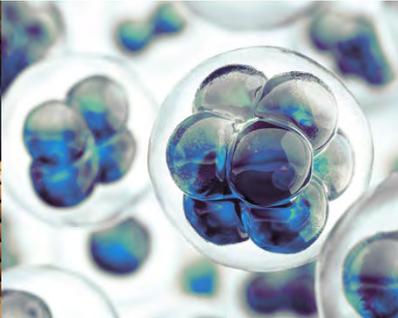




Europäisches  
Patentamt  
European  
Patent Office  
Office européen  
des brevets

# Future and emerging technologies - graphene in healthcare



Lana Follens (EPO) Nigel Clarke (EPO) Udo Gennari (EEN Business Upper Austria)

February 2021



Lana Follens

Patent examiner

Subject matter  
expert



Nigel Clarke

Patent Knowledge  
research



Udo Gennari

Patent Analyst

Senior Project  
Manager



# Background:

-  European Patent Office produces “Patent Insight Reports” to promote patent data as a resource for **innovation**



-  European Commission launches Flagship to promote **innovation** in Graphene technology



- EPO and EU agree to pursue common interests to support **innovation** in Graphene Technology

- Match



# Patent information and landscaping



- Patents are documents about **technical inventions**
- Patents describe something claimed as new, inventive and useful **innovation**
- Patents are available over **long time periods** and from **many countries**
- Patents are **publicly available** from patent search platforms like *Espacenet*
- Taking advantage of its **structured format**, patent statistics can be conducted on a large set of bibliographic patent references.
- This analysis can provide a **comprehensive snapshot of patenting activity in a specific technology**.
- Especially in **emerging and research intensive sectors**, a patent landscaping exercise can be of interest since the patent information offers a basis for analysis where other data is scarce.

119) 111) EP 3 428 121 A1

112) EUROPEAN PATENT APPLICATION  
published in accordance with Art. 153(1) EPC

143) Date of publication: 18.01.2019 Bulletin 091805

(51) Int. Cl. C02F 3/21 (2018.01) C02F 3/21 (2018.01)  
C02F 3/21 (2018.01) C02F 3/21 (2018.01)  
C02F 3/21 (2018.01) C02F 3/21 (2018.01)  
H01M 4/02 (2014.01) H01M 4/02 (2014.01)

(21) Application number: 1772076.8

(22) Date of filing: 20.02.2017

(86) International publication number: PCT/JP2017/00408

(87) International publication number: WO 2017/14523 (14.09.2017) German 201707

(84) Designated Contracting States: AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR  
Designated Extension States: BA ME  
Designated Validation States: MA MD

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Suga 520-8556 (JP)

(71) Applicant: Toray Industries, Inc.  
Tokyo 105-8565 (JP)

(74) Representative: Kasai & Hamada Patent  
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80408 München (DE)

(54) SURFACE-TREATED GRAPHENE, SURFACE-TREATED GRAPHENE/ORGANIC SOLVENT DISPERSION LIQUID, SURFACE-TREATED GRAPHENE/ELECTRODE ACTIVE MATERIAL COMPOSITE PARTICLES AND ELECTRODE PASTE

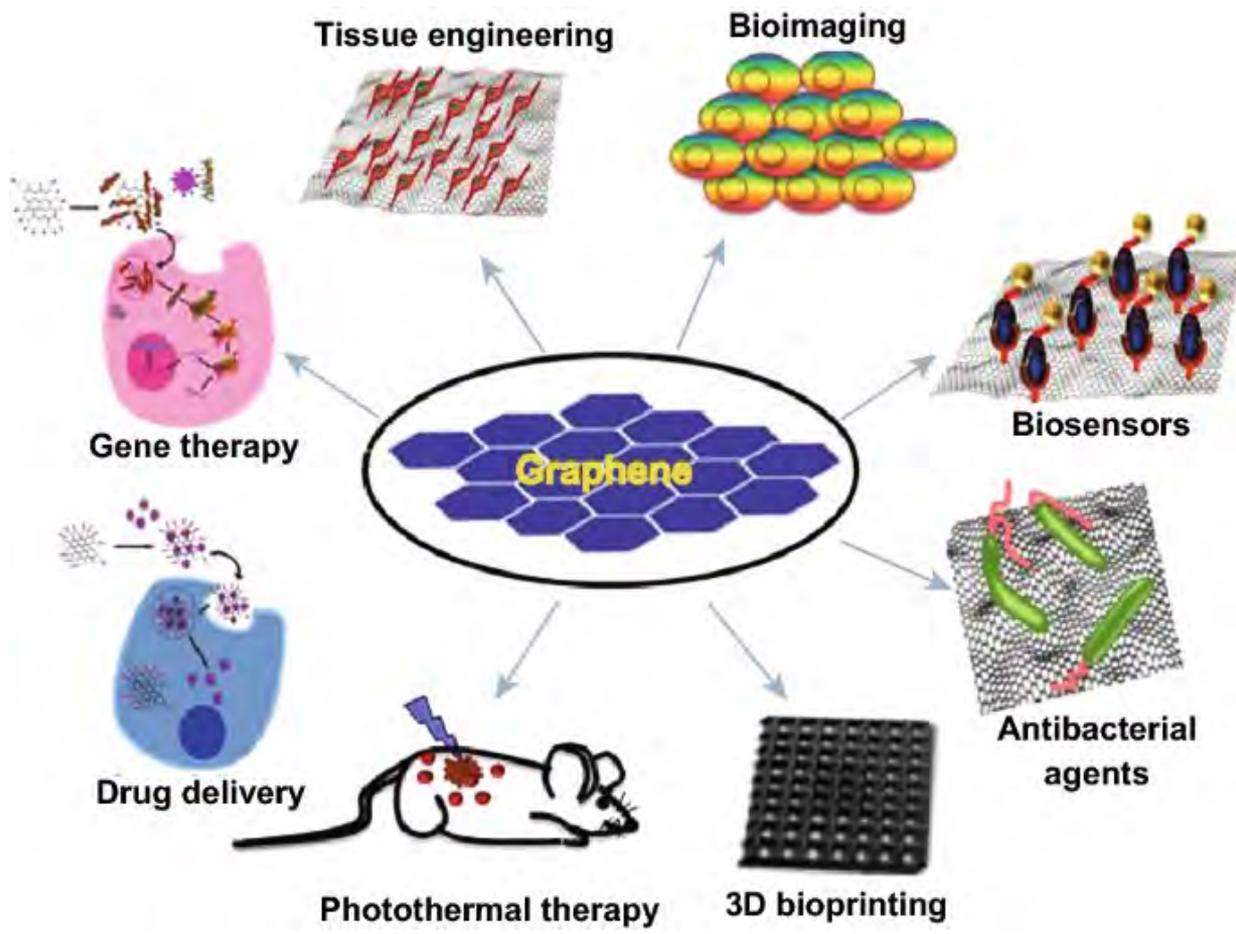
(57) The purpose of the present invention is to provide a graphene which has high dispersibility, high electrical conductivity and excellent mechanical strength and a graphene which has high electrochemical stability. In order to achieve the above-described purpose, a surface-treated graphene according to the present invention is obtained by having a compound represented by general formula (I) or a substituted derivative thereof adsorbed on graphene. (1) General formula (I): A compound represented by general formula (I) or a substituted derivative thereof is adsorbed on graphene.

Example of EP patent application front-page with bibliographic fields that can be statistically analysed like dates, title & abstract, inventors & applicants or technology classification



## Some definitions

- **Patent family** – a set of patents covering the same invention but filed at different patent offices
- **Invention** – practical embodiment which involves, requires or produces a technical effect
- **Classification** – system for codifying groupings of different technical fields
- **Patent application** – (document) summarising, describing, and defining the scope of an invention
- **Patent specification** – (document) defining an invention and the scope of its protection by patent.
- **Priority filing** – the first filed patent application of a family
- **Search report** – citations of previous publications impacting on patentability
- **Jurisdiction** – A country or countries (territory) for which a patent maybe granted by the corresponding Intellectual Property Office



# Leading fields of technology



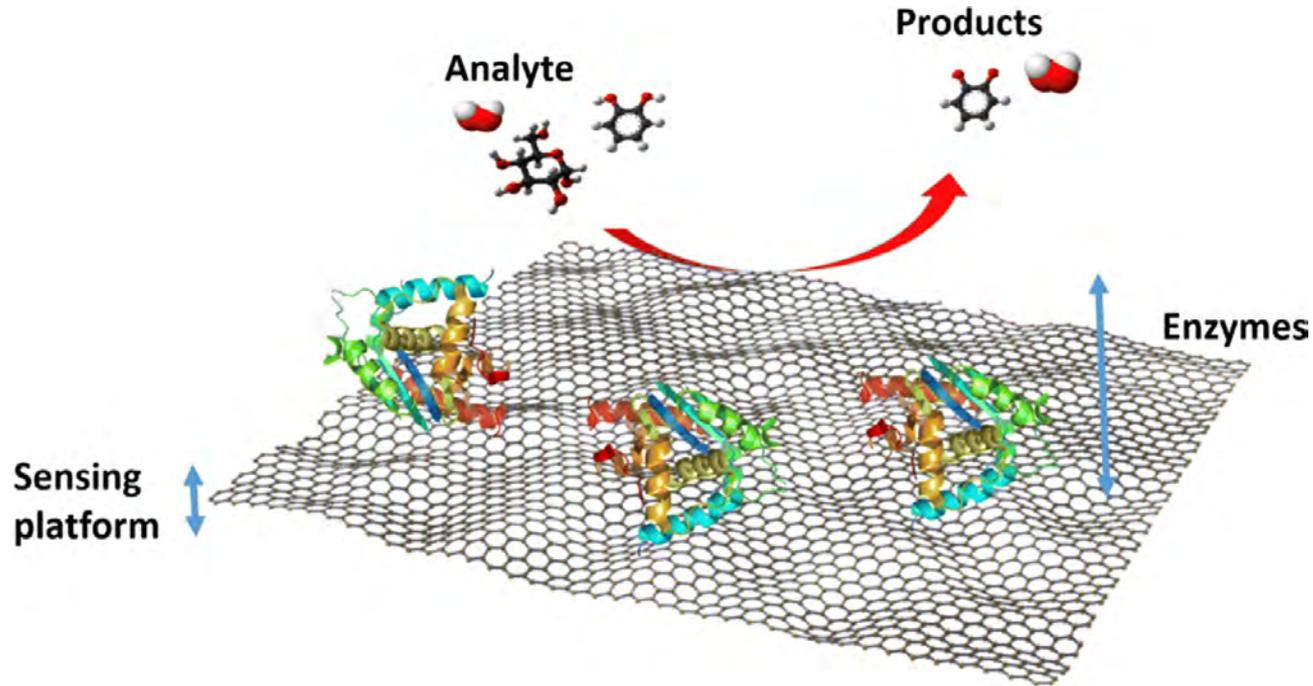
## TOP 10

			2019	Change	
1	Digital communication		14 175	19.6%	
2	Medical technology		13 833	0.9%	
3	Computer technology		12 774	10.2%	
4	Electrical machinery, apparatus, energy		11 255	5.5%	
5	Transport		9 635	6.6%	
6	Measurement		9 045	3.8%	
7	Pharmaceuticals		7 697	4.4%	
8	Biotechnology		6 801	1.7%	
9	Other special machines ranging from agriculture to 3D printing		6 436	1.5%	
10	Organic fine chemistry		6 167	-0.5%	

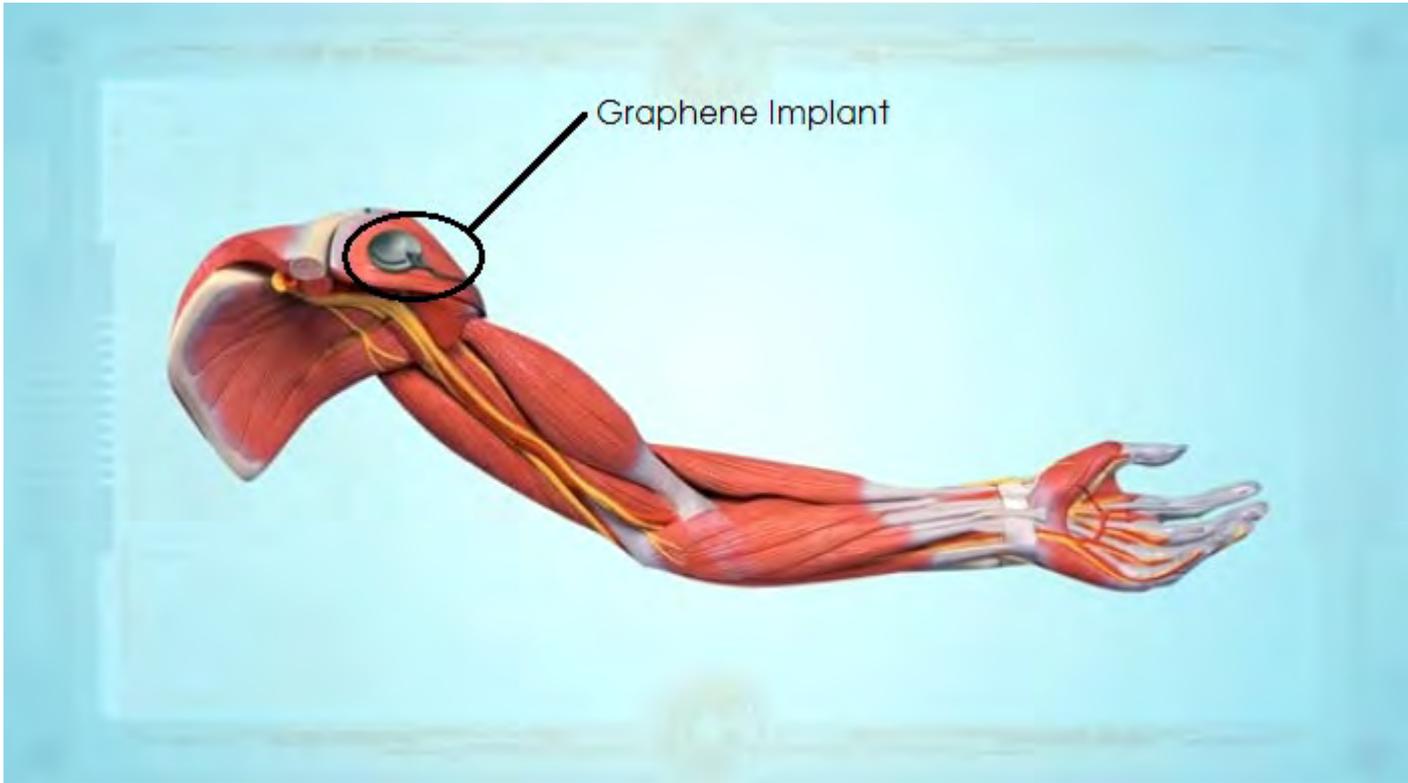
Source: EPO. Status: 27.1.2020.

European patent applications include direct European applications and international (PCT) applications that entered the European phase during the reporting period.

The definition of the fields is based on the WIPO IPC technology concordance.



Peña-Bahamonde, J., Nguyen, H.N., Fanourakis, S.K. *et al.* Recent advances in graphene-based biosensor technology with applications in life sciences. *J Nanobiotechnol* **16**, 75 (2018). <https://doi.org/10.1186/s12951-018-0400-z>  
[Download citation](#)



<https://graphenemining.wordpress.com/2012/12/16/graphene-as-an-implant-nano-way/#jp-carousel-110>

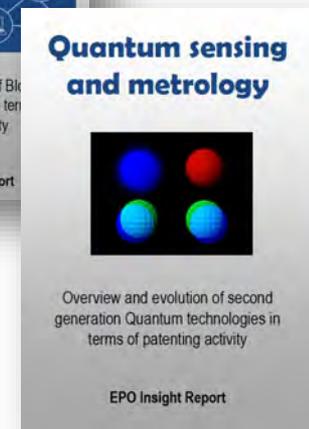




# Project objectives

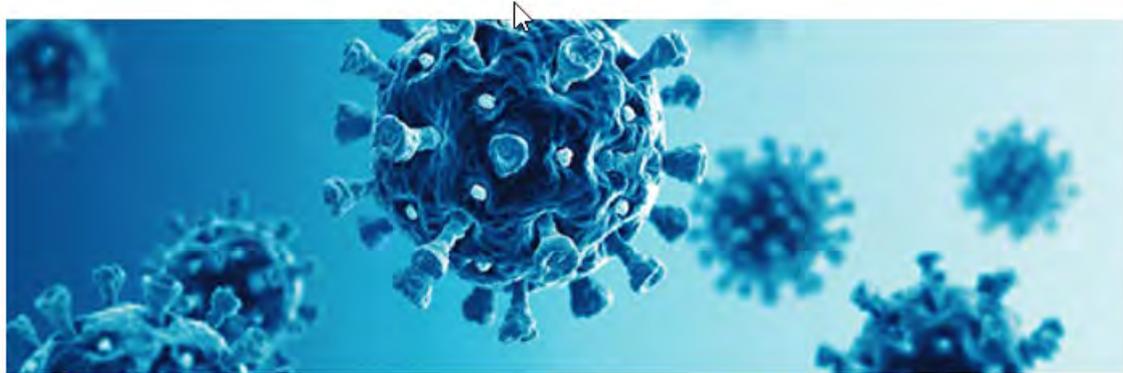
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- Engage with Business STEMM, R&D, innovation communities
- Demonstrate value of patent data and information
- Blockchain, CAR T-cell, Quantum sensing and metrology....for example
- Graphene





# Fighting coronavirus



The COVID-19 pandemic caused by the novel coronavirus SARS-CoV-2 has led to an urgent search for vaccines, treatments and technologies that can counter the spread of disease and save lives. The technical information published in patents advances human knowledge, helping researchers everywhere to understand the latest inventions.

# Graphene biosensor coronavirus

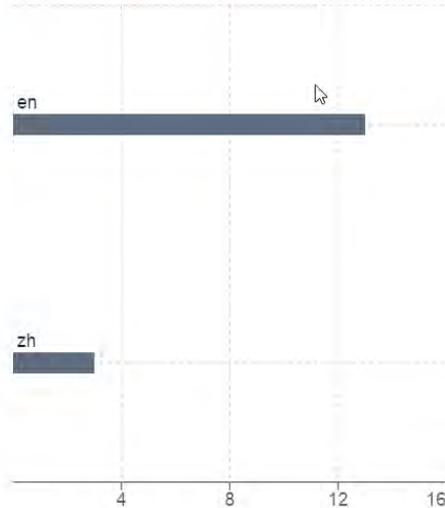


7 results found for: ftxt=("graphene" prox/distance<3 "biosens\*") AND (ftxt all "covid" OR ftxt all "corona vir\*" OR ftxt all "coronavir\*" OR ftxt all "Middle East respiratory" OR ftxt all "SARS")

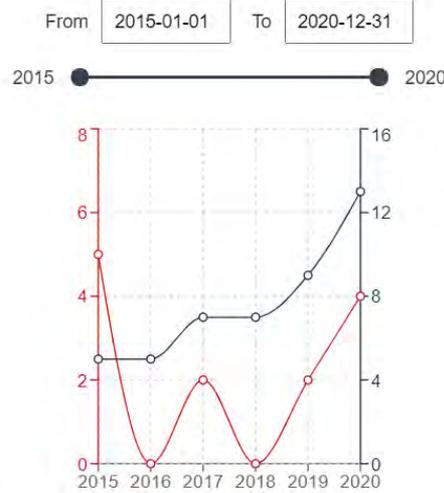
Countries (publication)



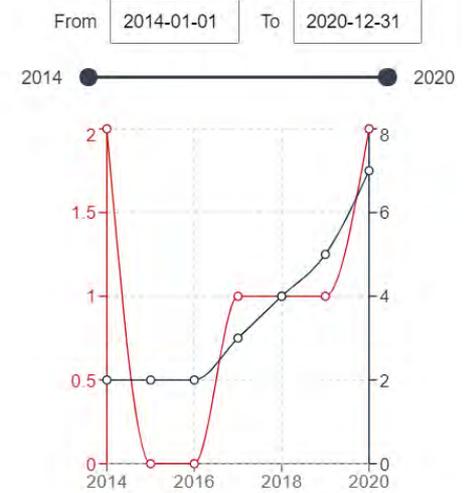
Languages (publication)



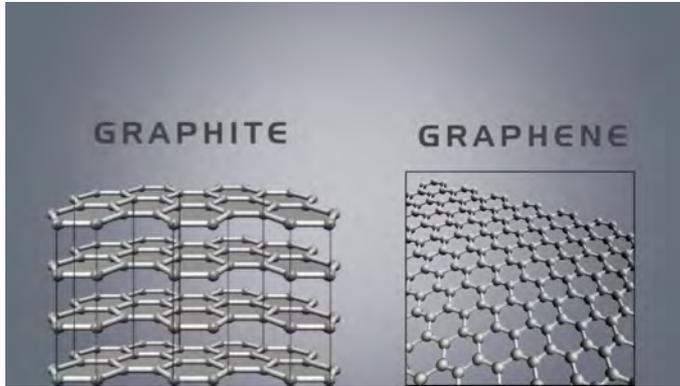
Publication date (publication)



Earliest priority date



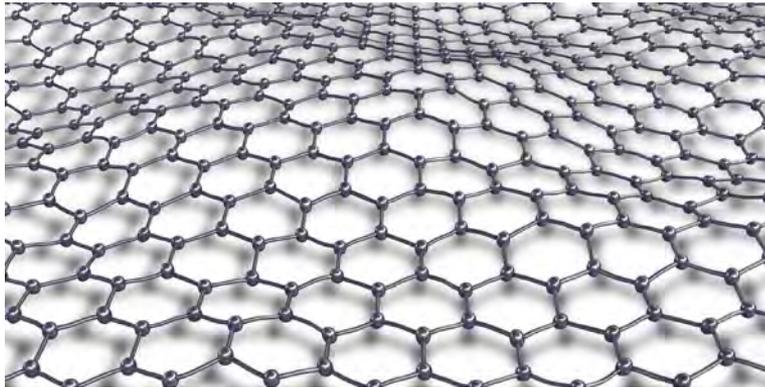
# Graphene



Definition

Discovery

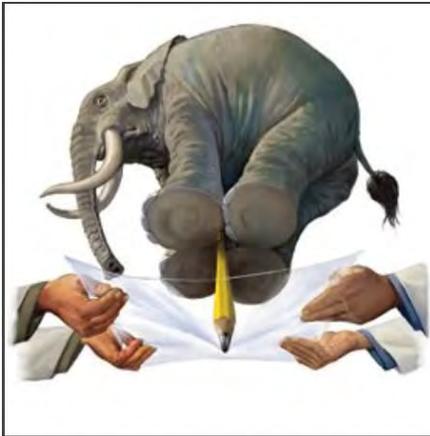
Production



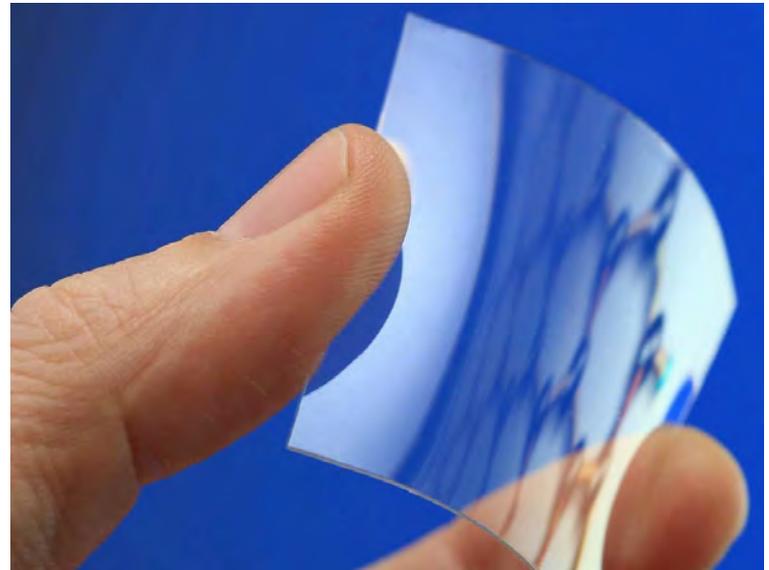
# Graphene



## Applications



## Properties



# Search



All relevant documents ?



Exclude/remove irrelevant documents ?

# Example - strategy



Sensor

a61/low/c

+sensor+

1 and 2

Graphen+ or (graphene w oxid+) or (few\_layer w graphit+) or GO or LDG or (laser w deriv+ w graphen+) or LIG or (laser w induc+ w graphen+) or rGO or (reduc+ w graphen+ w oxid+)

a61/low/c

sensor+ or bio\_sensor+

1 and 2

Graphen+ or (graphene w oxid+) or (few\_layer w graphit+) or GO or LDG or (laser w deriv+ w graphen+) or LIG or (laser w induc+ w graphen+) or rGO or (reduc+ w graphen+ w oxid+)

Health\_care or medical+ or therapeutic+ or therapy+ or skin+ or medicin+ or (healing w (product+ or material+)) or pharmaceutic+ or drug\_deliver+ or drug\_releas+ or cancer+ or tumor+ or tumor+ or vascular+ or vaccin+ or immuno+ or healing+ or bone\_regenerat+ or gene\_deliver+ or pharmacy+ or transmucosal+ or (wound w dress+) or ophthalmolog+ or dentistr+ or (contact w lens+) or bandage+

+sensor+

1 and 2

Graphen+ or (graphene w oxid+) or (few\_layer w graphit+) or GO or LDG or (laser w deriv+ w graphen+) or LIG or (laser w induc+ w graphen+) or rGO or (reduc+ w graphen+ w oxid+)

a61/low/c

portabl+ or implant+ or graft+ or engraft+ or transplant+

1 and 2

Graphen+ or (graphene w oxid+) or (few\_layer w graphit+) or GO or LDG or (laser w deriv+ w graphen+) or LIG or (laser w induc+ w graphen+) or rGO or (reduc+ w graphen+ w oxid+)

a61/low/c

implant+ or graft+ or engraft+

1 and 2

Graphen+ or (graphene w oxid+) or (few\_layer w graphit+) or GO or LDG or (laser w deriv+ w graphen+) or LIG or (laser w induc+ w graphen+) or rGO or (reduc+ w graphen+ w oxid+)

Health\_care or medical+ or therapeutic+ or therapy+ or skin+ or medicin+ or (healing w (product+ or material+)) or pharmaceutic+ or drug\_deliver+ or drug\_releas+ or cancer+ or tumor+ or tumor+ or vascular+ or vaccin+ or immuno+ or healing+ or bone\_regenerat+ or gene\_deliver+ or pharmacy+ or transmucosal+ or (wound w dress+) or ophthalmolog+ or dentistr+ or (contact w lens+) or bandage+

portabl+ or implant+ or graft+ or engraft+ or transplant+

1 and 2

Graphen+ or (graphene w oxid+) or (few\_layer w graphit+) or GO or LDG or (laser w deriv+ w graphen+) or LIG or (laser w induc+ w graphen+) or rGO or (reduc+ w graphen+ w oxid+)

Implant

# Patent statistics in a nutshell – Graphene Sensors



- 207 patent families\*
- 373 patent documents
- 15 Authorities: US (54), CN (52), EP (47), WO (22) with most applications
- 40 Jurisdictions: from US (113) down to Uruguay (1)
- 200 Standard Current Assignees
- Legal status / events :

Pending	66
Inactive	58
Active	50
PCT designated stage ex...	17
Undetermined	11
PCT designated stage	5

Transfer	43
Dual filing	5
License	4
Pledge	2

\* based on simple patent families. A simple patent family is a collection of patent documents covering a single invention with identical technical content and relating to the same priority dates.

**PatSnap** has been used for patent searches, patent statistics and patent landscaping. For comparison, also **IP7-Compass** has been used initially



# Patent statistics in a nutshell – Graphene Implants

- 298 patent families\*
- 537 patent documents
- 25 Authorities: EPO (50), US (47), DK (42), CN (40) = most applications
- 50 Jurisdictions: from WIPO (172), US (171) down to ARIPO (4)
- 200 Standard Current Assignees
- Legal status / events :

Pending	83
Inactive	82
Active	69
Undetermined	39
PCT designated stage ex...	17
PCT designated stage	8

Transfer	44
License	6
Pledge	1

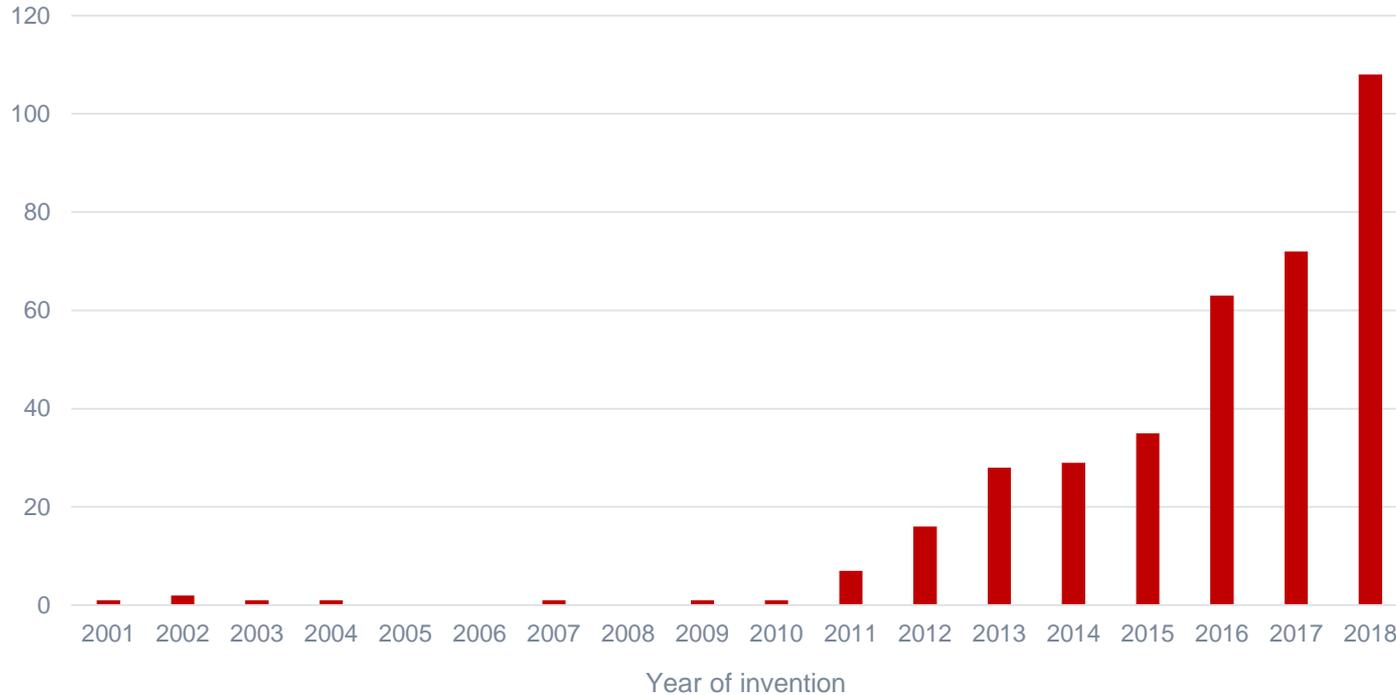
\* based on simple patent families. A simple patent family is a collection of patent documents covering a single invention with identical technical content and relating to the same priority dates.

**PatSnap** has been used for patent searches, patent statistics and patent landscaping. For comparison, also **IP7-Compass** has been used initially

# Global timeline sensors – no. families



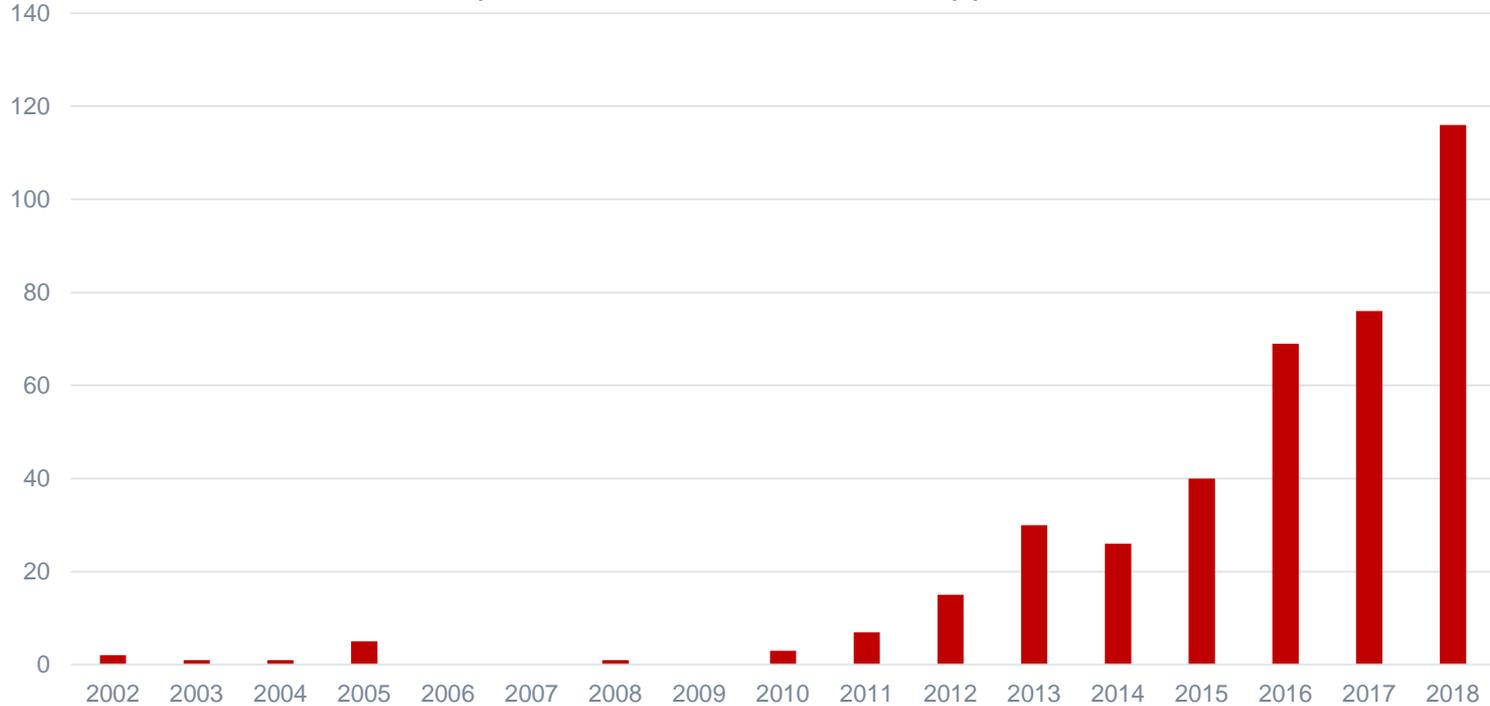
Graphene/sensors: Number of inventions



# Global timeline sensors – no. applications



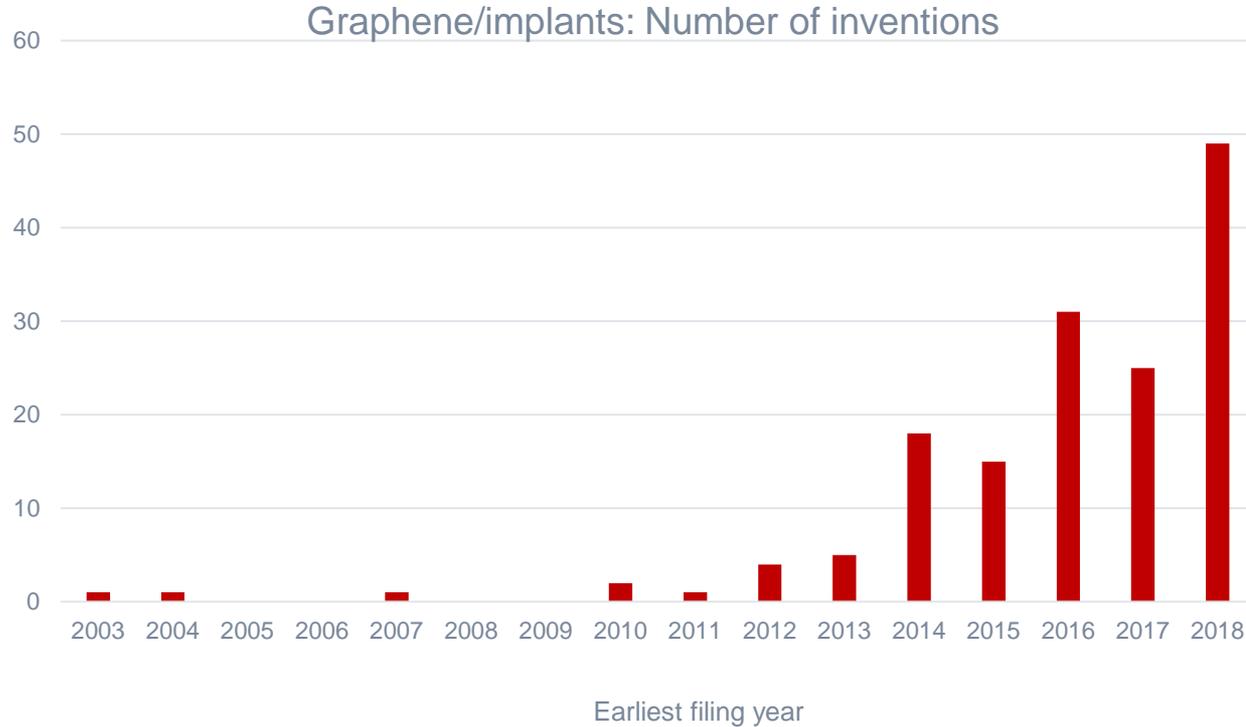
Graphene/sensors: Number of applications



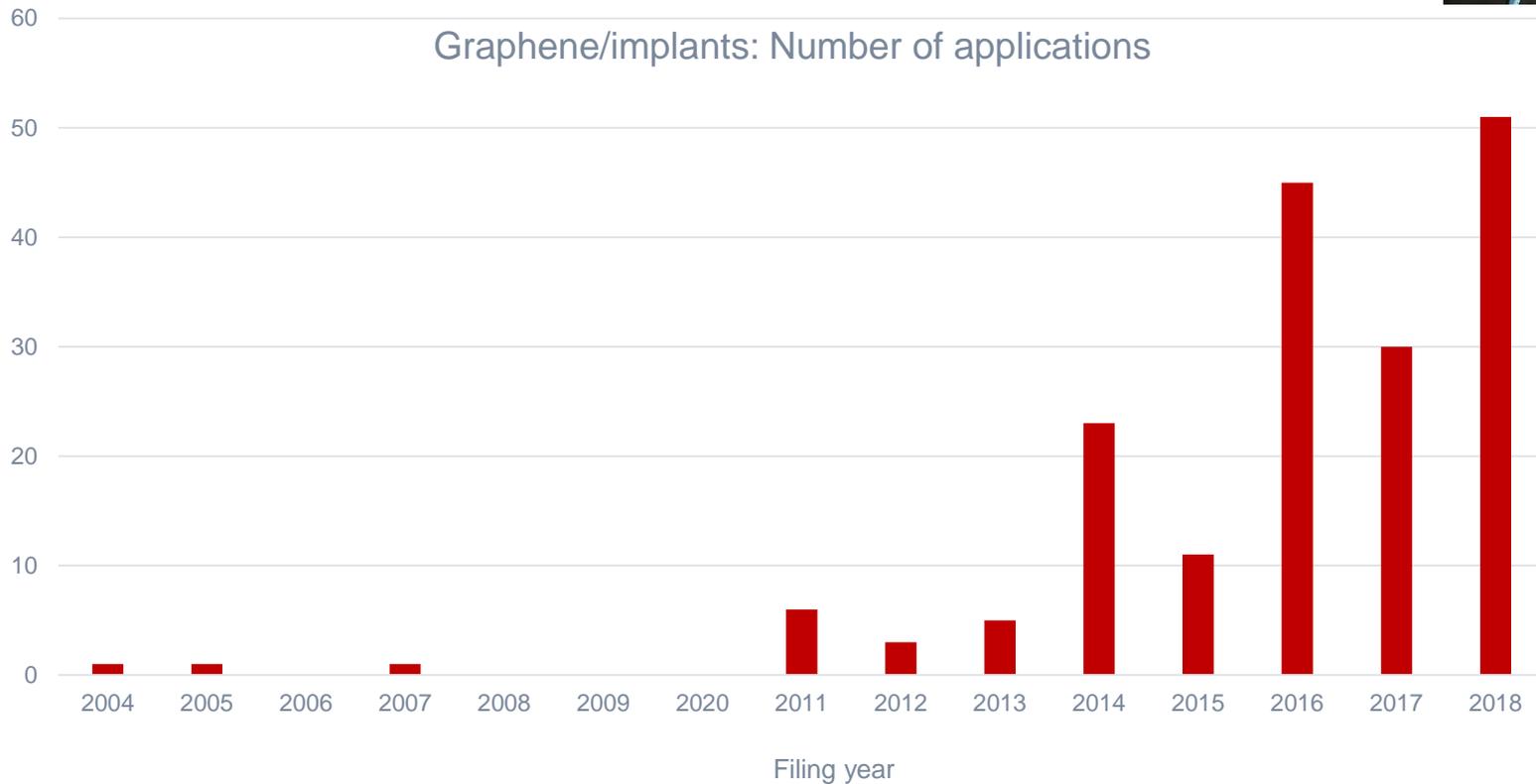
# Sensors – top applicants

Applicant name	Number of applications	Number of inventions
UNIVERSITY OF JINAN	39	39
SHANDONG UNIVERSITY OF TECHNOLOGY	20	20
CHONGQING INSTITUTE OF GREEN AND INTELLIGENT TECHNOLOGY, CHINESE ACADEMY OF SCIENCES	14	14
ZHEJIANG SCI-TECH UNIVERSITY	11	11
CHINESE ACADEMY OF SCIENCES	9	9
BOSTON SCIENTIFIC SCIMED	8	4
TSINGHUA UNIVERSITY	8	7
UNIVERSITY OF MINNESOTA	7	3
NINGBO UNIVERSITY	7	7
CHONGQING MEDICAL UNIVERSITY	6	6
GUANGXI VETERINARY RESEARCH INSTITUTE	6	6
JIANGNAN UNIVERSITY	6	6
NANJING NORMAL UNIVERSITY	6	6
COLUMBIA UNIVERSITY	5	4
NOKIA TECHNOLOGIES	5	2
QINGDAO UNIVERSITY	5	5
SICHUAN DONGDING LIZHI INFORMATION TECHNOLOGY COMPANY	5	5
ZHEJIANG UNIVERSITY	5	5
UNIVERSIDADE FEDERAL DE SAO CARLOS	4	1

# Global timeline - implants – no. families



# Global timeline – implants – no. applications



# Global implants top applicants

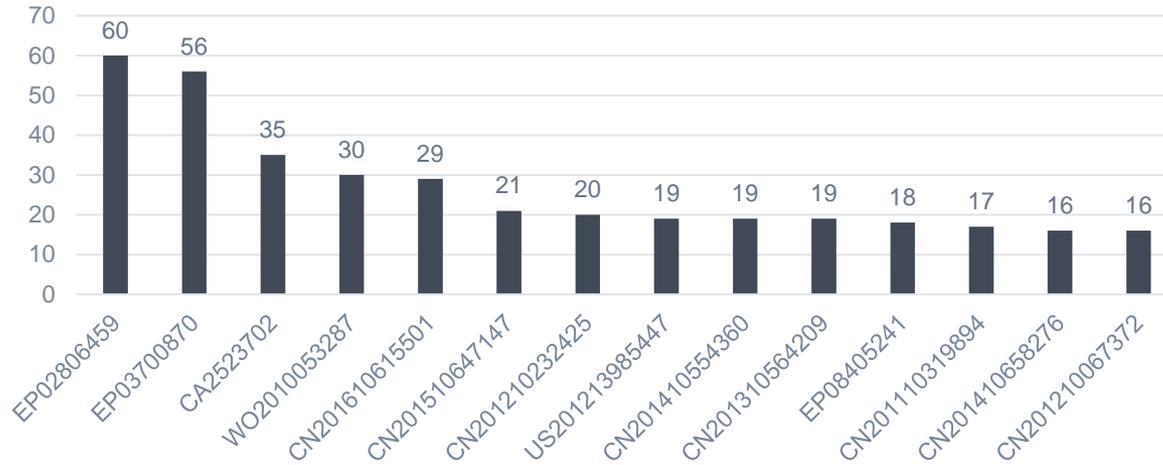


Applicant name	Number of applications	Number of inventions
LOCKHEED MARTIN CORPORATION	6	2
HUAIYIN INSTITUTE OF TECHNOLOGY	4	2
HUNAN UNIVERSITY OF SCIENCE AND TECHNOLOGY	4	4
NATIONAL UNIVERSITY OF SINGAPORE	4	1
TSINGHUA UNIVERSITY	4	4
SHT SMART HIGH TECH	3	1
WUHAN UNIVERSITY	3	3
ZHEJIANG DECANS MEDICAL INSTRUMENT COMPANY	3	3
NEW YORK SOCIETY FOR THE RUPTURED AND CRIPPLED MAINTAINING THE HOSPITAL FOR SPECIAL SURGERY	3	1
GUANGZHOU PASSIVHAUS TECHNOLOGY COMPANY	3	3
JOINTHERAPEUTICS	3	1
CENTRAL SOUTH UNIVERSITY	3	3
CONSIGLIO NAZIONALE DELLE RICERCHE	3	1
ZHONGZHOU UNIVERSITY	3	3
ZHEJIANG UNIVERSITY	2	2
WUHAN INSTITUTE OF TECHNOLOGY	2	2
CONTRALINE	2	1
CHINESE ACADEMY OF SCIENCES	2	2
CHU SHUANGYIN	2	2

# Most cited - sensors



Most cited applications  
Graphene Sensors



# Most cited - sensors

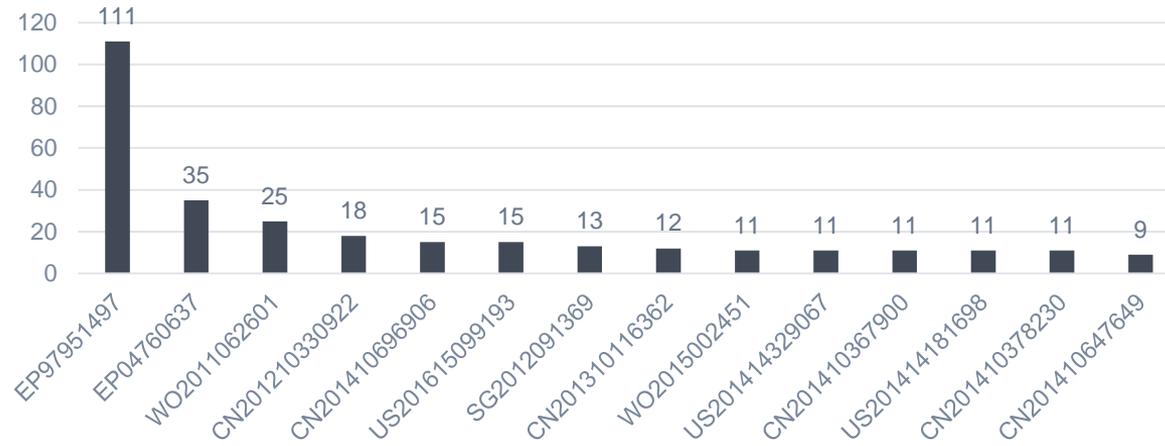


application	Title	Applicant
<a href="#">EP02806459</a>	IMAGING DEVICE AND RELATED METHODS	SCIMED LIFE SYSTEMS
<a href="#">EP03700870</a>	ULTRAVIOLET LAMP VENTILATION APPARATUS AND METHOD	VENT MASTER (EUROPE)
<a href="#">CA2523702</a>	NORMALIZATION METHOD FOR A CHRONICALLY IMPLANTED OPTICAL SENSOR	MEDTRONIC
<a href="#">WO2010053287</a>	PIEZOELECTRIC BODY, ULTRASONIC TRANSDUCER, MEDICAL ULTRASONOGRAPH, AND NONDESTRUCTIVE ULTRASONIC INSPECTION INSTRUMENT	KONICA MINOLTA MEDICAL & GRAPHIC
<a href="#">CN201610615501</a>	Method for detecting aflatoxin through immunosensor	HONGHE COLLEGE
<a href="#">CN201510647147</a>	Stretchable optoelectronic device, method of manufacturing the same, and apparatus, light-emitting device, sensor system, and sensor circuit including the stretchable optoelectronic device	SAMSUNG ELECTRONICS COMPANY
<a href="#">CN201210232425</a>	Preparation method and application of environmental estrogen electrochemical immunosensor	UNIVERSITY OF JINAN
<a href="#">US201213985447</a>	BIOCOMPATIBLE GRAPHENE SENSOR	WAYNE STATE UNIVERSITY
<a href="#">CN201410554360</a>	Method for multifunctional sorting of textile by using graphene oxide derivative	JIANGNAN UNIVERSITY
<a href="#">CN201310564209</a>	Optical fiber Fabry-Perot sound pressure sensor manufacturing method based on graphene membrane and measuring method and device thereof	BEIHANG UNIVERSITY
<a href="#">EP08405241</a>	DEVICE FOR TOMOGRAPHIC SCANNING OBJECTS	MHT OPTIC RESEARCH
<a href="#">CN201110319894</a>	Preparation method of electrochemistry immunosensor for determining alpha fetoprotein	UNIVERSITY OF JINAN
<a href="#">CN201410658276</a>	Flexible temperature sensor based on graphene nanometer wall and preparing method thereof	CHONGQING INSTITUTE OF GREEN AND INTELLIGENT TECHNOLOGY, CHINESE ACADEMY OF SCIENCES
<a href="#">CN201210067372</a>	Graphene film sensitized D-shaped optical fiber surface plasmon resonance (SPR) sensor and preparation method thereof	UNIVERSITY OF ELECTRONIC SCIENCE AND TECHNOLOGY OF CHINA

# Most cited - implants



Most cited applications  
Graphene Implants



# Most cited - implants



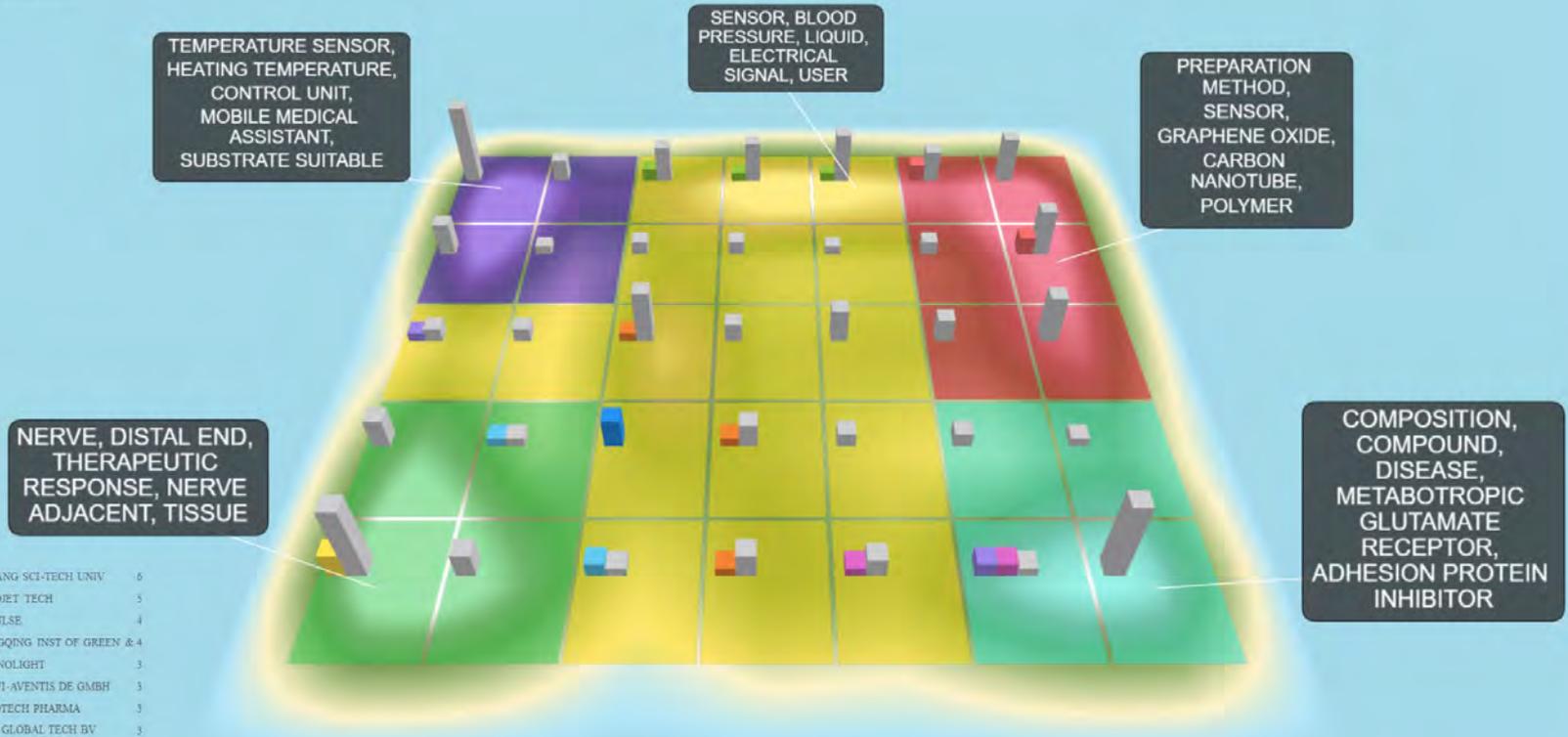
application	Title	Applicant
<a href="#">EP97951497</a>	GRAFT LIGAMENT ANCHOR AND METHOD FOR ATTACHING A GRAFT LIGAMENT TO A BONE	SKLAR, JOSEPH H.
<a href="#">EP04760637</a>	NORMALIZATION METHOD FOR A CHRONICALLY IMPLANTED OPTICAL SENSOR	MEDTRONIC
<a href="#">WO2011062601</a>	GRAPHENE ELECTRODES ON A PLANAR CUBIC SILICON CARBIDE (3C-SIC) LONG TERM IMPLANTABLE NEURONAL PROSTHETIC DEVICE	UNIVERSITY OF SOUTH FLORIDA
<a href="#">CN201210330922</a>	Implanted electrode and preparation method thereof and medical assembly comprising implanted electrode	TSINGHUA UNIVERSITY
<a href="#">CN201410696906</a>	Preparation method of water-soluble graphene	HUNAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
<a href="#">US201615099193</a>	IMPLANTABLE GRAPHENE MEMBRANES WITH LOW CYTOTOXICITY	LOCKHEED MARTIN CORPORATION
<a href="#">SG2012091369</a>	METHOD FOR CONTROLLING AND ACCELERATING DIFFERENTIATION OF STEM CELLS USING GRAPHENE SUBSTRATES	NATIONAL UNIVERSITY OF SINGAPORE
<a href="#">CN201310116362</a>	Preparation method for antibacterial coat for fixing various cell growth factors on medical metal	SOUTHWEST JIAOTONG UNIVERSITY
<a href="#">WO2015002451</a>	NOVEL ANTIMICROBIAL POLYMER-GRAPHENE-SILVER NANOCOMPOSITE	ALFAISAL UNIVERSITY
<a href="#">US201414329067</a>	Transparent and flexible neural electrode arrays	WISCONSIN ALUMNI RESEARCH FOUNDATION
<a href="#">CN201410367900</a>	Flexible three-dimensional nano bioelectrode and preparation method thereof	WUHAN UNIVERSITY OF TECHNOLOGY
<a href="#">US201414181698</a>	Antimicrobial polymer-graphene-silver nanocomposite	ALSHARAEH, EDREESE HOUSNI
<a href="#">CN201410378230</a>	Graphene oxide/chitosan grafted type double-network hydrogel and preparation method thereof	CHINA UNIVERSITY OF GEOSCIENCES (WUHAN)
<a href="#">CN201410647649</a>	Malignant-tumour-resistant graphene oxide nano-drug delivery system and preparation method thereof	SHANGHAI JIAO TONG UNIVERSITY

# Patent landscape – Graphene Sensors

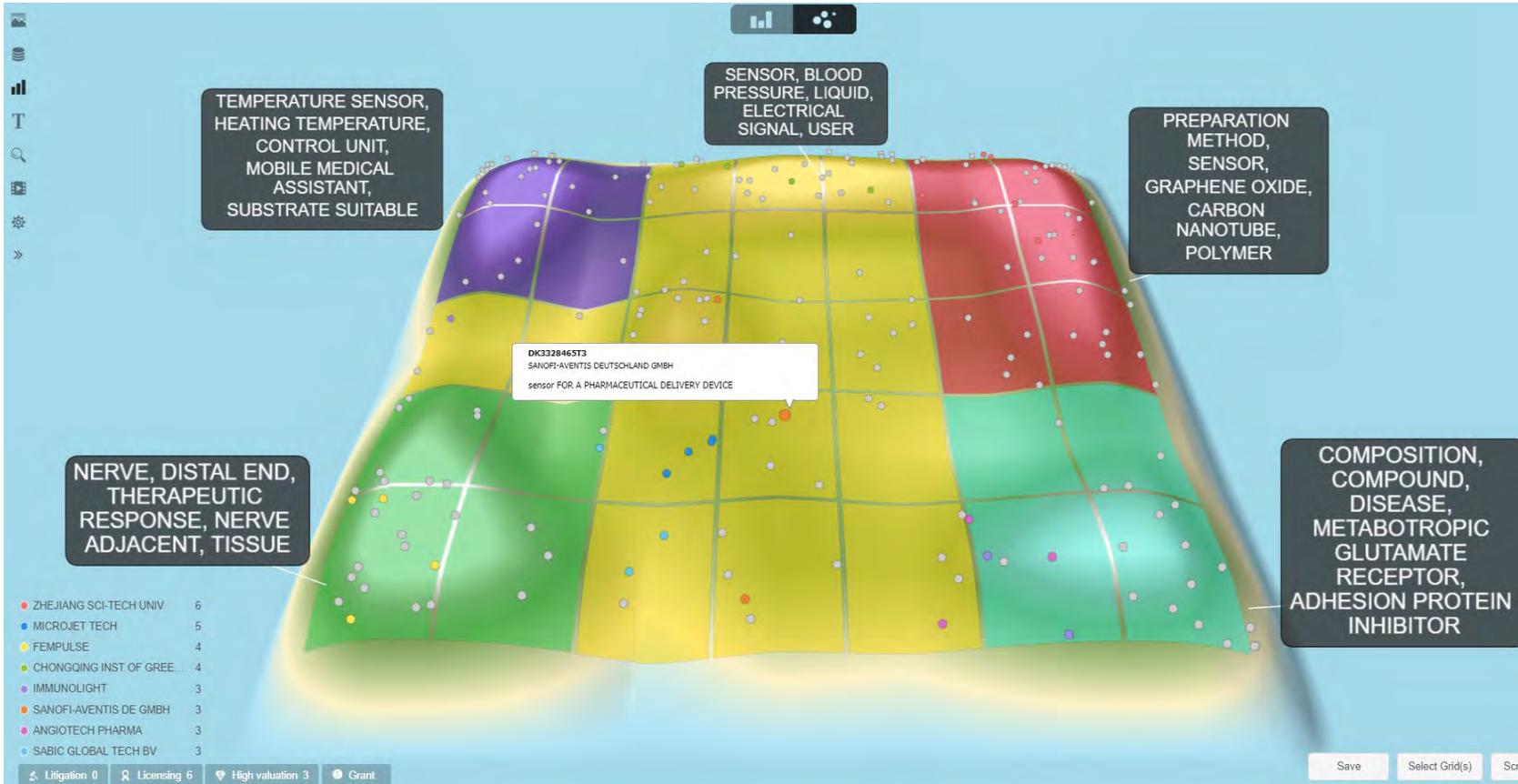


Sensors\_Graphene\_A61\_Landscape\_revised

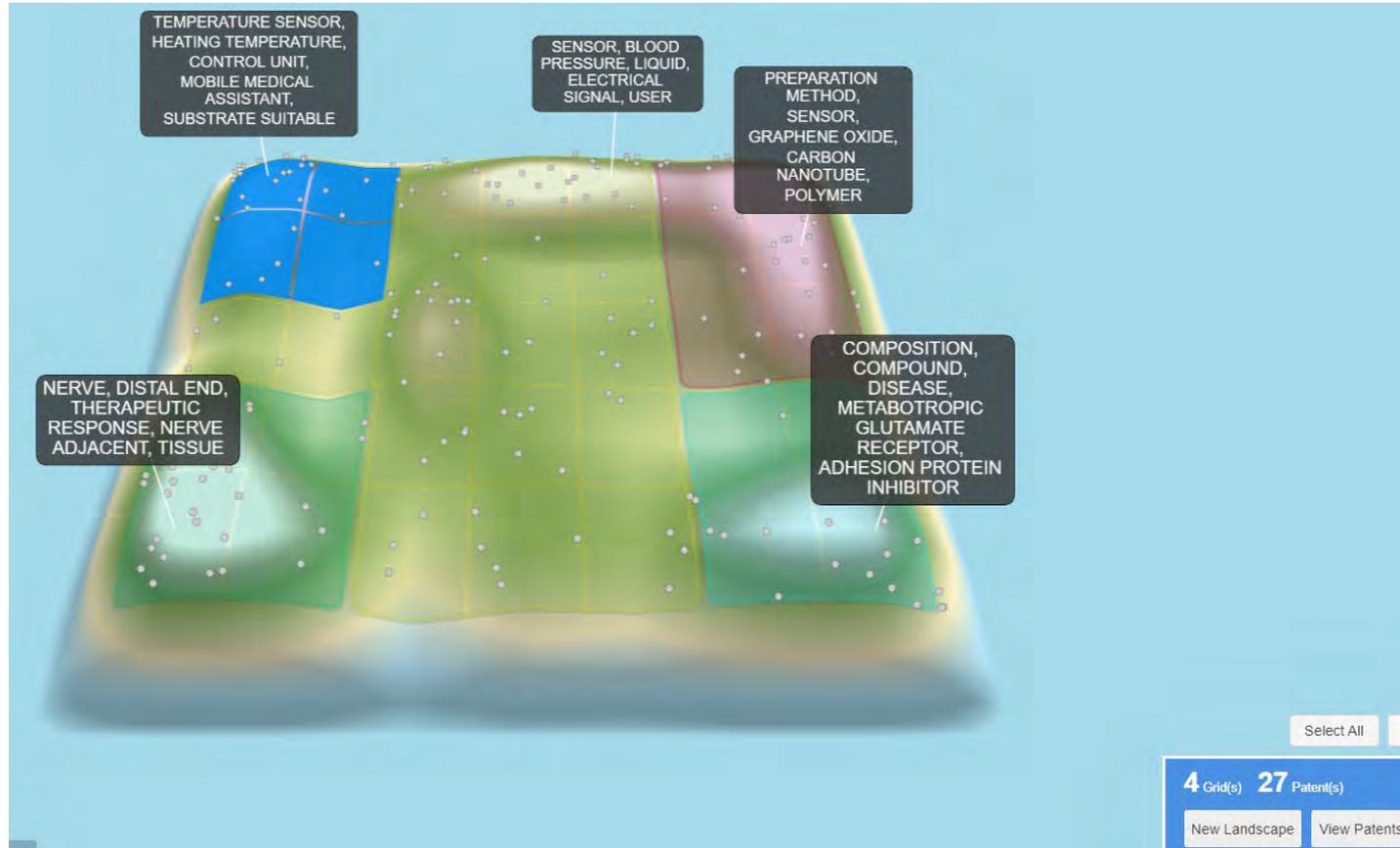
207 patent families



# Patent landscape – Graphene Sensors



# Cluster chosen in Landscape Graphene Sensors



# View Patents of chosen Cluster-Graphene Sensors



27 / 27 Patents



**US20190297961A1** (2019.10.03)

Textile product with skin-contact element and/or establishing external contact with the skin-contact element, and method for producing the same

M3S GMBH

**KR1020150087014A** (2015.07.29)

Portable beauty device and control method thereof

(주)폭스엔플렉스 (FOX&PLANET C...

**CN209108427U** (2019.07.16)

Medical nursing belt used after cesarean operation of gynaecology and obstetrics

杨玉妹

**CN110916889A** (2020.03.27)

Far infrared graphene intelligent mask

广州雅南无纺布制品有限公司

**CN109600868A** (2019.04.09)

Functional transparent graphene heating film

成都石墨烯应用产业技术研究院有限...

**CN209500555U** (2019.10.18)

Graphene far-infrared therapeutic instrument

广西中医药大学 \*1

**CN209967431U** (2020.01.21)

Graphene waist seal

常州华祥碳材料科技有限公司

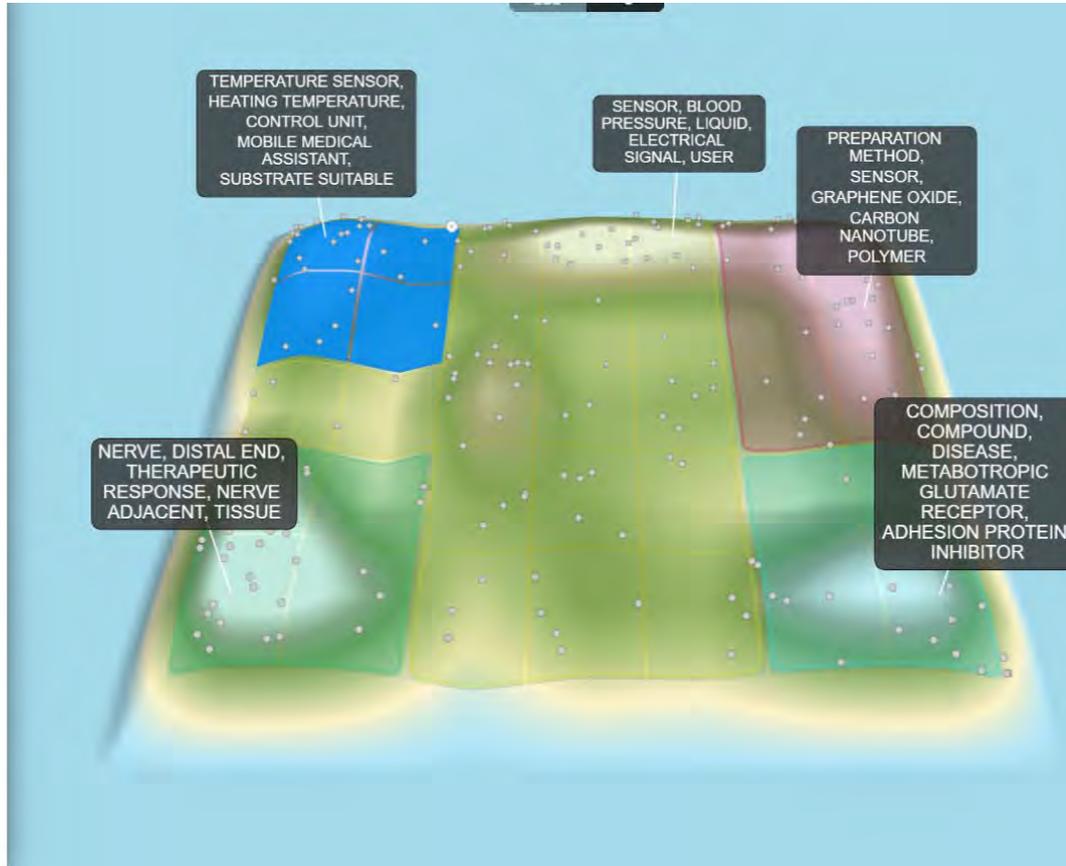
**CN108744787A** (2018.11.06)

Air purifying medical device

长春工业大学

**CN209965264U** (2020.01.21)

Graphene heating waistcoat



Add to Workspace



Export



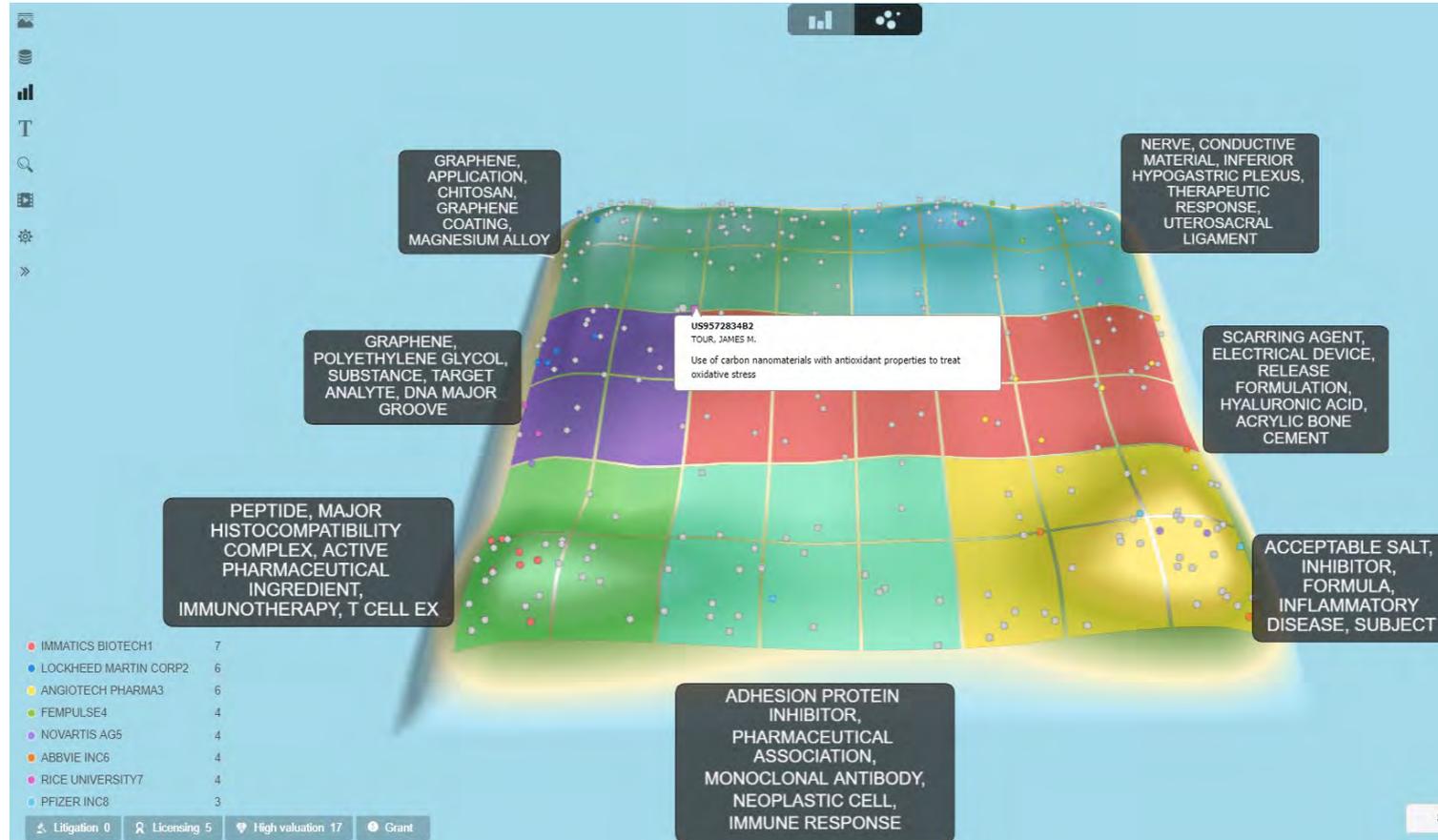
# Zoomed Patent landscape – Graphene Sensors



# Patent landscape – Graphene Implants



# Patent landscape – Graphene Implants



# Resources



## Graphene-Based Materials for Implants

[V.O. Fasiku](#) [S.J. Owonubi](#) [E. Mukwevho](#) [B.A. Aderibigbe](#) [Y. Lemmer](#) [Revaprasadu Neerish](#) [E.R. Sadiku](#)

Book Editor(s): [Edvige Celasco](#) [Alexander N. Chaika](#) [Tobias Stauber](#) [Mei Zhang](#) [Cengiz Ozkan](#) [Umit Ozkan](#) [Barbara Palys](#) [Sulaiman Wadi Harun](#)

First published: 17 June 2019 <https://doi.org/10.1002/9781119468455.ch117>



Review

### Recent advances in graphene-based biosensors

Tapas Kuila<sup>a</sup>, Saswata Bose<sup>a</sup>, Partha Khanra<sup>a</sup>, Ananta Kumar Mishra<sup>b</sup>,  
Nam Hoon Kim<sup>c</sup>, Joong Hee Lee<sup>a,b,c,\*</sup>

<sup>a</sup> Department of BIN Fusion Technology, Chonbuk National University, Jeonju, Jeonbuk 561-756, Republic of Korea

<sup>b</sup> BIN Fusion Research Center, Department of Polymer & Nano Engineering, Chonbuk National University, Jeonju, Jeonbuk 561-756, Republic of Korea

<sup>c</sup> Department of Hydrogen and Fuel Cell Engineering, Chonbuk National University, Jeonju, Jeonbuk 561-756, Republic of Korea

# SQL PATSTAT – data post processing



Geert Boedt



Christian  
Soltmann



```
SELECT appln_auth+appln_nr application, tls201_appln.docdb_family_id, nb_citing_docdb_fam, appln_title,
psn_name
FROM [patstat2020b].[dbo].[GRAPHENE_IMPLANT_nogo_tls201]
join tls201_appln on tls201_appln.appln_id =
[GRAPHENE_IMPLANT_nogo_tls201].[appln_id]
left join tls202_appln_title on tls201_appln.appln_id =
tls202_appln_title.appln_id
left join tls207_pers_appln on tls201_appln.appln_id =
tls207_pers_appln.appln_id
left join tls206_person on tls207_pers_appln.person_id =
tls206_person.person_id
where applt_seq_nr = 1

order by nb_citing_docdb_fam desc

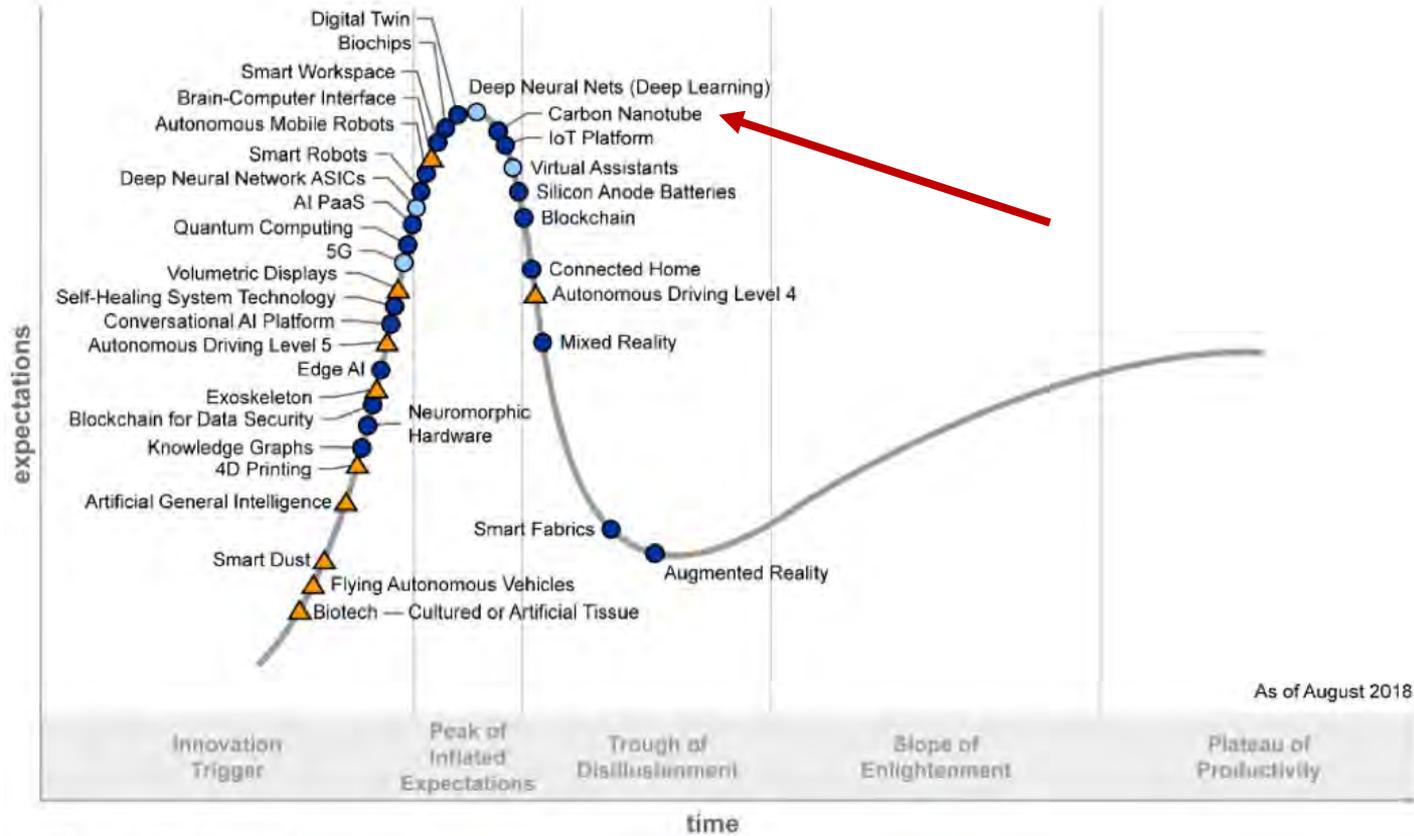
--543 records
SELECT distinct graphene_sensor, publn_auth, publn_nr, tls201_appln.appln_id,
docdb_family_id
into graphene_sensor_nogo_tls201
FROM
[patstat2020b].[dbo].[GRAPHENE_SENSOR_WITHOUTGO]
join tls211_pat_publn on (tls211_pat_publn.publn_auth + tls211_pat_publn.publn_nr =
graphene_sensor)
or (tls211_pat_publn.publn_auth + tls211_pat_publn.publn_nr+publn_kind =
[graphene_sensor])
join tls201_appln on tls201_appln.appln_id =
tls211_pat_publn.appln_id

order by appln_id

--225 records
```



Graphene in medical technology-  
-a work in progress



Plateau will be reached:

- less than 2 years
- 2 to 5 years
- 5 to 10 years
- ▲ more than 10 years
- ⊗ obsolete before plateau

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