to encrustation and biofilm formation.

GRAPHICAL ABSTRACT

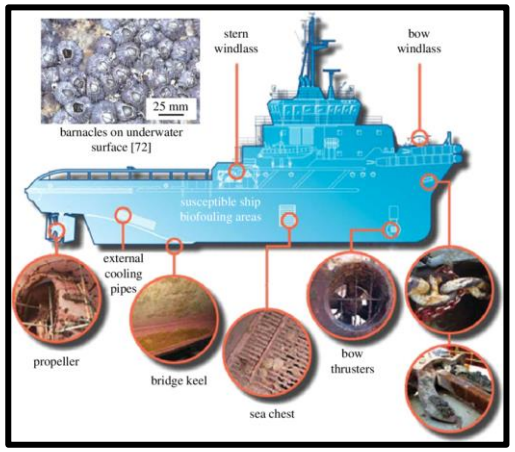
Aorta
Kidneys
Bladder
Before immersion in urine
After 2 weeks
Inner coating
Coating stent
Commercial stent

한미약품
한미학술상
국내부문 - Stone & Endourology

❖ 세계 최초 직경 1.6 mm 이하 튜브 내부 플라즈마 코팅
❖ 국내의료연구 학회 최우수연구상
❖ 국내 및 미국 특허 등록완료

Research : Marine ship & mine window (Non-fouling)

Bio non-fouling coating application with marine ship



Problems

- Decreased fuel economy
- periodic maintenance
- Performance degradation
- Increased corrosion

바닷물 노출 전 부표

지속적인 바닷물 노출로 부식된 부표

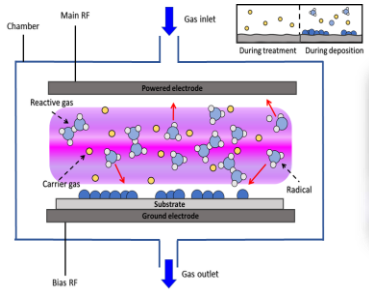
해상 기뢰

부식으로 인한 오작동 우려
동작 상태점검의 어려움

Conventional coating method

(Anti-fouling paint)

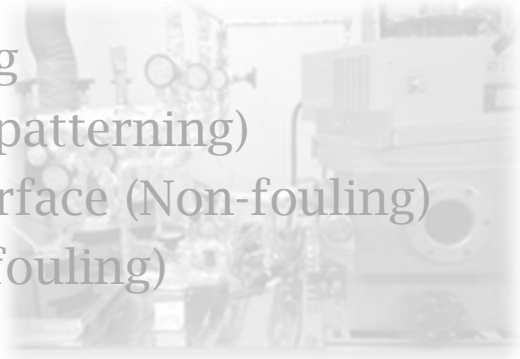
Plasma surface coating

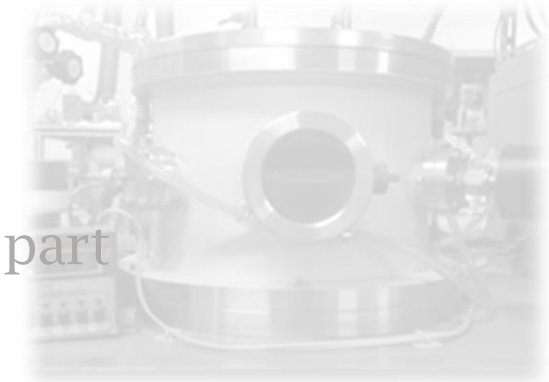


Conventional coating	Plasma coating
Low stability and durability	High stability and durability
Need for drying process	No drying process required
cause environmental pollution	Relatively Non-toxic
Substrate selection considering adhesion	Wide selection of substrates

❖ 기존 페인트에 쓰이던 원료(소재)
특성을 활용한 Plasma 코팅 가능

CONTENTS





Patent list

순번	국가	출원일자 등록일자	출원번호 등록번호	발명인	발명 명칭	
~~1~~	~~대한민국~~	~~2001.09.28~~ ~~2004.09.06~~	~~10-2001-0060556~~ ~~10-04488800000~~	~~정동근, 김진모, 박헌용~~	~~단백질칩 기판 및 플라즈마를 이용한 단백질칩 기판의 제조방법~~	소멸특허 (공개)
2	대한민국	2005.12.28	10-2005-0131921	정동근, 여상학, 최창록	플라즈마를 이용한 단백질칩 기판의 제조방법 및 이로부터 제조된 단백질칩 기판	
		2004.09.06	10-07709450000			
	미국	2005.12.28	11/616483			
		2010.08.31	US7785649			
	일본	2006.11.16	2006-353470			
		2010.06.11	4527711			
3	대한민국	2010.09.28	10-2010-7021614	정동근, 최창록, 여상학, 박헌용, 인경민	세포 고정화용 기판의 제조방법, 세포 고정화용 기판, 세포의 고정 방법 및 세포칩	
		2012.03.26	10-11323170000			
4	대한민국	2009.09.01	10-2009-0082152	정동근, 김경섭, 최창록	패턴화된 세포 배양용 기판의 제조방법, 패턴화된 세포 배양용 기판, 세포의 패턴화된 배양 방법 및 패턴화된 세포칩	
		2012.03.14	10-11290900000			
	미국	2010.08.31 (출)	12/872903			
		2015.02.27 (출)	US.201514634190.A			
		2017.02.28 (등)	US.9580681.B2			
5	대한민국	2013.03.08	10-2013-0025350	정동근, 하명훈, 박지수, 박헌용, 이혜림	패턴화된 세포 배양용 기판의 제조방법, 패턴화된 세포 배양용 기판 및 세포칩	
		2014.11.11	10-14627650000			
	~~미국~~	~~2014.02.19~~	~~US14/183961~~			
6	대한민국	2013.03.07	10-2013-0024725	정동근, 조용기, 박대원, 박헌용, 이혜림	플라즈마를 이용하여 내부표면이 개질된 튜브 및 이의 제조 방법	
		2015.01.12	10-14838460000			
	미국	2014.01.29	US14/167251		탄화수소류 튜브 / 플라즈마 처리를 통해 내부 표면 성질 바꿈 / 친수성, 소수성, 세포부착	
		2017.01.24	US09/549807			
7	대한민국	2013.10.15	10-2013-0122884	채희엽, 박민우,. 김훈배, 이채민, 정동근	유기전자소자용 폴리머/ 무기 다층 박막 봉지	
		2014.04.18	10-13891970000			
		2014.02.14	10-2014-0017311			
		2015.07.16	10-15388830000			
	미국	2014.01.08	14/149852			
		2015.11.24	9196849			

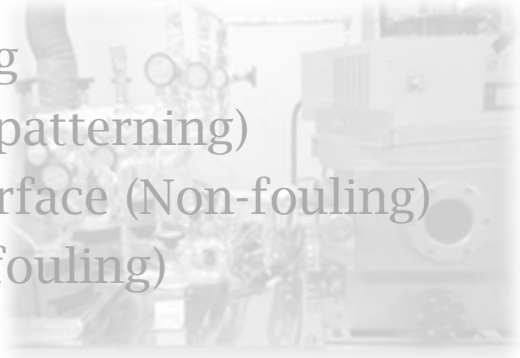
Patent list

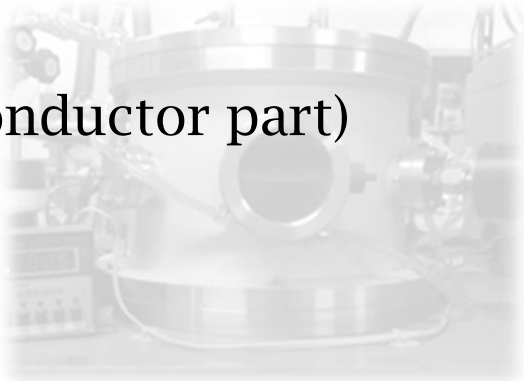
순번	국가	출원일자 등록일자	출원번호 등록번호	발명인	발명 명칭	
8	대한민국	~~2014.09.05~~	~~10-2014-0119310~~	정동근, 조용기, 반원진	유전체에 균일하게 플라즈마를 발생시키는 방법 (Method for generating plasma uniformly on dielectric material)	
		—	—			
	미국	2015.09.04	US14/846048			
		2019.01.22	10184181			
9	대한민국	2015.02.16	10-2015-0023297	정동근, 이재원, 권성률, 반원진	산소 및 수분 차단용 다층 박막	
		2017.08.21	10-17716010000			
10	대한민국	2015.11.12	10-2015-0159154	정동근, 반원진, 권성률	탄소, 산소 및 금속을 포함하는 금속 탄화 산화물 박막 및 그 제조 방법	
		2018.01.09	10-18186100000			
	PCT	2016.11.11	PCT/KR2016/013037			
		—	—			
11	대한민국	2017.06.22	10-2017-0079013	정동근, 반원진, 권성률, 임현아, 박윤수	줄기세포 배양용 기판의 제조 방법	
		2019.06.10	10-19894680000			
	미국	2018.06.19	16/012038			
		2021.09.28	11130941			
12	대한민국	2018.09.05	10-2018-0105839	정동근, 반원진, 권성률, 임현아, 박윤수, 김영현	저유전 플라즈마 중합체 박막 및 그 제조 방법 (Plasma polymerized thin film having low dielectric constant and preparing method thereof)	
		2020.07.21	10-21381020000			
	미국	—	16/549150			
		—	16/549150			
13	대한민국	2022.10.26	10-2022-0138864	정동근, 백남욱, 차지환, 장태순, 강신원, 박윤수, 임현아	구리 확산 방지를 위한 플라즈마 중합체 박막 및 이의 제조 방법	
14	대한민국	2022.11.07	10-2022-0147171	한덕현, 정재훈, 정동근, 박윤수, 임현아, 백남욱, 조용기	요관 삽입용 고분자 복합체, 이의 제조방법 및 이를 이용한 요관 삽입용 스텐트 (Polymer complex for inserting ureter, manufacturing methode therof, stent for inserting ureter using the same)	

Thank you!

Supplements

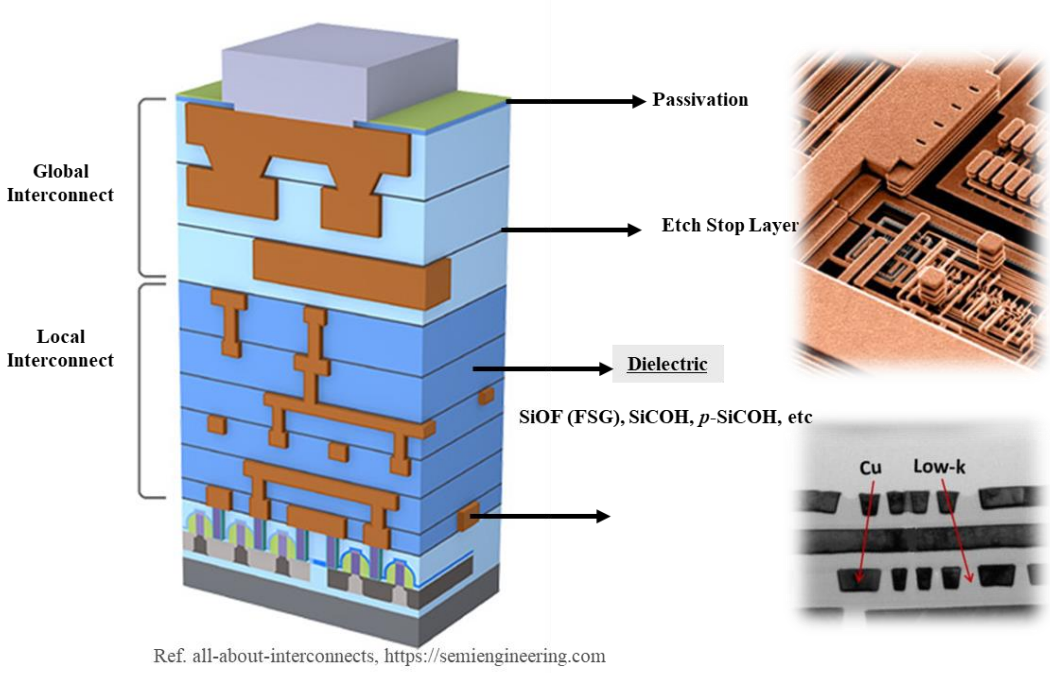
CONTENTS





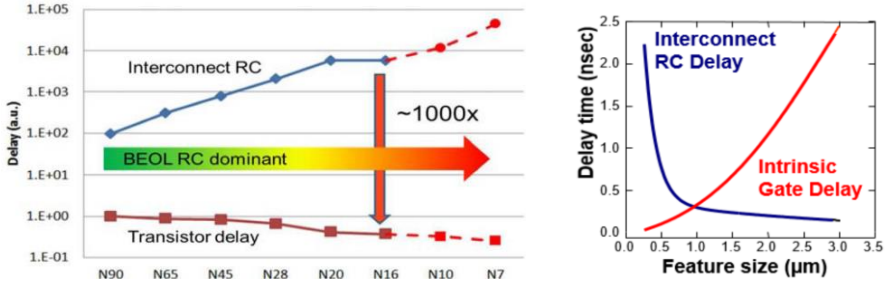
Semiconductor part: Multilevel metallization

Low dielectric constant material for multilayer interconnect in semiconductor chip



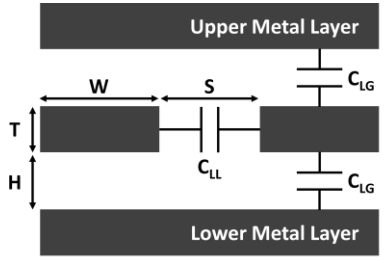
Ref. all-about-interconnects, https://semiengineering.com

<Typical chip cross section>



<Interconnect delay trend>

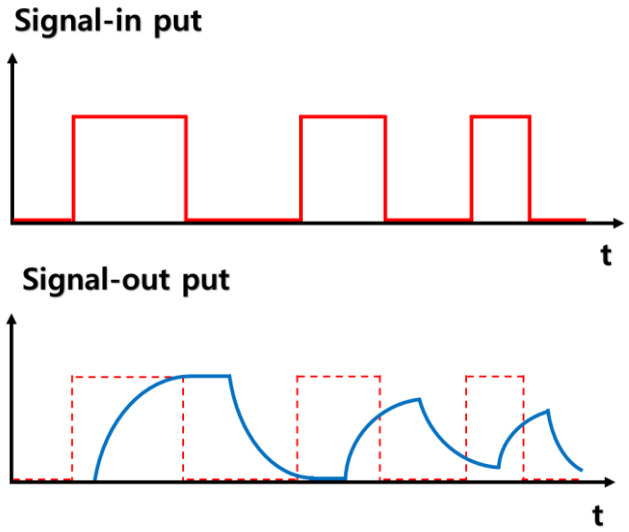
Signal distortion from RC-delay



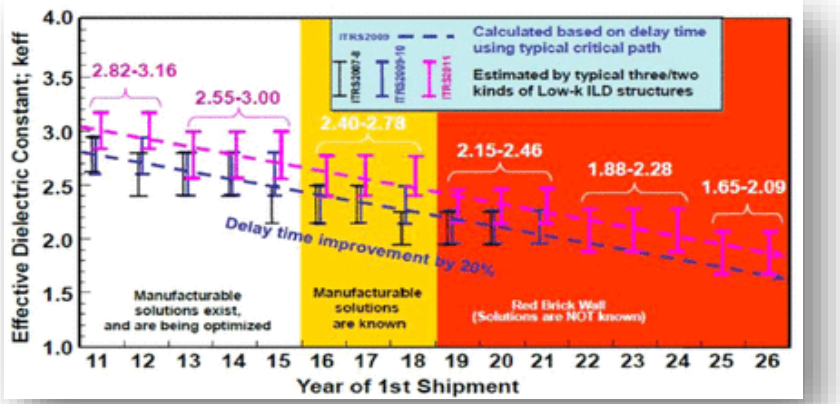
$$R = \frac{2\rho L}{WT}$$

$$C = 2(C_{LL} + CLG) = 2k\varepsilon_0\left(\frac{LT}{S} + \frac{LW}{H}\right)$$

$$\text{RC delay} = 2\rho k\varepsilon_0 L^2\left(\frac{1}{WS} + \frac{1}{TH}\right)$$

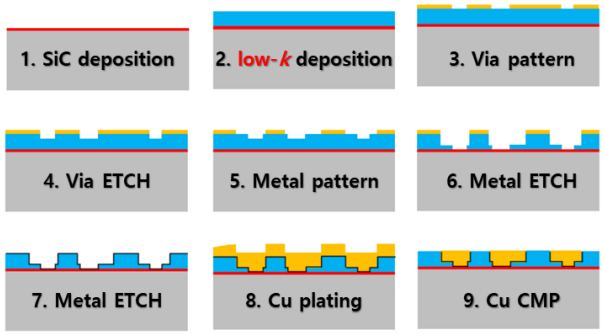


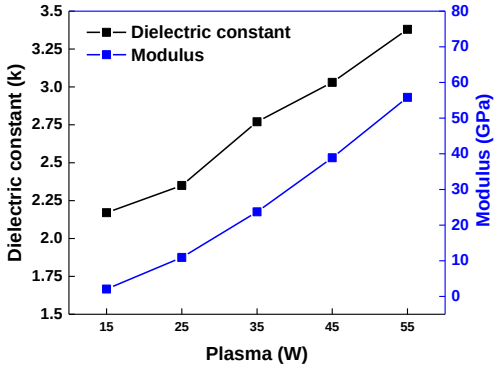
Trend of logic IC & Low-*k* roadmap progression



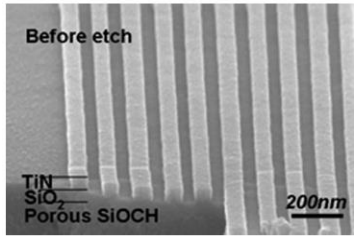
Semiconductor part: Multilevel metallization

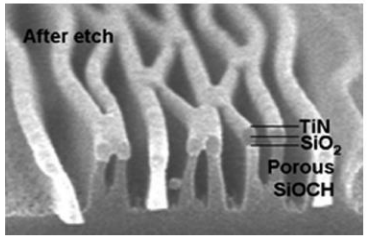
➢ Compatibility with Damascene process

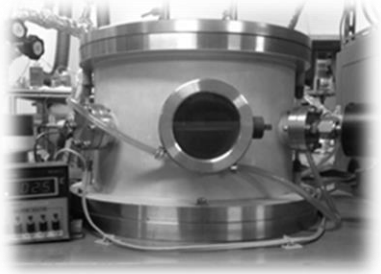


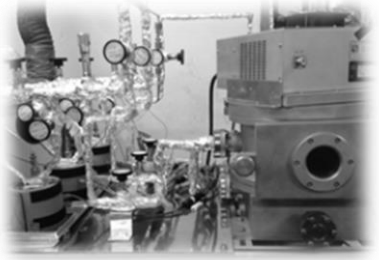


➢ Etching stability



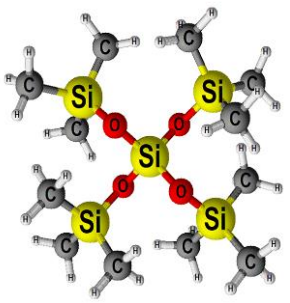


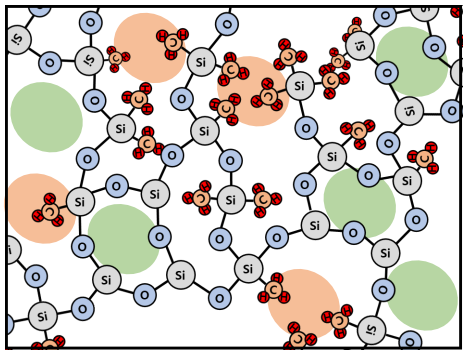


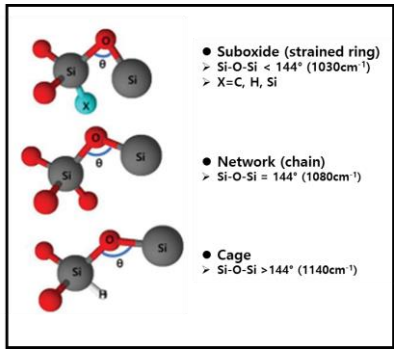


plasma enhanced chemical vapor deposition system (PECVD)

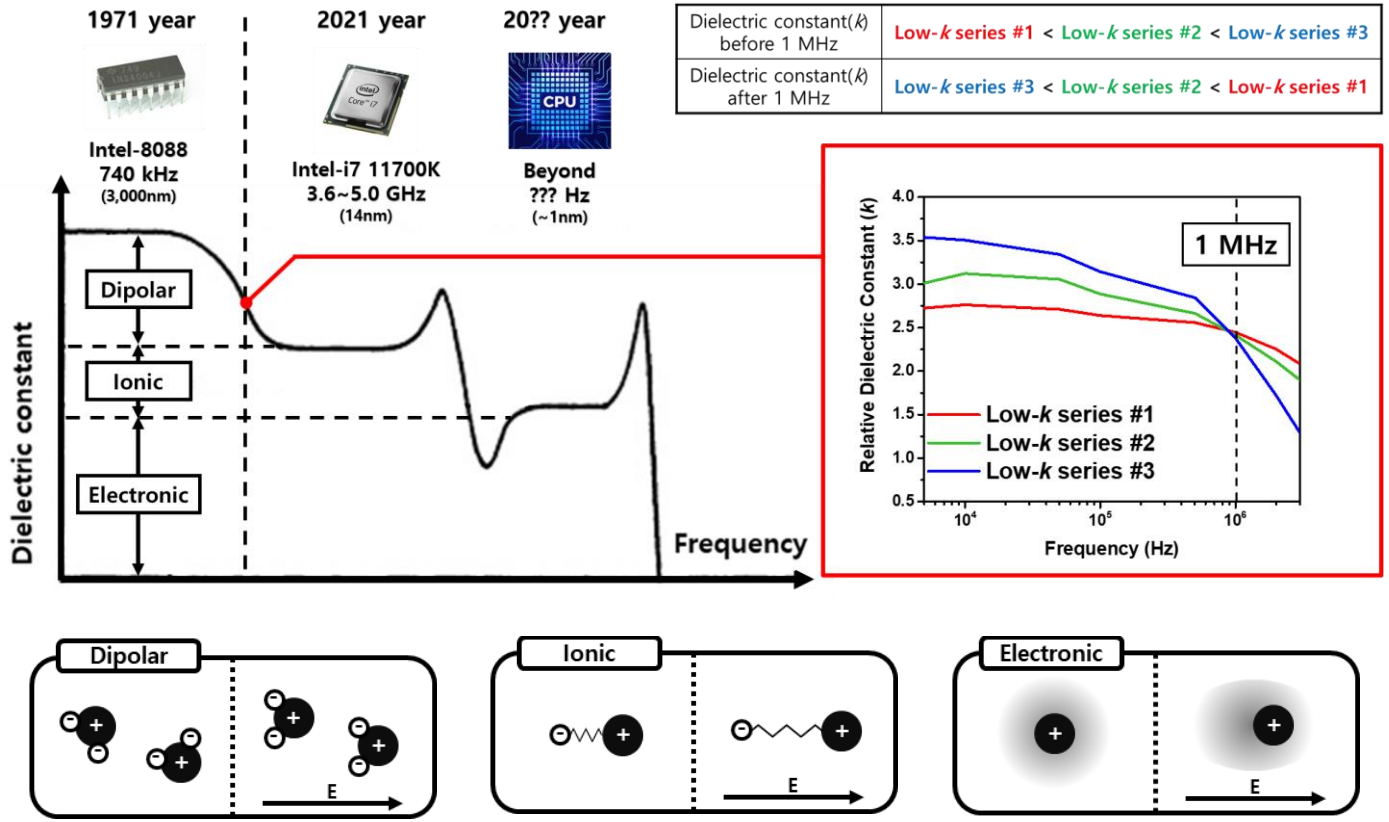
Inductively coupled plasma enhanced chemical vapor deposition system (ICP-PECVD)





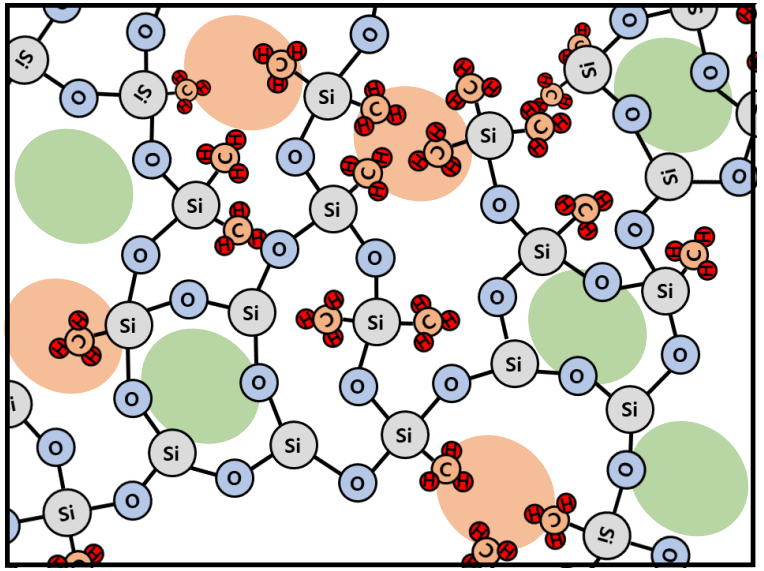


Semiconductor part: Dielectric characteristics of low-*k*



<Dielectric constant mechanism according to the operating frequency region of the device>

$$Maximum\ operating\ frequency \propto \frac{1}{\tau_{gate} + \tau_{RC}},\ (\tau_{gate}: gate\ delay, \tau_{RC}: RC\ delay)$$



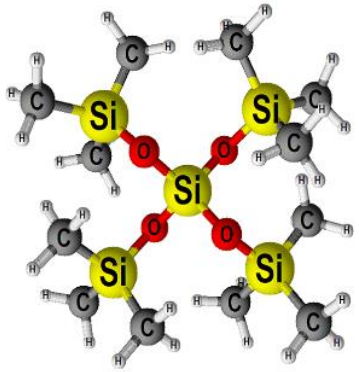
<SiCOH film>

: Hydrocarbon group

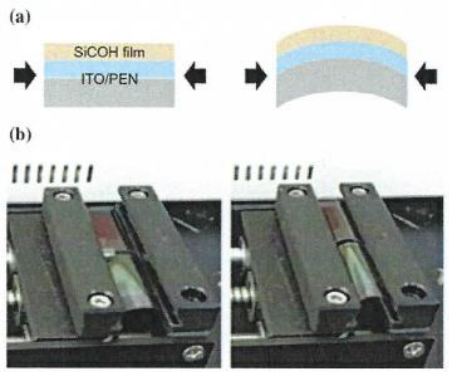
: SiCOH 전구체의 구조로 부터 형성된 기공

Semiconductor part: Flexible low-*k* (with University of)

Dielectric material for Flexible devices

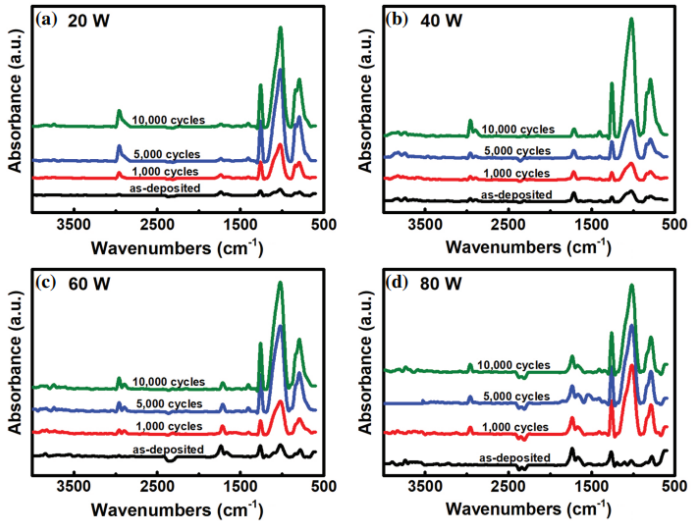


Tetrakis-(trimethylsilyloxy)silane (TTMSS)

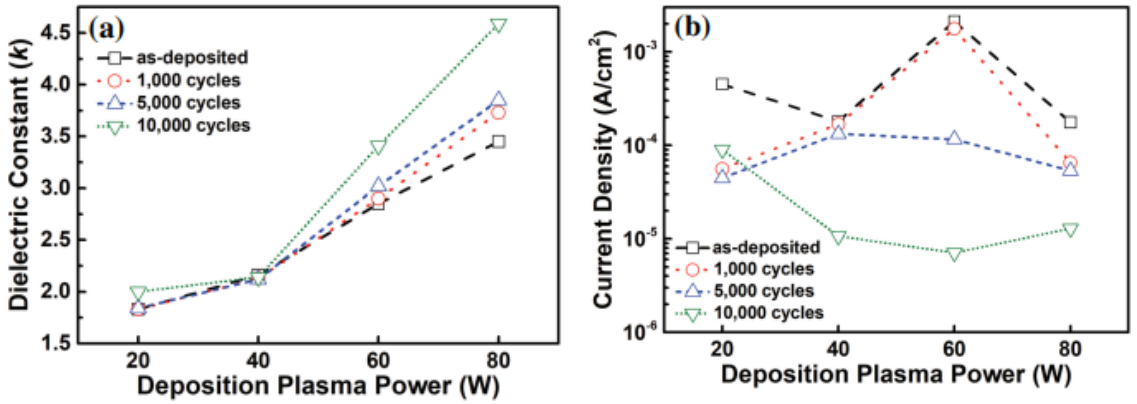


Film bending test

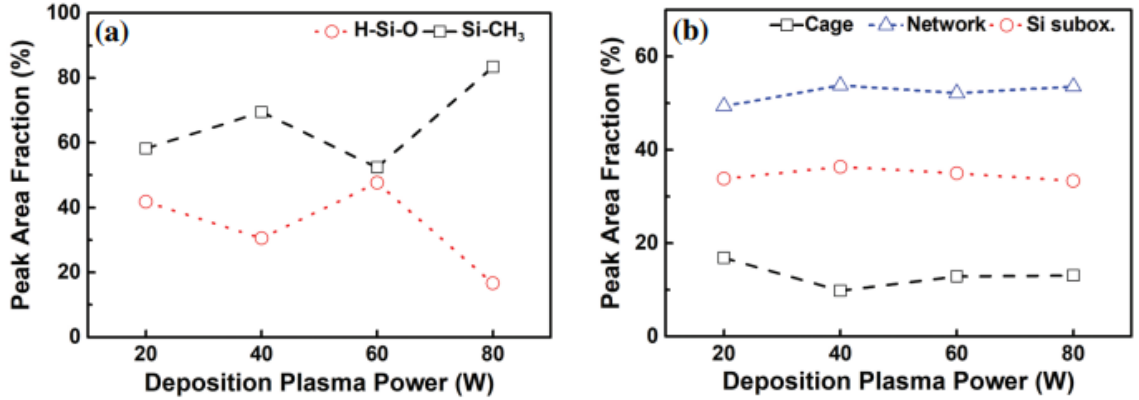
The SiCOH film on the substrate mounted on the motor equipped motion controller (left) and the bent substrate after bending (right)



FTIR spectra in the wave number from 400 to 600 cm-1 of the SiCOH film on ITO/PEN substrate and the films, after having been subjected to bending tests at different deposition plasma power



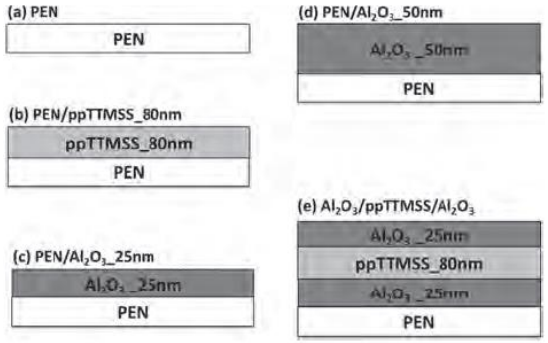
(a) Dielectric constants and (b) current densities at the electric field of 1.0 MV/cm of the as-deposited SiCOH films on ITO/PEN substrates and the films after having been subjected to bending tests with bending cycles of 1000, 5000, and 10000 as a function of deposition plasma powers between 20 and 80 W.



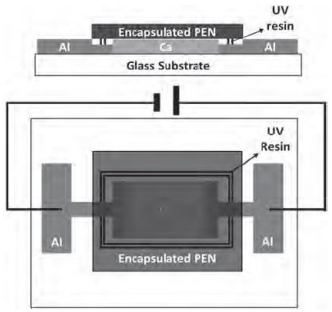
Peak area fractions of (a) H–Si–O/Si–CH3 peaks at 920–720 cm−1 and (b) Si–O–Si cage/network/suboxide structures at 1200–950 cm−1 , for the as-deposited SiCOH films on Si substrates

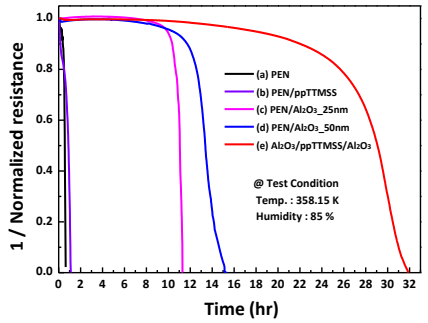
Semiconductor part: Thin film encapsulation

Atomic layer deposition system (ALD)



Schematic diagram of multilayer encapsulation film





Water Vapor Transmission Rate TEST

Because the life-time and performance of OEDs can be lowered by permeation of the moisture and oxygen during the atmospheric exposure, the transparent encapsulation layer was developed to block moisture and oxygen. Since the multilayer encapsulation film of Al2O3/plasma polymer film/Al2O3 has also flexible and transparent characteristics, it has applicable to flexible OEDs.

반도체와 디스플레이에 필수인 봉지막(Encapsulation) 공정 페널을 구부리면 ???