Selected Novel Technologies for Licensing

MRS Fall 2011

Carbon Related Materials

- Graphene, Bucky Gel, Bucky Ball, Carbon Nanotube, Carbon Nanohorn, Carbon Nanowall etc.

Other Innovative Technologies

- Isotopomer, Dendrimer, Optical Catalyst, $12CaO \cdot 7Al_2O_3$, MRDFT etc.

Japan Science and Technology Agency

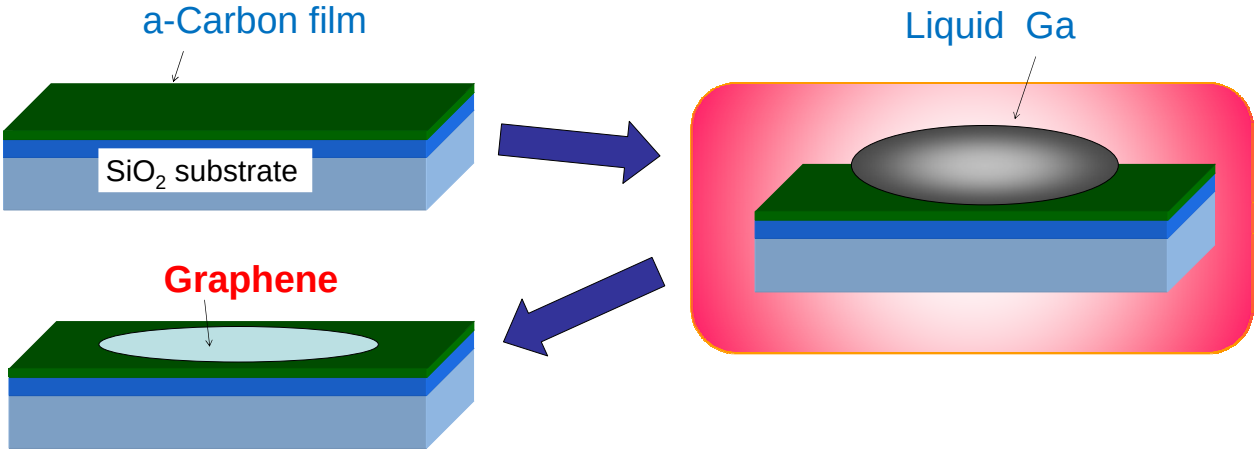
Carbon Related Materials

Fabrication of Graphene Using Liquid Ga and its Electrical Properties

Prof. Jun-ichi FUJITA (University of Tsukuba)

1. Fabrication of Graphene film

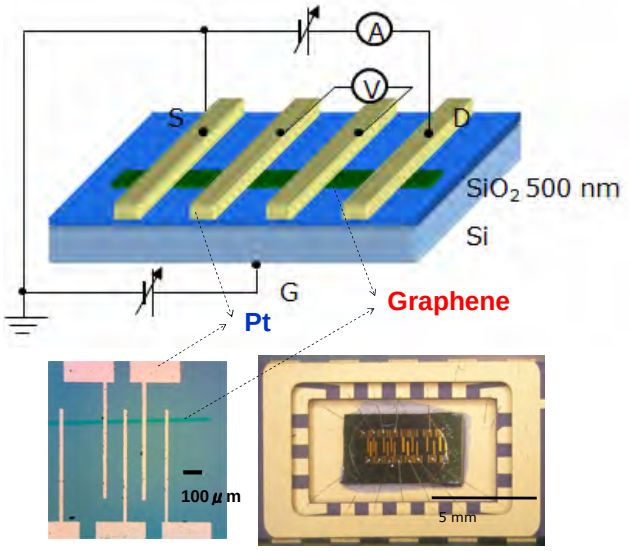
- 20nm amorphous-Carbon film is deposited on the substrate.
- Liquid Ga is put on the amorphous carbon film and is annealed at 1000℃ for 30 min under 5 x 10^{-4}Pa.
- Ga droplet is removed by soaking it in dilute HCl.



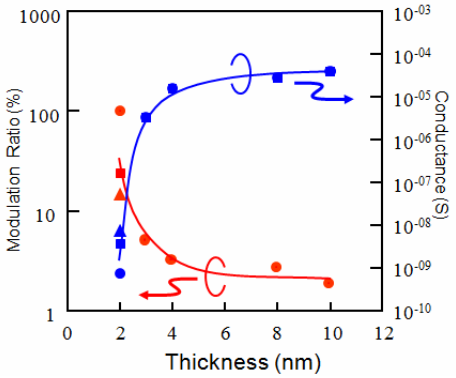
2. Feature of Our Method

Method	Mechanical Delamination	High temperature anneal of carbon film on SiC crystal substrate	High temperature CVD on metal crystal substrate	Our method
Example	K. S. Novoselov et al. PNAS 102 (2005) 10451.	W. Norimatsu,et al.Chem. Phys. Lett. 468 (2009) 52.	J. Coraux et al. Nano Lett. 8 (2008) 565.	J. Fujita et al. J. Appl. Phys. Lett. 49, 06GC01 (2010)
Fabrication Temperature	–	1500℃	900~1000℃	900~1000℃
Large area fabrication	X	△	○	○
Electron mobility	◎	○	○	△ (improved)
High volume production	XX	X	○	◎
Device fabrication	X	△	○	◎
Others		Expensive SiC crystal		•Flexible substrate is available •No transcription

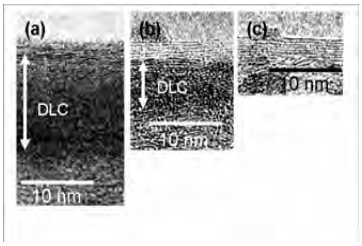
3. Trial of Graphene Transistor



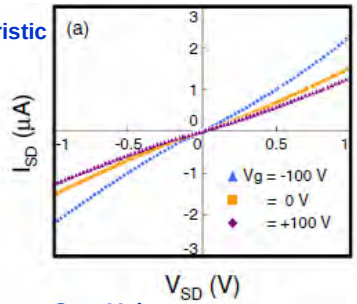
4. a-Carbon Thickness Dependencies of Channel Conductance and Moduration ratio



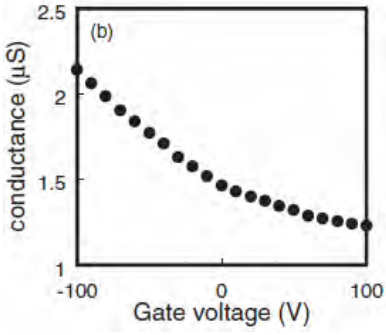
- a-Carbon (DLC) thickness



- I-V Characteristic



- Conductance vs. Gate Voltage



4. Patent status & Patent owner contact

- **Patent license is available.**

Patent No. :PCT/JP2010/054602

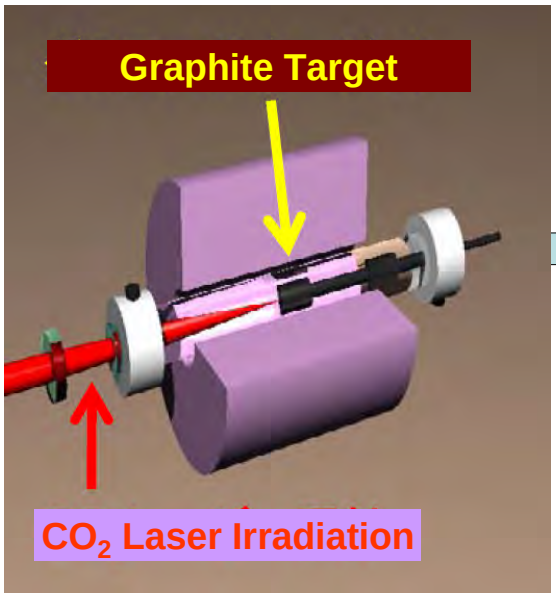
Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

Carbon Nanohorn

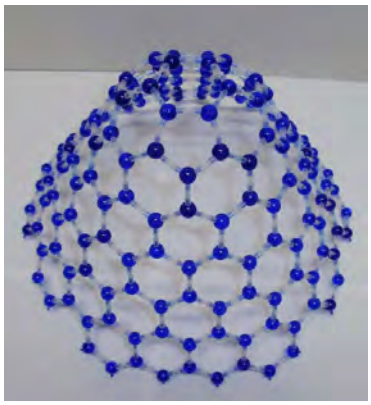
Prof. Sumio IIJIMA (Meijo University)
Prof. emeritus Hidekazu TOUHARA (Shinshu University)

Fabrication of Carbon Nanohorn

- Carbon nanohorns are manufactured by the CO_2 laser ablation of carbon.



Carbon Nanohorn



2～4 nm

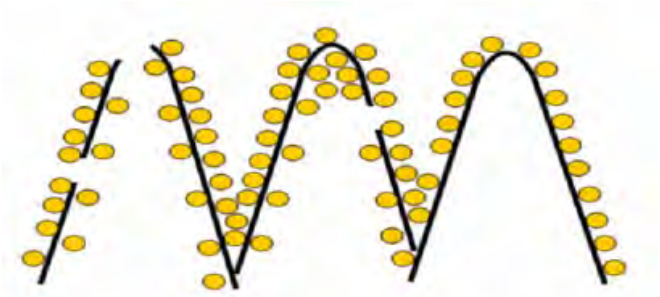
Application

- Electrical conductors
- Drug delivery
- Li^+ capacitor battery
- Metal absorber
- *Gas absorber*
  ex. Fluorine Gas

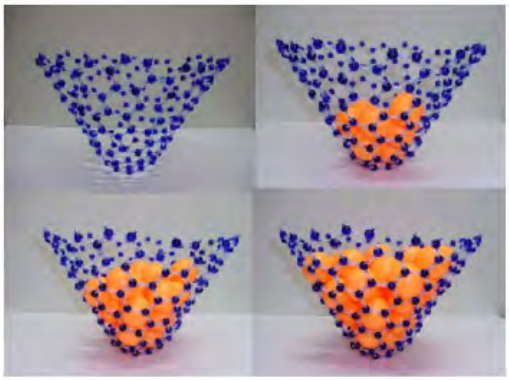
Fluorine (F_2) storage nano-cylinder

This research was sponsored by NEDO (New Energy & Industrial Technology Development Organization.

- Carbon nanohorns (CNHs) indicate the behavior of F_2 adsorption- desorption.
- Hole-opend CNHs is one of the best candidate as a nano-cylinder for F_2 storage which adsorbs 100 wt% F_2/CNH and releases almost 100% of adsorbed F_2 .



Hole-opened CNH As grown CNH



F_2 storage 100 wt%

- F_2 purity more than 99%
- Repeated use of CNHs
- F_2 release on heating under reduced pressure

CNHs Fabrication Patent owner contact

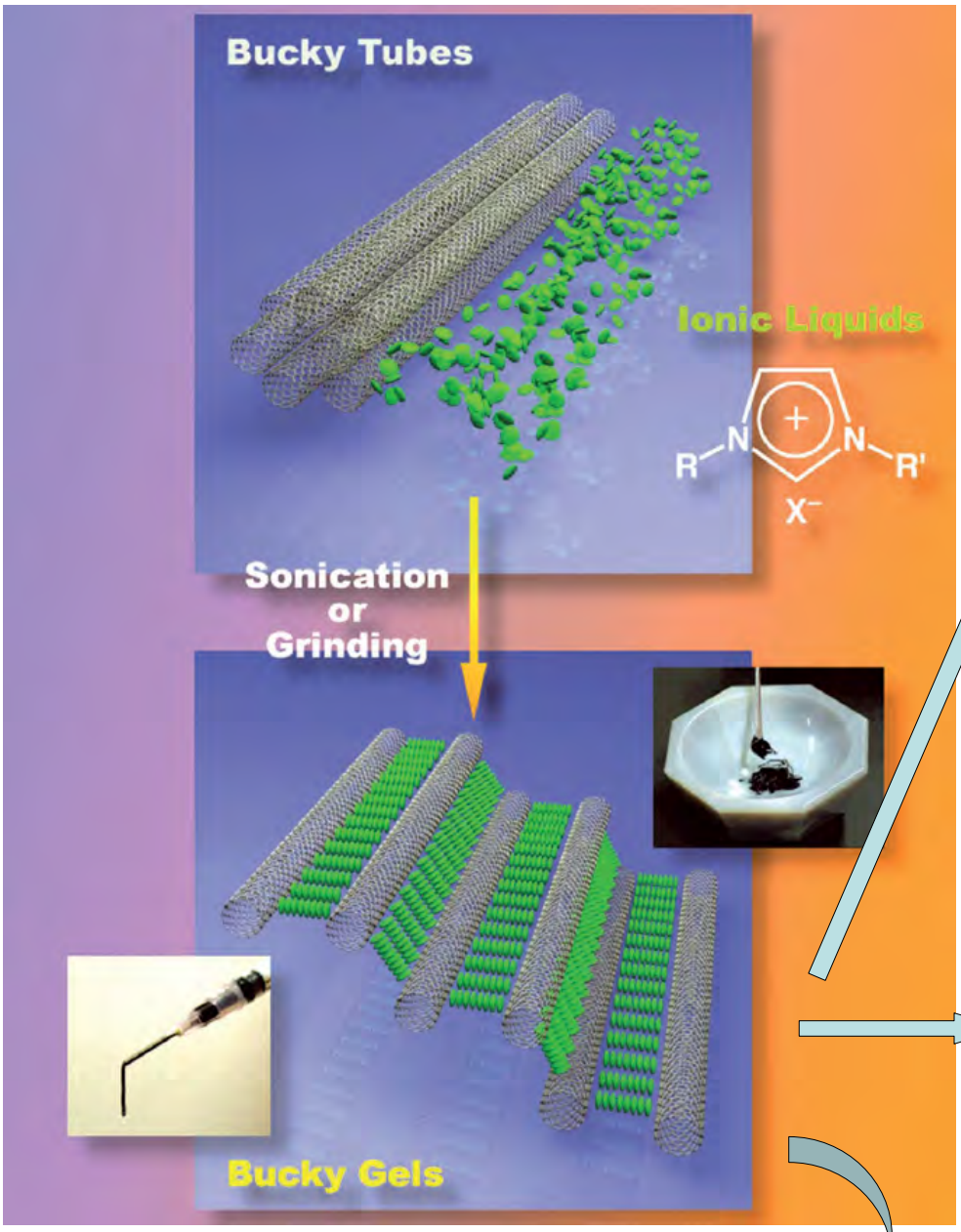
- Patent license is available.

Patent No. : JP4394383,US10/560808,EP4745618.1,CN200480016853.9;
JP3479889,US10/483796,EP2746051.8,CN200202814122.9

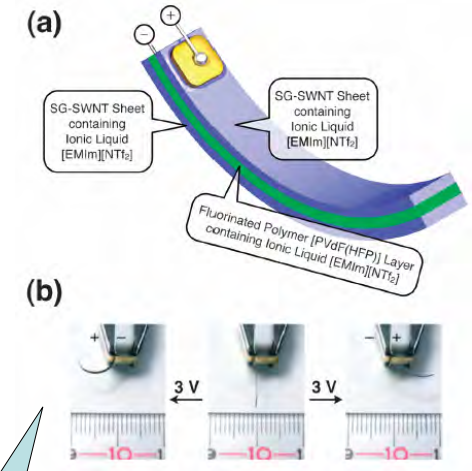
Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486, e-mail: license@jst.go.jp

Carbon Nanotubes Encounter Ionic Liquids to create New Soft Materials

Prof. Takuzo AIDA (Tokyo University)

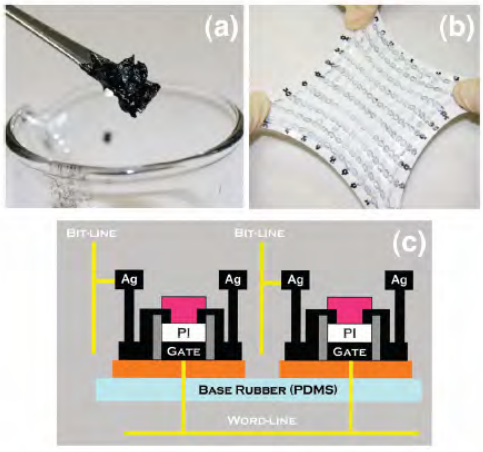


▪ Actuator



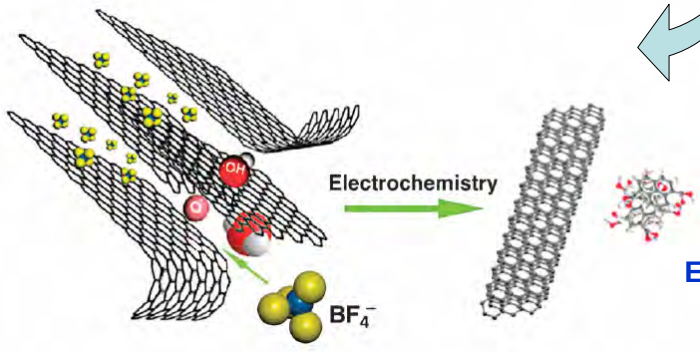
Quick bending motion (＜1s) with 3V

▪ Electrical conductors



Stretch & elastic conducting wires by screen-printing

▪ Exfoliation/dispersion of graphenes



Exfoliation of graphite into graphene nanosheets, nanoribbons or nanoparticles

Patent status & Patent owner contact

- **Patent license is available.**

Patent No. : US7531114, JP3676337, KR627184, CN200380101950.3, (EP1555242)

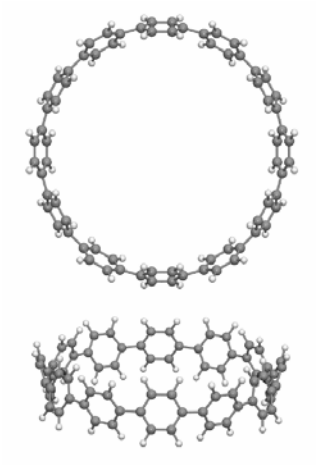
Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486, e-mail: license@jst.go.jp

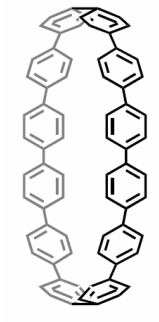
Cycloparaphenylene (CPP)

Prof. Kenichiro ITAMI (Nagoya University)

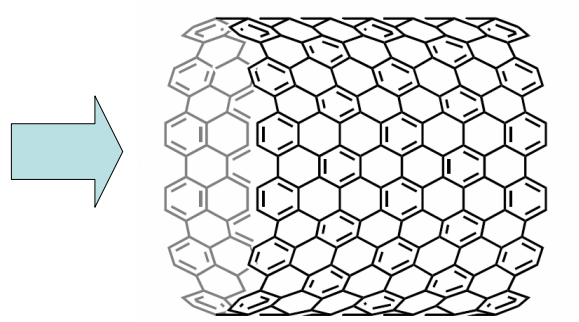
1. CPP Molecular Structure

- Despite the structural simplicity and beautiful structure of CPP, no successful synthesis had been reported at the inception of our work.
- CPP has a potential precursors in the preparation of structurally uniform armchair or carbon nano-tube.





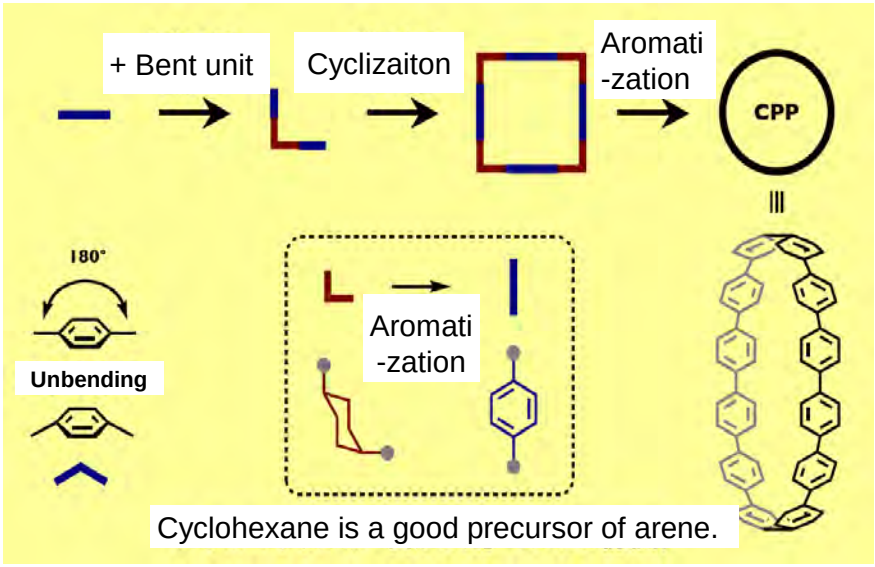
CPP

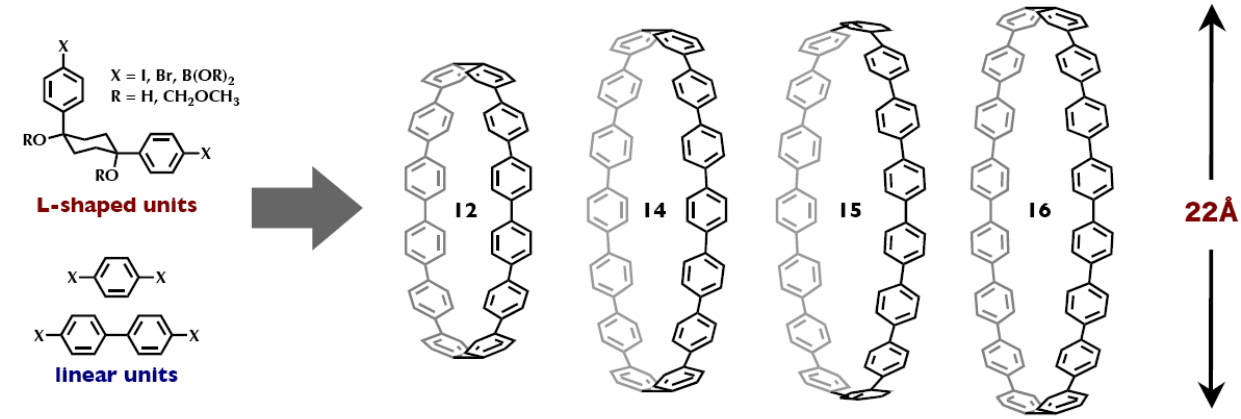


Carbon Nano Tube

2. Synthesis of CPP

- Synthesis strategies are ;
  1) Using linear (arene) & bent (cyclohexane) units
  2) Using Pd-catalyzed Suzuki-Miyaura cross-coupling reactions to connect both linear and bent units
  3) Using acid for final transformation to CPP
- Our success in synthesis of CPP (n=9,12,14,15,16)





3. Patent Status & Patent contact

- Patent license is available.

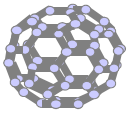
Patent No. : PCT/JP2011/052948, PCT/JP2011/055423

Patent contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486, e-mail: license@jst.go.jp

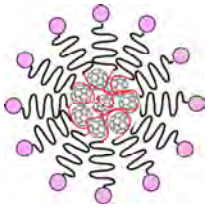
Water Soluble Fullerenes for Biomaterials

1. Solubilization of Fullerenes by water soluble block copolymers

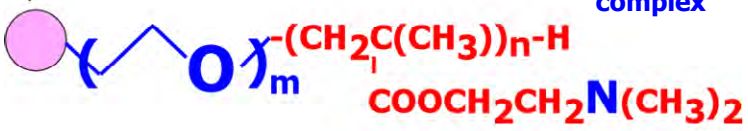
University of Tsukuba



C_{60}, $Ga@C_{82}$, etc.



Fullerene/polymer complex

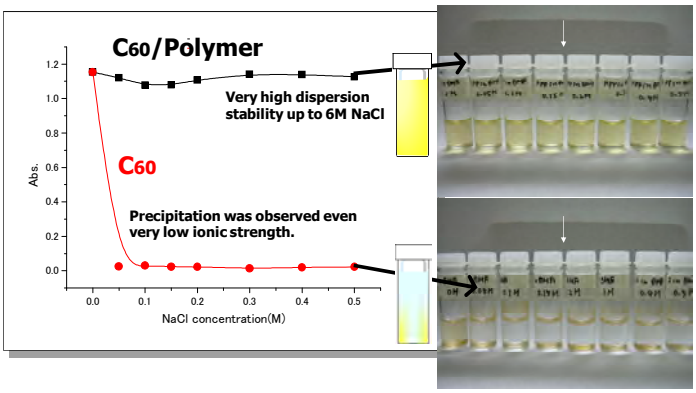


- In vivo imaging
- In vivo Therapy
- ROS* Scavenger
  (* Reactive Oxygen Species such as O_2^-)

Prof. Yukio NAGASAKI

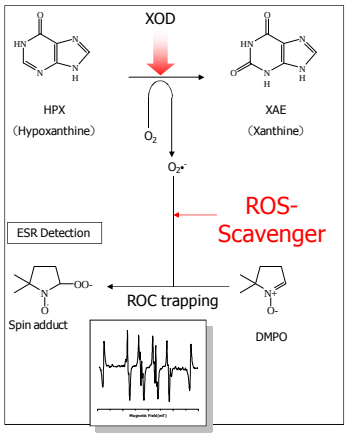
Dr. Yukichi HORIGUCHI

- C60/polymer is extremely stable under high salt conditions

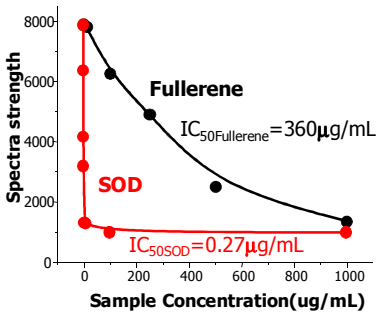


2. ROS Scavenger

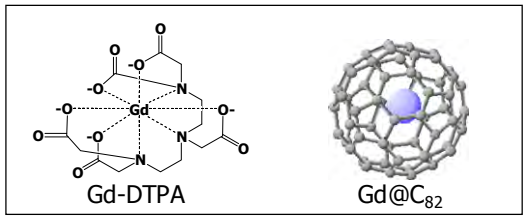
- C60/polymer complex can scavenge ROS



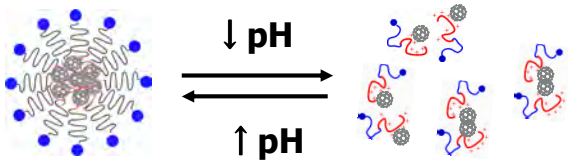
Evaluation of scavenger activity by spin-trapping method



3. Application of Gd-fullerene as pH-sensitive MRI contrast agent



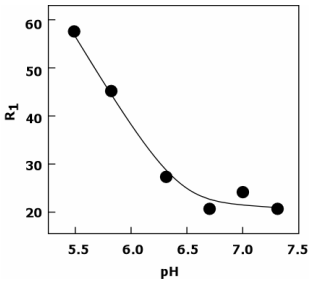
- Many lone pairs of Gd have shortening water relaxation time due to strong electron-proton spin-spin interaction.



Fullerene/polymer complex change its conformation by an environmental pH

pH variation in vivo

Organ	pH
General	7.4
Stomach	6.0 - 2.0
Intestine	7.8 - 7.0
Tuomr	7.0 - 6.0
Ischemia	6.5 - 6.2
Inflammation	<7.0



MRI contrast performance increases under acidic environment

Patent status & Patent owner contact

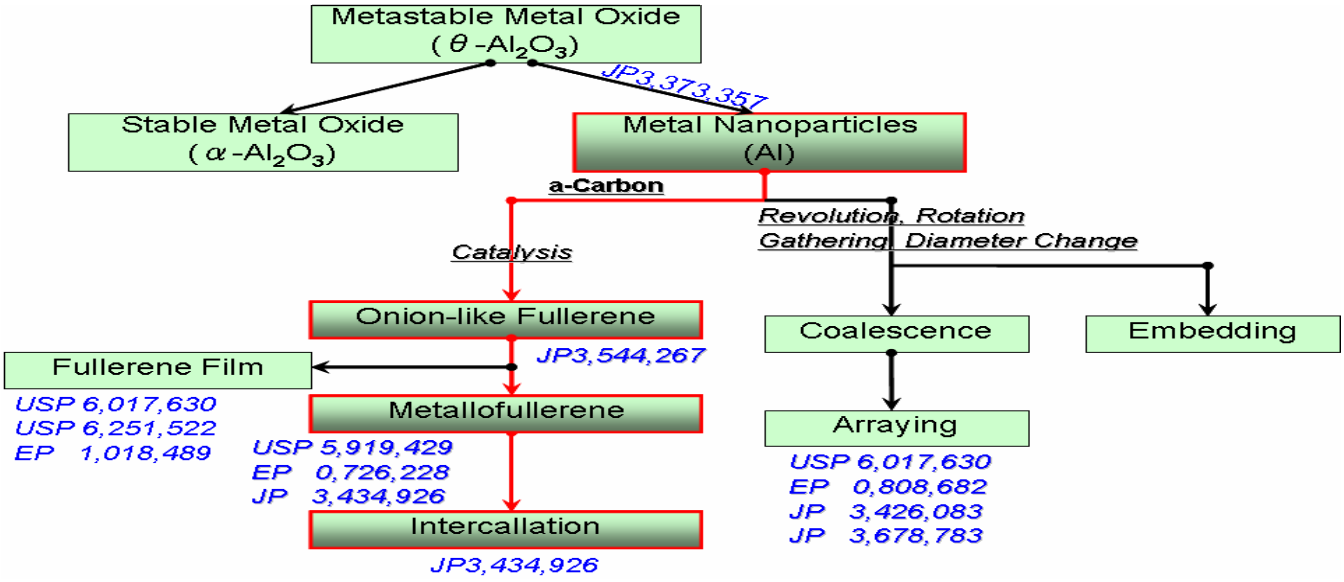
Patent license is available!

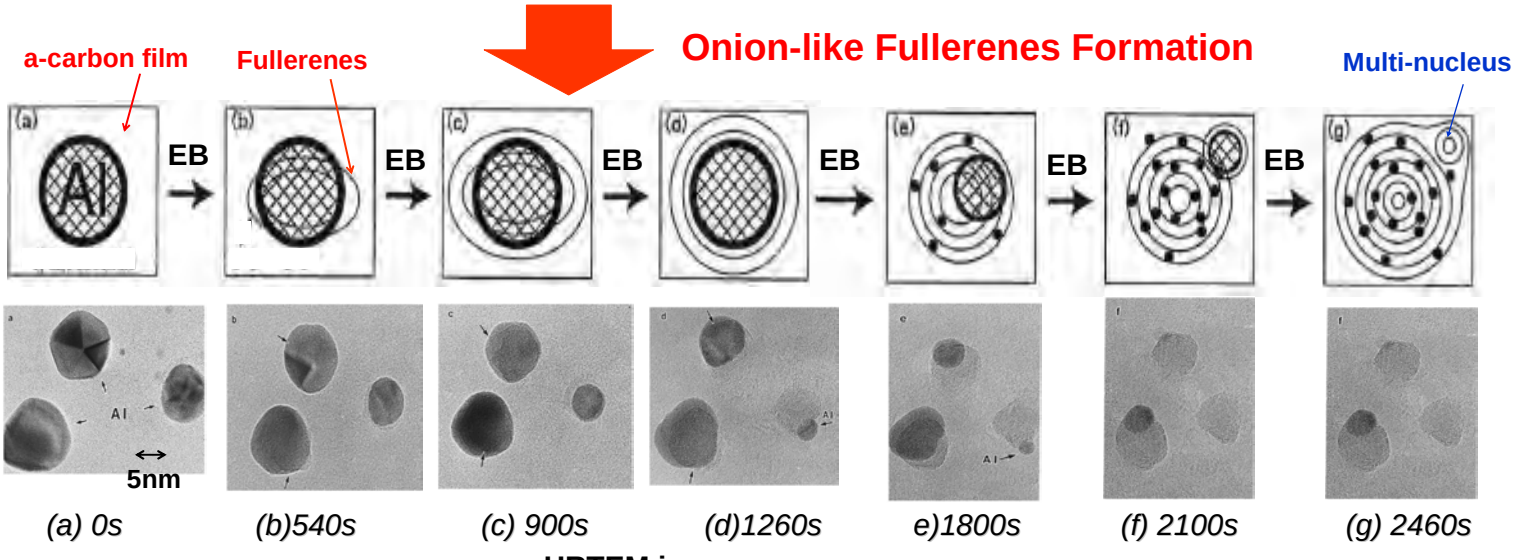
Patent No. :WO2005/035651 Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486 e-mail: license@jst.go.jp

Formation of Fullerene Nanostructures from Metastable Metal Oxides on a-C thin film by Electron Beam Irradiation

Prof. Shun-Ichiro TANAKA (IMRAM, Tohoku University)

1. Formation of Various Fullerene Nanostructures

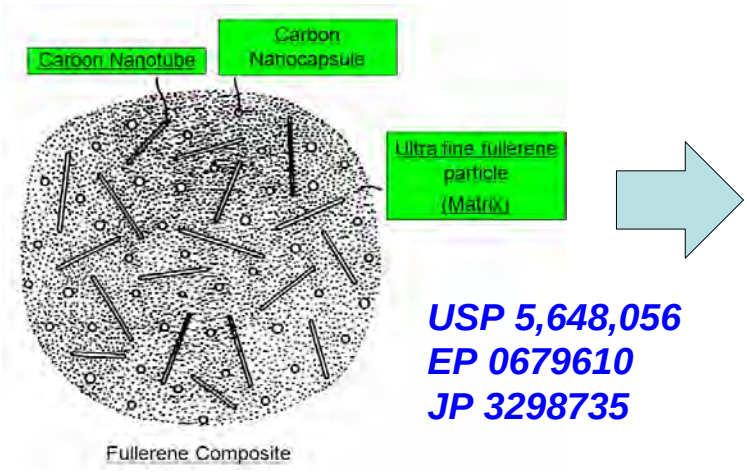




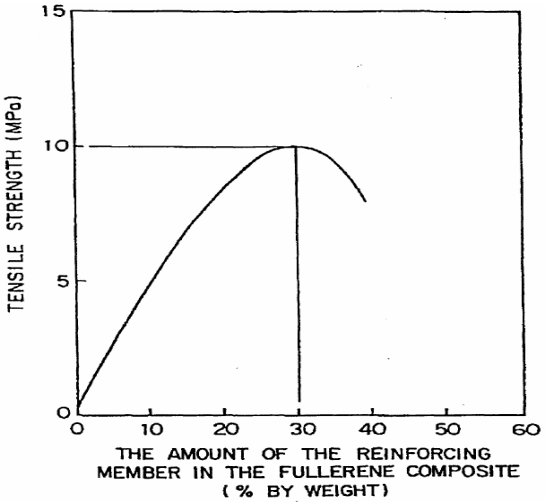
HRTEM images

2. Fullerene Composite and its tensile strength reinforcement

***Fullerene Composite* reinforces the tensile strength of C60 drastically**



USP 5,648,056
EP 0679610
JP 3298735



Ductile Deformation of Fullerene composite

Matrix: C60
Filler : Carbon Nanotube, Carbon Nanocapture

3. Patent status & Patent owner contact

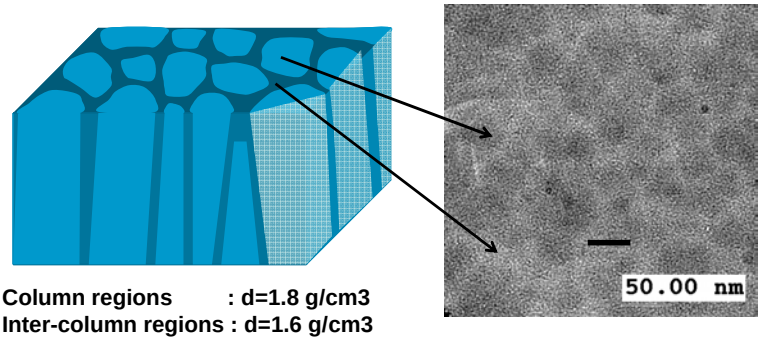
Patent license is available.

Patent owner contact: Hisanori Moriuchi(JST)
Tel:+81-3-5214-8486 e-mail: license@jst.go.jp

Excellent Mechanical Properties of Hybridized Carbon Nano-composite Thin Films

Dr. Eiji IWAMURA (Arakawa Chemical Ind. Ltd.)

1. Fabrication of Hybridized Carbon Films

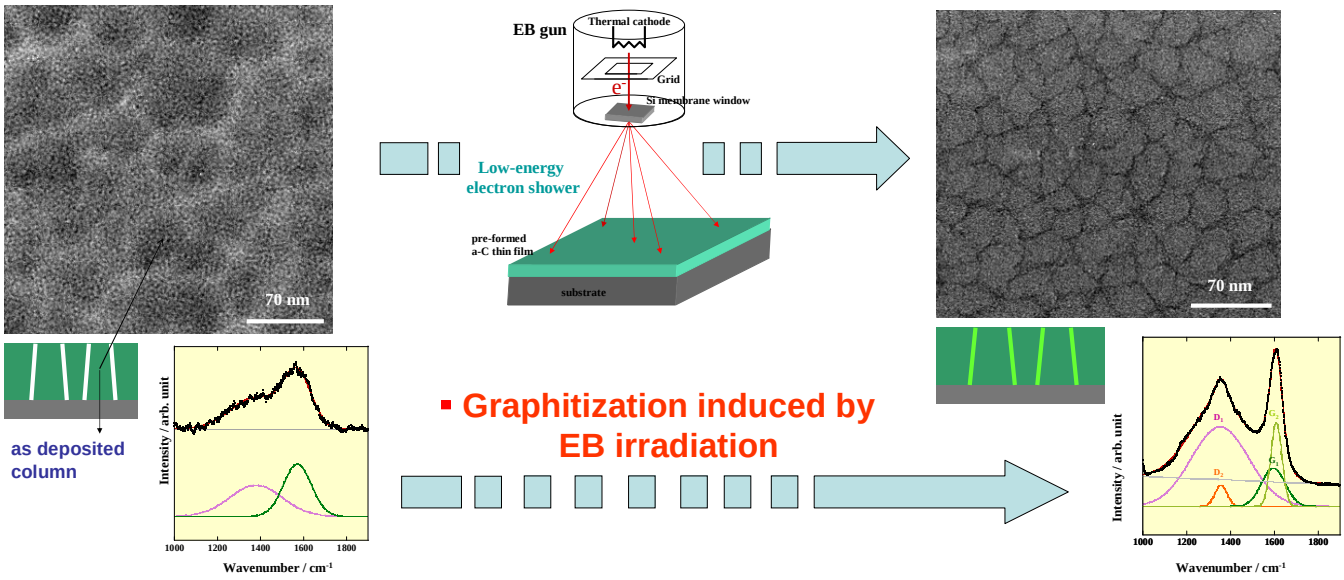


Column regions : d=1.8 g/cm3
Inter-column regions : d=1.6 g/cm3

- **Sputtering method is used under the conditions of both low temperature of substrate and high pressure of atmosphere gas for fabrication of network structures consisting of columns and inter-column regions in a-C films.**

Hybridized a-C film : Thickness: 500 nm
Sputter deposited on Si wafer
Substrate : Room temp.
Ar+CH_4 gas pressure: 4Pa

2. Structural Modification by low-energy EB Irradiation

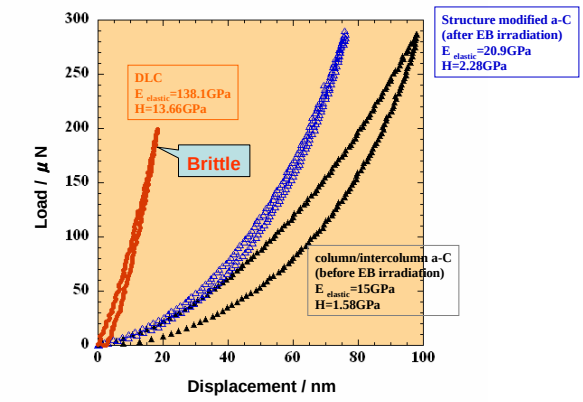


- **Graphitization induced by EB irradiation**

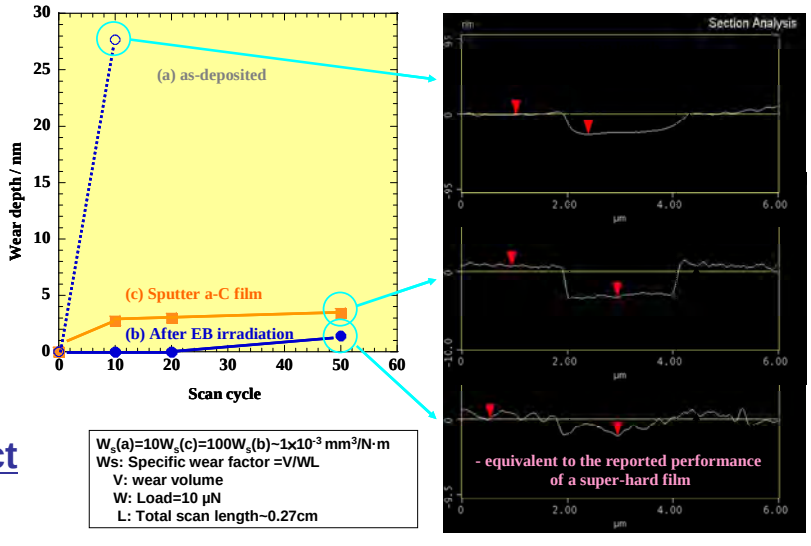
3. Mechanical Properties of EB irradiated film

- **EB irradiated film shows not only superior wear resistance but high elasticity.**

Film hardness : Nanoidentation test



Micro-wear resistance test



$W_s(a)=10W_s(c)=100W_s(b)\sim1\times10^{-3}$ mm³/N·m
Ws: Specific wear factor =V/WL
V: wear volume
W: Load=10 μN
L: Total scan length~0.27cm

4. Patent status & Patent owner contact

- **Patent license is available.**

Patent No. :WO2005/083144
Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

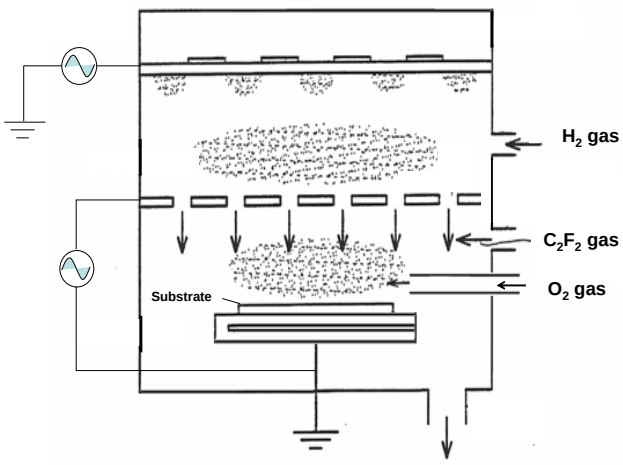
Carbon Nanowall Substrate for Matrix-free Laser Desorption/Ionization Mass Spectrometry

Prof. Masaru HORI (Nagoya University)
Dr. Hiroaki SATO (AIST)

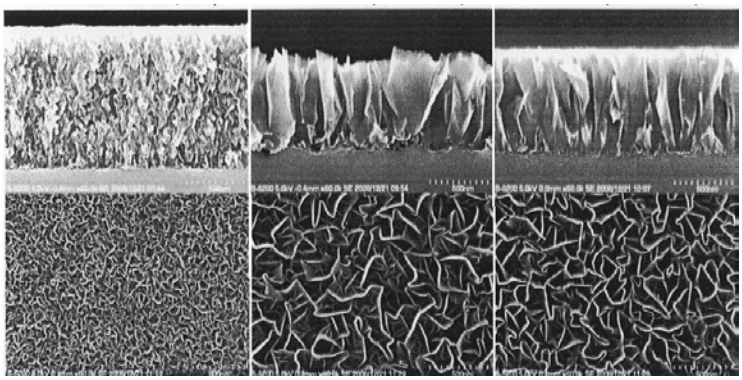
Carbon nanowall substrate, which is fabricated by RI-PECVD (Radical Injection Plasma-enhanced CVD), is very useful for matrix-free laser desorption ionization-mass spectrometry in which mass spectra can be easily observed without obstructive peaks and with good reproducibility.

1. Fabrication of Carbon Nanowall

- **RI-PECVD Equipment**



- **Carbon Nanowall Substrate ; Low cost & Wide variation**



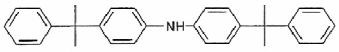
O_2:	0 sccm (0%)	2 sccm (1.3%)	5 sccm (3.2%)
Thickness:	1200 nm	760 nm	890 nm
Growth rate:	60 nm/min	19 nm/min	22 nm/min

2. Mass Spectra using Cabon Nanowall

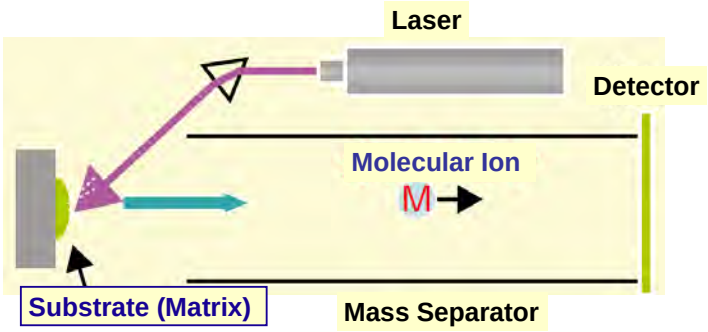
- **No noise peaks**
- **High resolution**
- **Good reproducibility**

Typical examples:

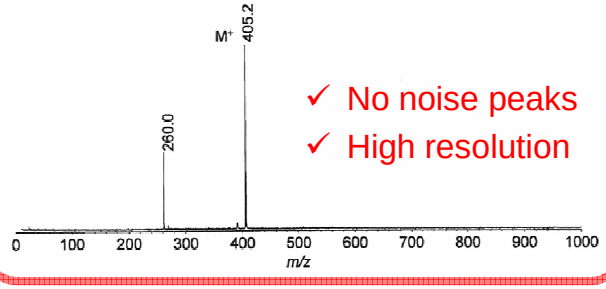
Specimen:
4,4'-(α,α-dimethylbenzyl)diphenylamine



◆ MALDI-Mass Spectrometry

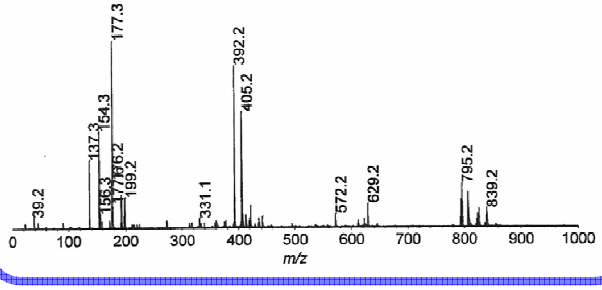


■ **This study:**
Carbon Nanowall Substrate



✓ No noise peaks
✓ High resolution

■ **Conventional Matrix**
(2,5-dihydroxybenzoic acid, DHB)



3. Patent status & Patent contact

- **Patent license is available.**

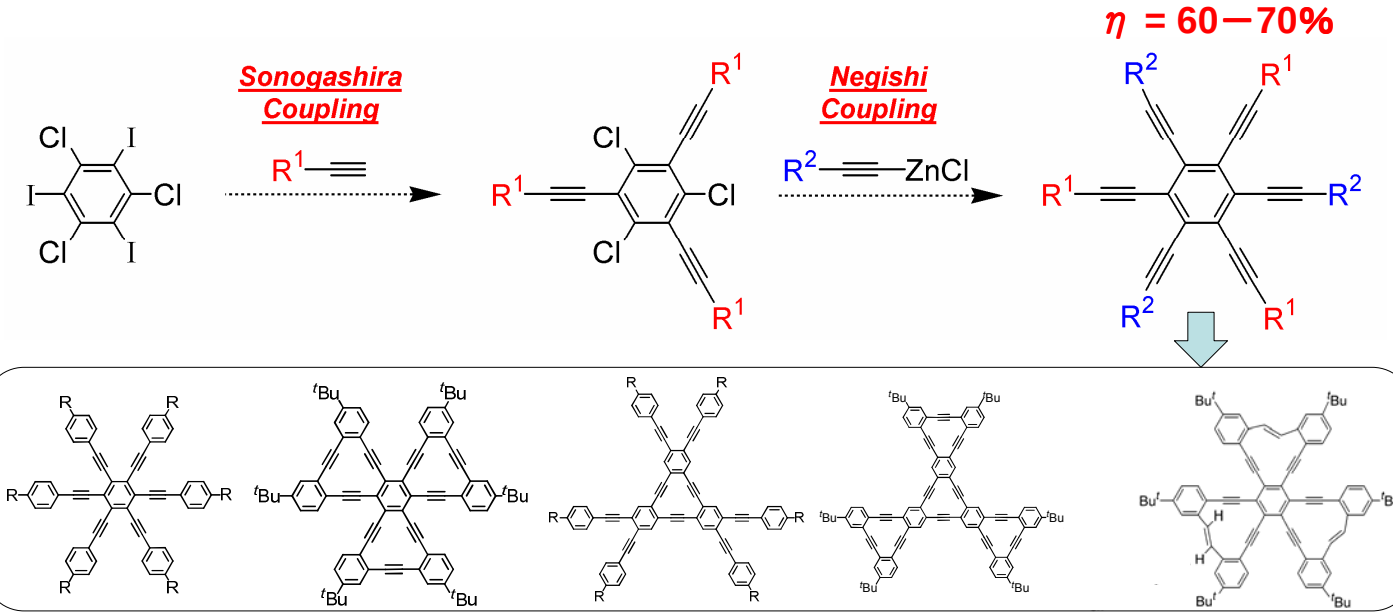
Patent No. : JP2009-183797, PCT application
Patent contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486, e-mail: license@jst.go.jp

Synthesis of Giant π Conjugated Aromatic Compound

Prof. Yoshito TOBE (Osaka University)

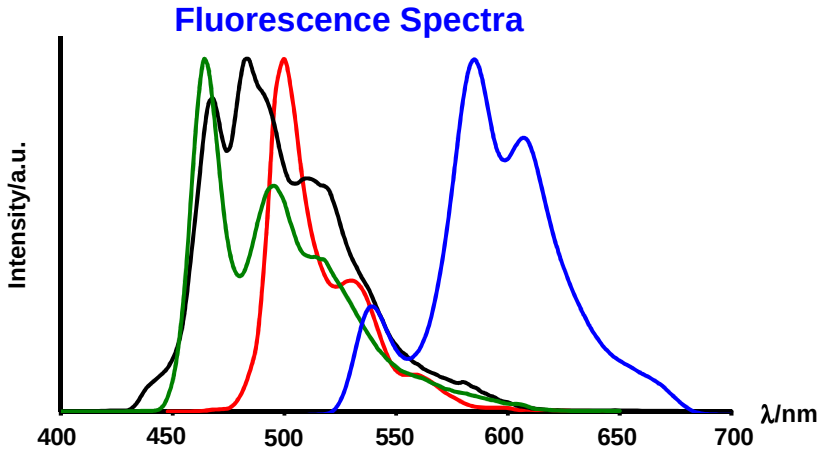
1. Synthesis of Substituted Hexaethynylbenzenes

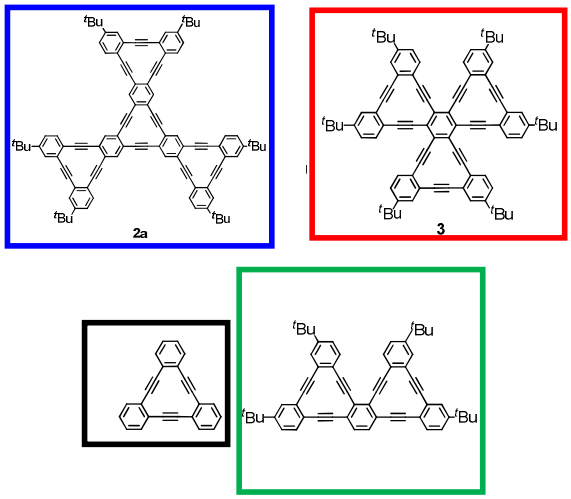
- **Highly efficient synthesis method of differentially substituted hexaethynylbenzens from chloroiodobenzenes.**



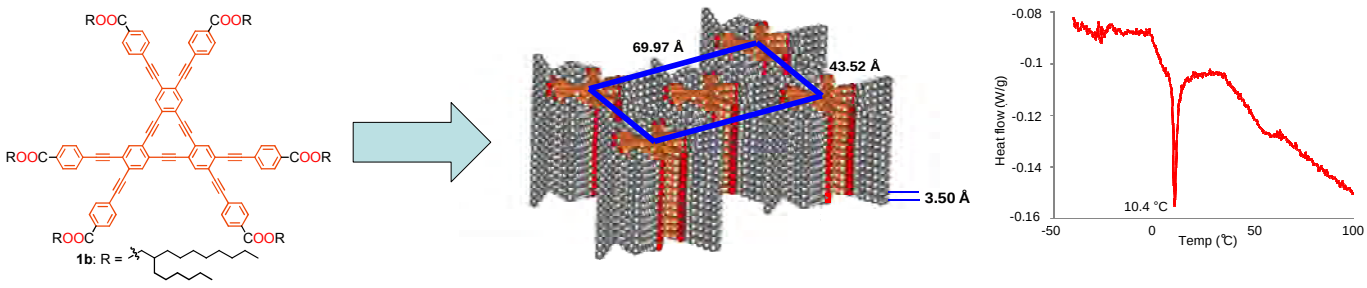
2. Emission Spectra

- **Elongated π-conjugated compounds show red-shift emission spectra, which indicate small band gap.**





3. Liquid Crystal Behavior



4. Patent status & Patent owner contact

- **Patent license is available.**

Patent No. : US6953871, JP4150168

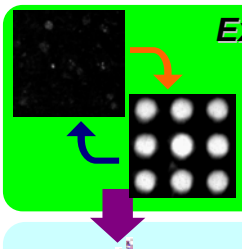
Patent owner contact: Masaru OZAKI (JST)

Tel:+81-3-5214-8486, e-mail: license@jst.go.jp

Diamond DNA Sensor

Dr. Hiroshi KAWARADA (Waseda University)

1. Fast, easy, and lowcost label-free detection can be obtained by FET type sensor.



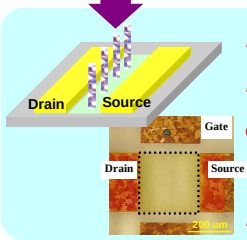
Existing general method

→ Fluorescent observation

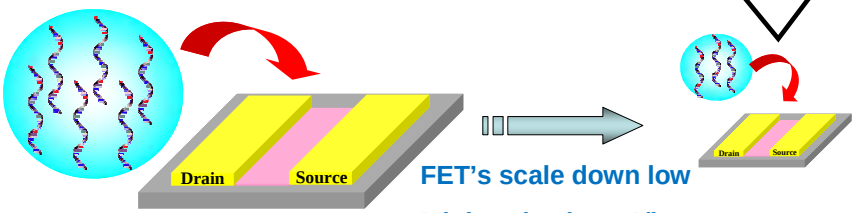
- Target molecules are labeled.
- Large equipment is needed for analyzing

Sensitivity : 1
Chip size : $1/k^2$
Sample amount : 1

Sensitivity : 1
Chip size : $1/k^2$
Sample amount : $1/k^2$ ~ $1/k^3$



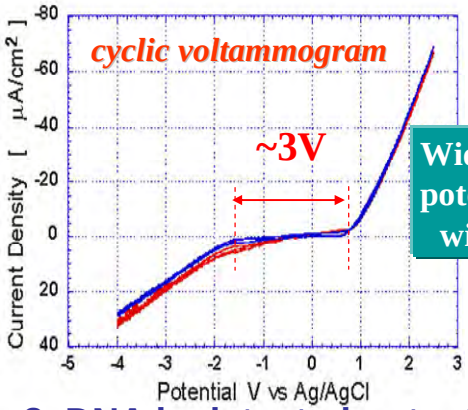
By using FET sensor, label-free detection and downsizing of the device comes to be possible.



FET's scale down low

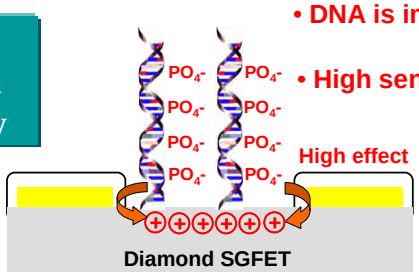
Miniaturization : 1/k

2. High sensitivity can be demonstrated on diamond electrolyte solution gate field effect transistor (SGFET).



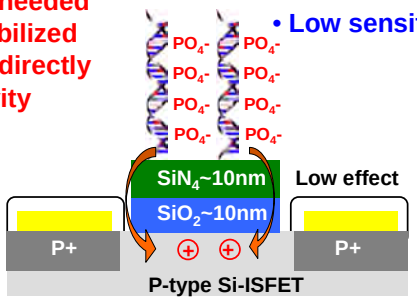
Diamond SGFET

- The gate insulator is not needed
- DNA is immobilized directly
- High sensitivity

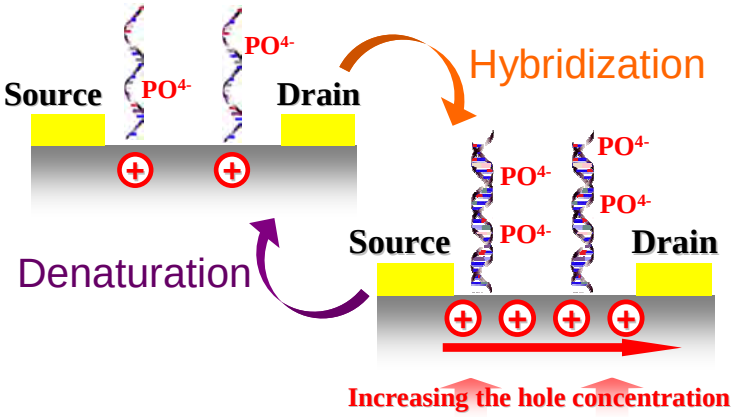


Si-ISFET

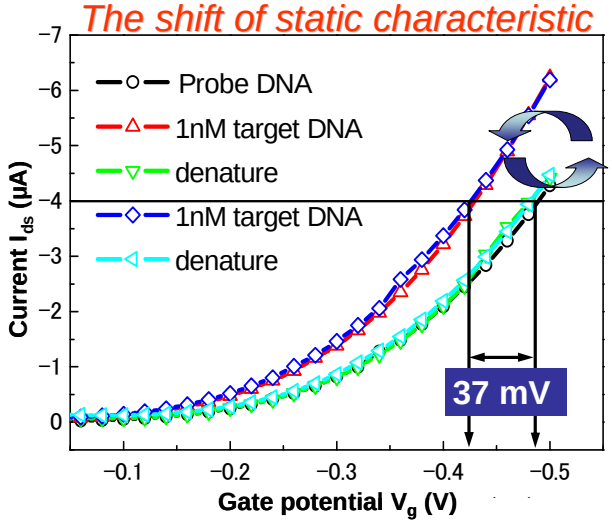
- The gate insulator is needed
- Low sensitivity



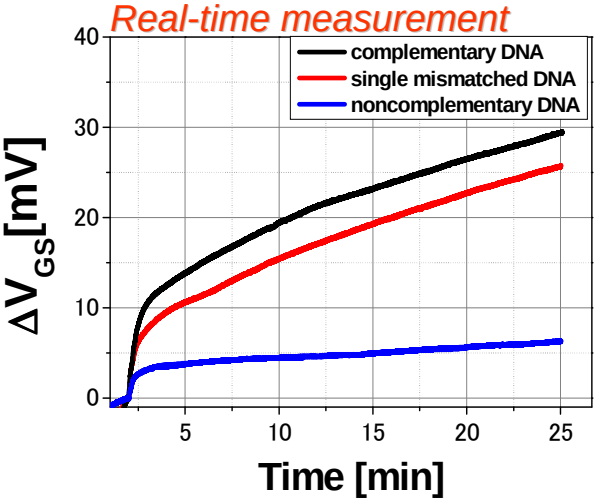
3. DNA is detected potentiometrically in static and real-time measurement.



The shift of static characteristic



Real-time measurement



4. Patent status & Patent owner contact

- **Patent license is available.**

Patent No. : WO2006-025180
Apply country : JP,US, EP
Patent owner contact: Hisahiro Moriuchi (JST)
Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

Nanographite Structure/Metal Nanoparticle Composite

Kiyotaka SHIBA (JFCR), Kenichi SANO (RIKEN) and Kenji IWAHORI (NAIST)

The ferritin molecule displaying carbon nanohorn binding peptide-1 (NHBP-1) on its surface makes it possible to construct nanographite-metal nanoparticle composite by filling the interior of ferritin with metal dots.

1. Construction NHBP-1 displaying ferritin

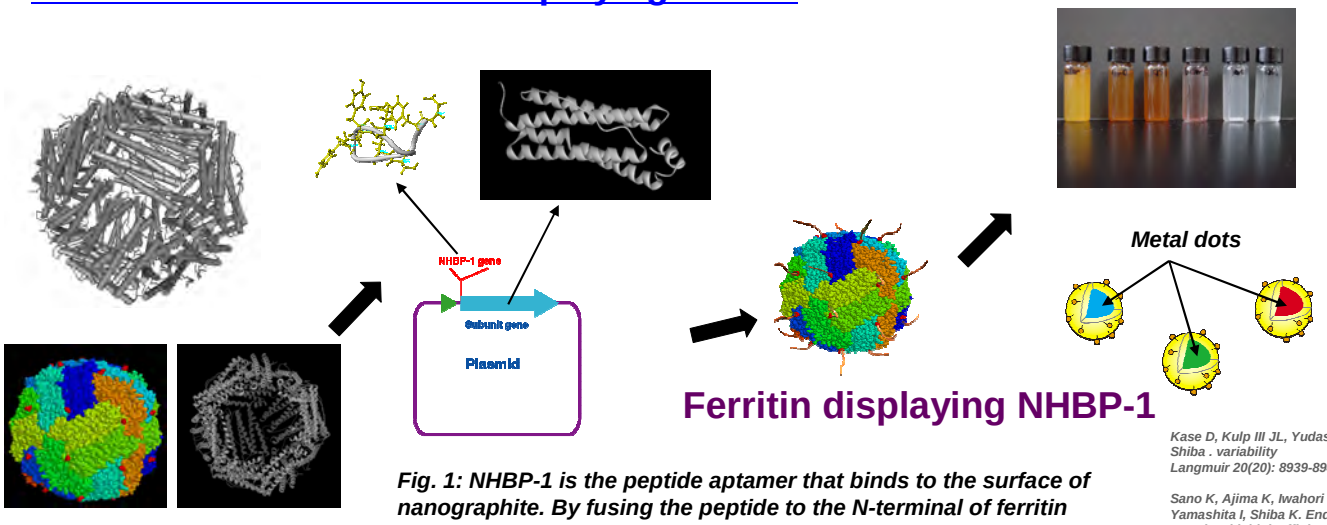


Fig. 1: NHBP-1 is the peptide aptamer that binds to the surface of nanographite. By fusing the peptide to the N-terminal of ferritin subunit, we can endow ferritin with graphite binding ability. Ferritin can be deposited with various metal nanodots in its inner space.

Kase D, Kulp III JL, Yudasaka M, Evans JS, Iijima S, Shiba . variability
Langmuir 20(20): 8939-8941 (2004)

Sano K, Ajima K, Iwahori K, Yudasaka M, Iijima S, Yamashita I, Shiba K. Endowing a ferritin-like cage protein with high affinity and selectivity for certain inorganic materials
Small 1 (8-9): 826-832 (2005)

2. Making nanoelectronic devices using NHBP-1 displaying ferritin filled with metal dots.

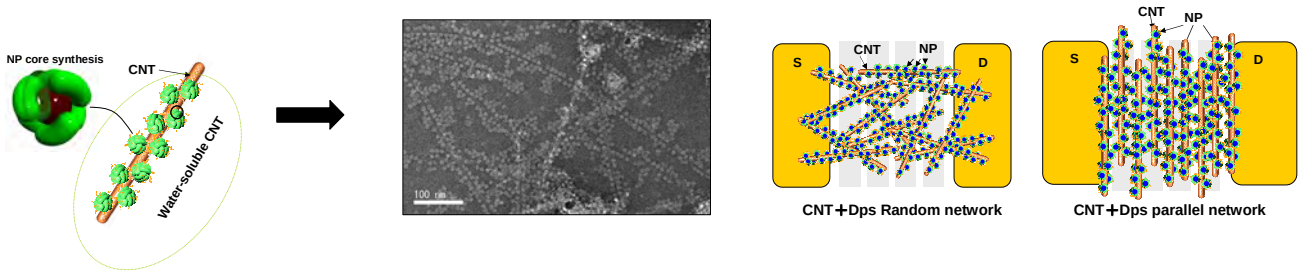


Fig. 2: Recently, Yamashita et al. at NAIST are using this technology to make novel type of electronic devices, in which they fused NHBP-1 to bacterial ferritin, Dps, and prepared the carbon nanotube (CNT)-semiconductor nanodots composites for novel type of electronic devices (personal communication).

3. Growing giant two-dimensional NHBP-1 displaying ferritin filled with metal dots.

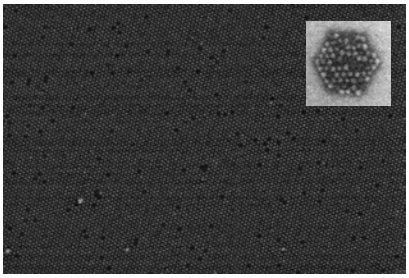


Fig. 3: NHBP-1 has a self-assembling ability that makes it possible to grow two-dimensional array of metal-containing ferritin.

Matsui T, Matsukawa N, Iwahori K, Sano K, Shiba K, Yamashita I. Realizing a two-dimensional ordered array of ferritin molecules directly on a solid surface utilizing carbonaceous materials-affinity peptides.
Langmuir 23(4): 1615 -1618 (2007)

Ikezoe Y, Kumashiro Y, Tamada K, Matsui T, Yamashita I, Shiba K, Hara M. Giant growth of two-dimensional crystal of protein molecules from a three-phase contact line.
Langmuir 24(22): 12836-12841 (2008)

4. Patent status & Patent owner contact

•Patent license is available.

Patent No. : US-2010-0029910-A1
Patent owner contact: Yoshihiro Murai (JST)
Tel:+81-3-5214-8486
e-mail:license@jst.go.jp

Other Innovative Technologies

High-water-content Hydrogel

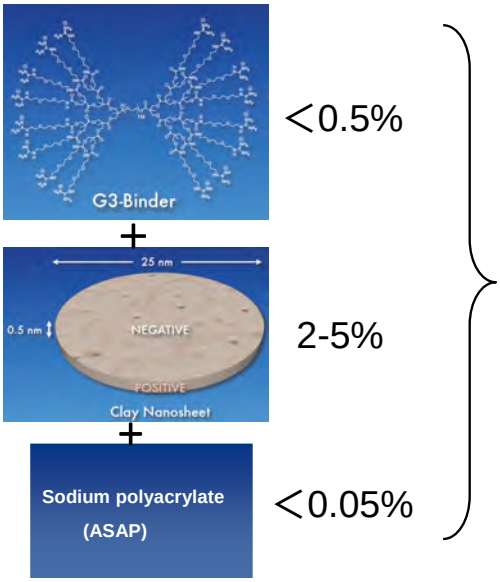
Prof. Takuzo AIDA (Tokyo University)

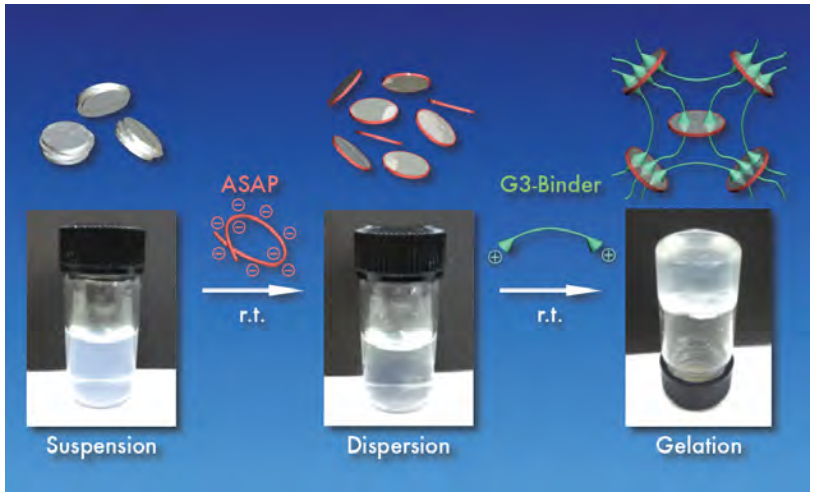
1. New Aqua Material

- Mostly water (＞95% Water ; ＜0.2% Organic)
- Easily preparable
- Disposable (Environment friendly)
- Self-standing (Transportable)
- Self-healable
- Adhesive
- Transparent
- Non-flammable
- Capable of containing bioactivities

2. Preparation of New Aqua Material

- Aqua material can readily be prepared by mixing three components in water at RT.





3. Properties of New Aqua Material

- Moldable, Self-standing, & Transparent

- Comparison of Hydrogels

	Water Content	Content of Organic Components	Mechanical Strength	Required Skill (time)	Self-healable	Resistant to Organic Solvents
Double Network Hydrogel	90%	10%	17 MPa	Very High (2 days)	NO	YES
Nanocomposite Hydrogel	89%	8%	1 MPa	Very High (20 h)	NO	YES
Aqua Material (Our Hydrogel)	**98% 95%**	**0.2%**	**0.1 MPa 0.5 MPa**	**Just Mixing (3 sec)**	**3 sec (100%)**	**YES**
Oligoelectrolyte Hydrogel	97%	3%	0.01 MPa	Low (30 min)	10 sec (100%)	NO
Oligopeptide Hydrogel	99%	1%	0.00017 MPa	Low (overnight)	24 h (100%)	NO

4. Patent status & Patent owner contact

- Patent license is available.

Patent No. : PCT/JP2010/004267, JP2009-156670
Apply country : Worldwide
Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486, e-mail: license@jst.go.jp

Application

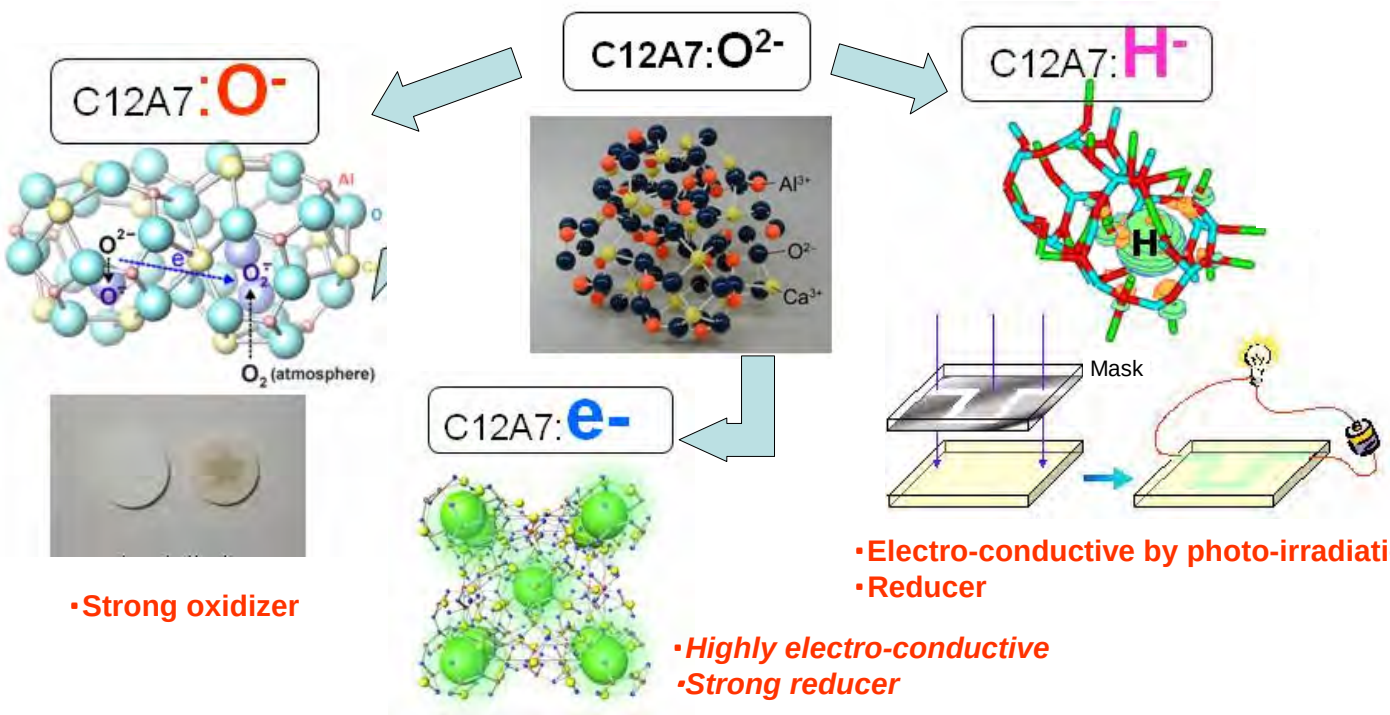
- Regenerated material for bone, cartilage etc.
- Buffer material for sports shoes etc.
- Alternative rubber, plastic etc.
- Fire extinguishant etc
- ・・・・・・・

Electro-conductive & Transparent Nano-porous Compound C12A7

Prof. Hideo HOSONO (Tokyo Institute of Technology)

1. Novel Compound $12CaO \cdot 7Al_2O_3$ (i.e.C12A7)

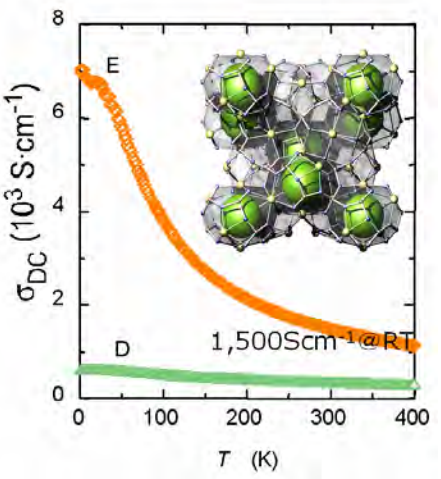
- C12A7 is composed of materials of alumina cements, and has 6 cages with an inner free space of 0.4nm of which only one cage is filled by O^{2-}. These 80% cages are free spaces.
- The oxide ions can be replaced by various anions such as O^-, H^-, OH^-, e^- etc and show very interesting functions.



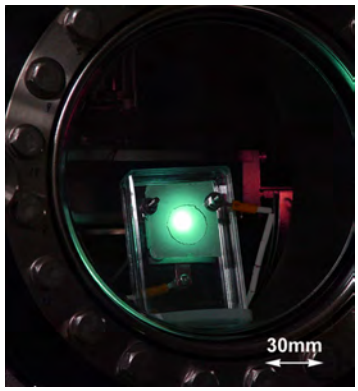
- Strong oxidizer
- Electro-conductive by photo-irradiation
- Reducer
- *Highly electro-conductive*
- *Strong reducer*

2. Electride C12A7: e^-

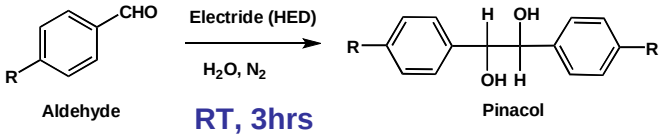
- Conductivity of C12A7: e^-



- Cathode ray emission from C12A7: e^-

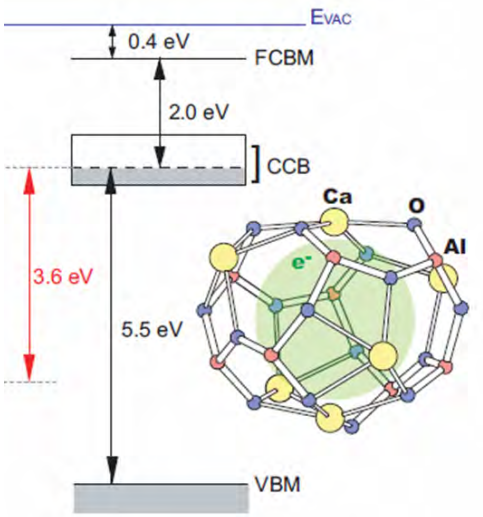


- Reduction reaction using C12A7: e^-



η = 96%

3. Small work function of C12A7: e^-



4. Patent status & Patent owner contact

- Patent license is available.

Patent No. :US6818192,7462334.7235225,7507289,7465433, EP1717217, JP4147324,4219821,4245608, TW283234 etc

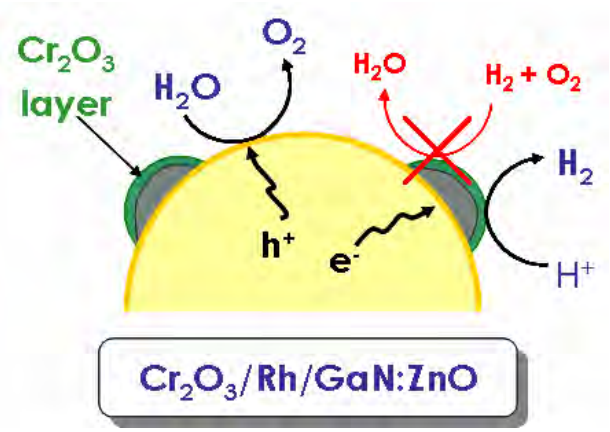
Patent owner contact: Masaru OZAKI (JST)
Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

Photocatalyst Releasing Hydrogen from Water

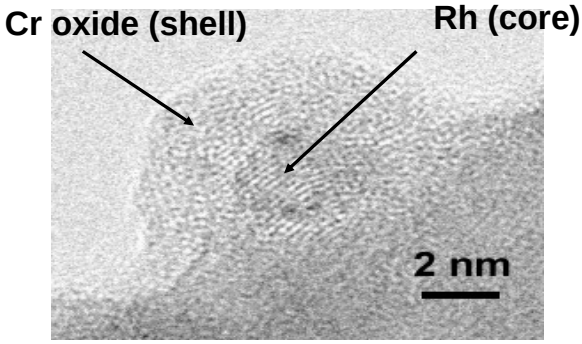
Prof. Kazunari DOMEN (University of Tokyo)

1. Direct Splitting of Water by Visible Light

- New catalyst is a solid solution of Ga-Zn-O (ex.$Ga_{0.7}Zn_{0.3}N_{0.7}O_{0.3}$) modified with nano-particles of Rh-Cr oxide

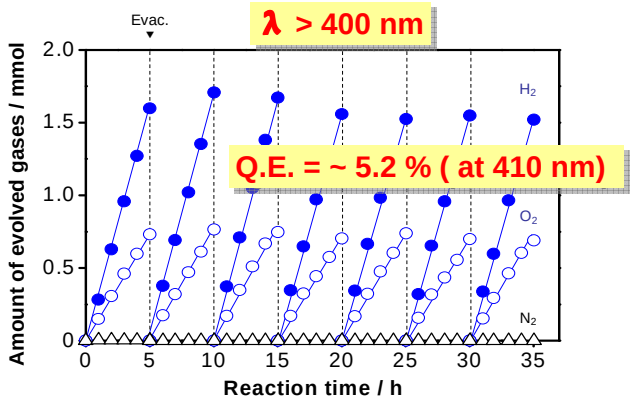


High resolution TEM image



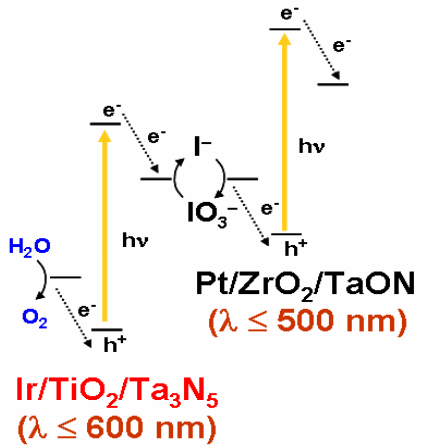
Cr oxide/Rh/GaN:ZnO
after Cr^{3+} deposition

- The quantum efficiency of water splitting by visible light is about 5% at 410nm

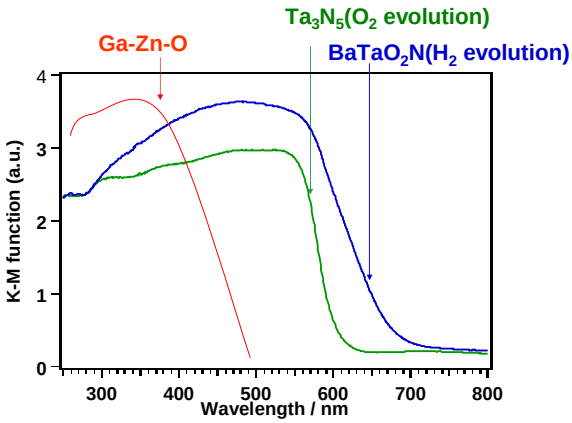


2. Improved Method for Higher Quantum Efficiency

- Two step excitation system on water splitting under visible light



- Using photocatalysts to extend the absorption edge to longer wavelengths



3. Patent status & Patent owner contact

- Patent license is available.

Patent No. : USP6878666, 6864211, 6838413, 7015171, 7670712

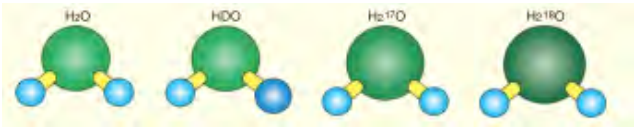
Patent owner contact: Masaru OZAKI (JST) Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

Measurement of Water Isotopomers and its Applications

Prof. Naohiro YOSHIDA (Tokyo Institute of Technology)

1. Water Isotopomers (WI)

Isotopomers of water molecule



Isotopomer ratio	Rel. abundance	Conventional technique	Expression
$HD^{16}O/H_2{}^{16}O$	0.03%	Reduction to H_2 H_2 equilibration with Pt catalyst Laser spectroscopy	δ D*1
$H_2{}^{18}O/H_2{}^{16}O$	0.20%	CO_2 equilibration Laser spectroscopy	$\delta\,^{18}O$
$H_2{}^{17}O/H_2{}^{16}O$	0.04%	Fluorination with BrF_5 (CoF_3)	$\delta\,^{17}O$

*1: δ D (‰) = $(D/H)_{sample}$ / $(D/H)_{VSMOW}$ – 1
VSMOW: Vienna Standard Mean Ocean Water provided by IAEA and NIST/USA

Analysis of WI is applicable to;

- — global environments
- — traceability of foods
- — medical cares
- — criminal investigations

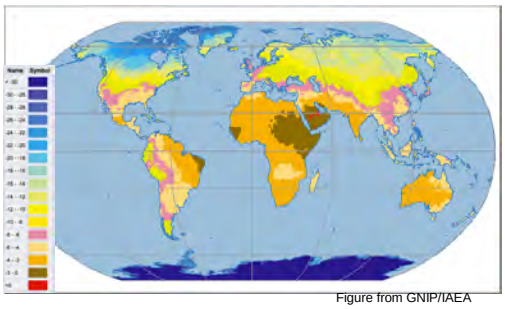
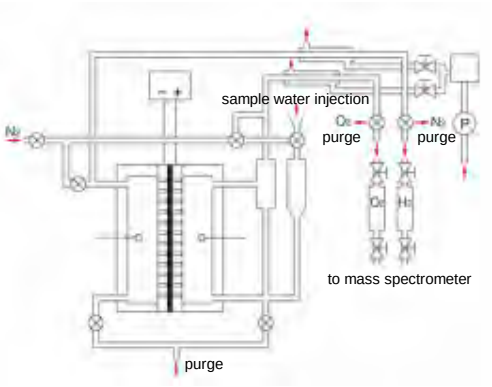


Figure from GNIP/IAEA

Global mapping of isotope ratio ($\delta\,^{18}O$) in precipitation

2. Rapid and Precise WI Analysis by Water Electrolysis Device (WED)

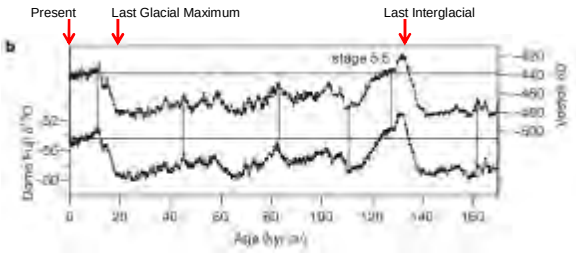


Comparison with other techniques

	Equilibration	Fluorination (for O) Reduction (for H)	Laser Spectroscopy	WED
Advantage	Longest history Commercially available	Micro-liter sample Commercially available (reduction)	Micro-liter sample Fastest analysis	Fast analysis Micro-liter sample
Disadvantage	Slowest analysis Difficult for micro-liter	Chemical hazardous Difficult to control	Worst precision	
^{17}O analysis	Possible but difficult	OK (by fluorination)	Impossible	OK

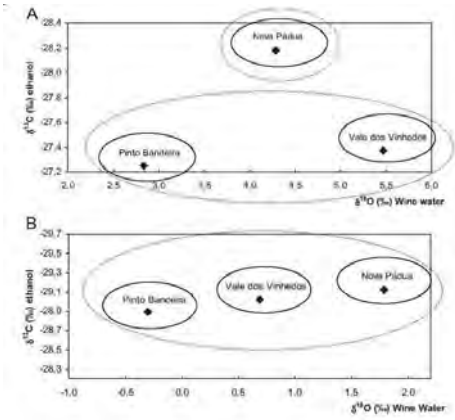
3. Applications of WI Analysis-Environment, Food and Human Diagnosis

Historical change of global temperature reconstructed from Antarctic Ice Core.



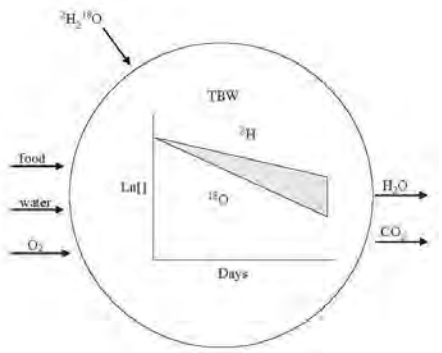
Watanabe, Yoshida, et al. (Nature, 2003)

Geographic origin (cultivation regions) identified using δ 18O of wine water.



Example for Brazilian wines Adami et al., *RCM*, 2010

Metabolic energy measured by doubly labeled water (DLW) method



Schoeller , *International J. Obesity*, 2008

4. Patent status & Patent owner contact

- **Patent license is available.**

Patent No. : WO00/49640, WO00/58712
Apply country : JP,US, EU
Patent owner : JST, Tokyo Institute of Technology

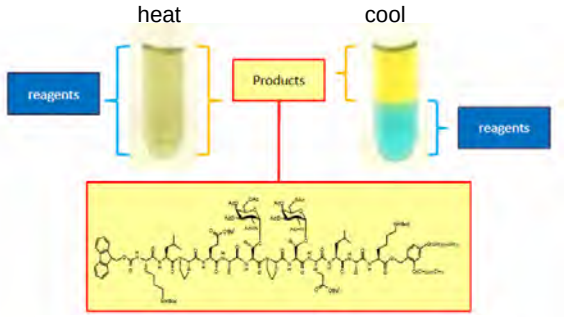
Contact: O.KANZAKI (JST) Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

A Novel Technology for Solution Phase Peptide Synthesis

Dr. Kazuhiro CHIBA（Tokyo University of Agriculture and Technology）

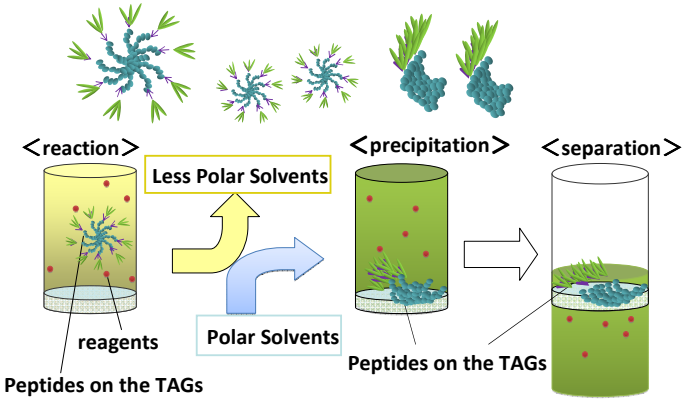
1. Introduction

Basic Technology
Chemical Synthesis in biphasic miscible organic solution

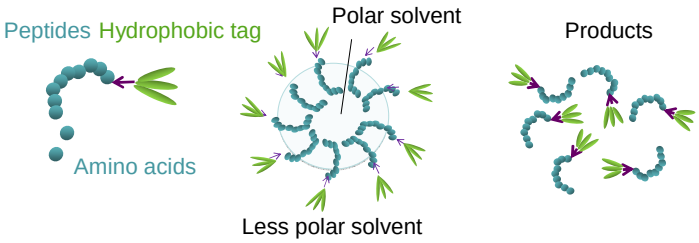


Cyclohexane-based biphasic miscible organic solution

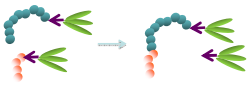
Example of Application
Product Separation in biphasic immiscible solvents



2. Application for peptide synthesis

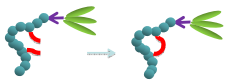


Fragment synthesis



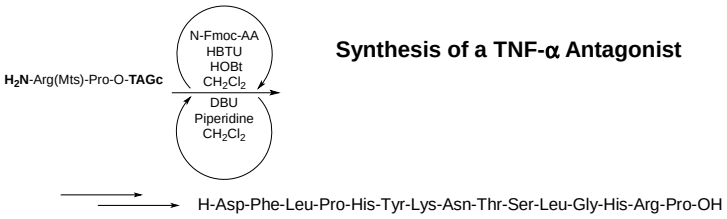
Up to equimolar reactions

Bridge formation

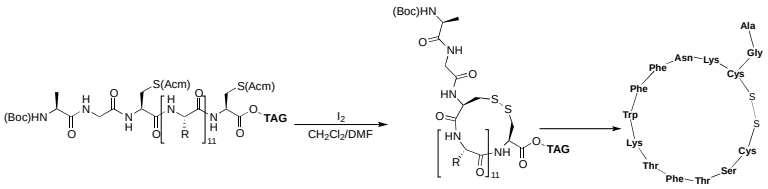


Varied modifications

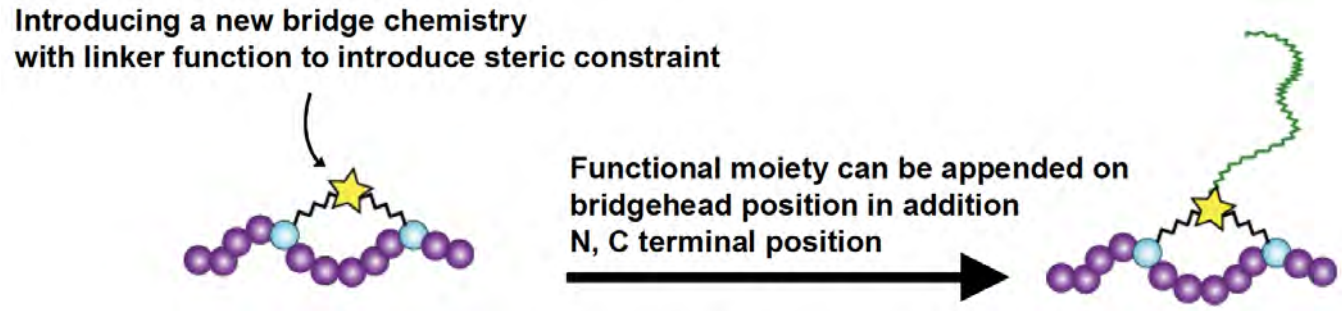
Synthesis of a TNF-α Antagonist



Synthesis of Somatostatin



3. Peptune™ (commercially available product) approach



Peptune™ provides new peptide scaffolds with artificial bridge which is;

1. introducing other functional moiety into peptide's backbone as well as controlling structural constraint of peptides
2. as a similar approach to medicinal chemistry
3. with a unique liquid phase synthesis method
4. applicable to peptide therapeutics, delivery motives, and diagnostics

4. Patent status & Patent owner contact

Patent license is available.

Patent No. : 3538672（JP) and others
Applied in : JP,US,EP,CN
Patent owner contact : Osamu KANZAKI
Tel: +81-3-5214-8486
e-mail: license@jst.go.jp
Peptune patent filed in worldwide by JITSUBO Co.Ltd., a Japanese licensee of JST for the basic patent and also available for licensing.

Ultrasonic Elasticity Imaging of Arterial Wall for Tissue Characterization

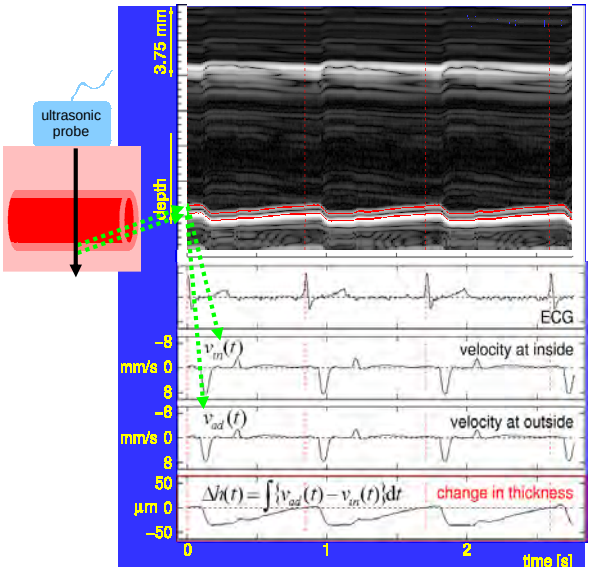
Prof. Hiroshi KANAI (Tohoku University)

【Summary】

Diagnosis of vulnerability of atheroma is important for prevention of cardiovascular and cerebrovascular events. We have developed a method for measurement of the regional elasticity of the arterial wall with transcutaneous ultrasound. This method has potential for noninvasive tissue characterization of artery wall.

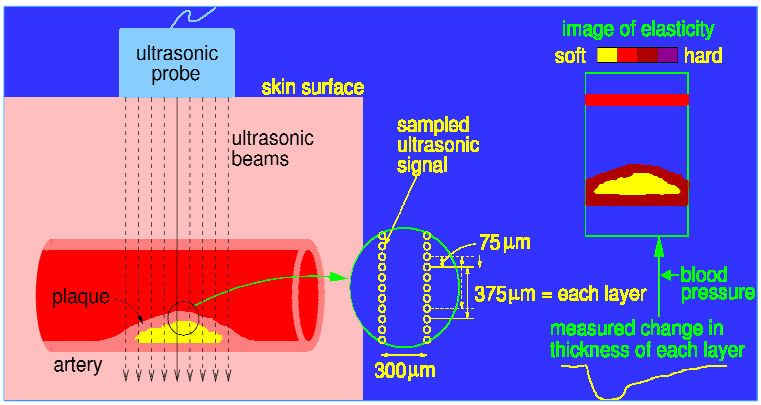
【Phased Tracking Method】

for measuring small change in thickness (strain) of artery wall caused by heartbeat

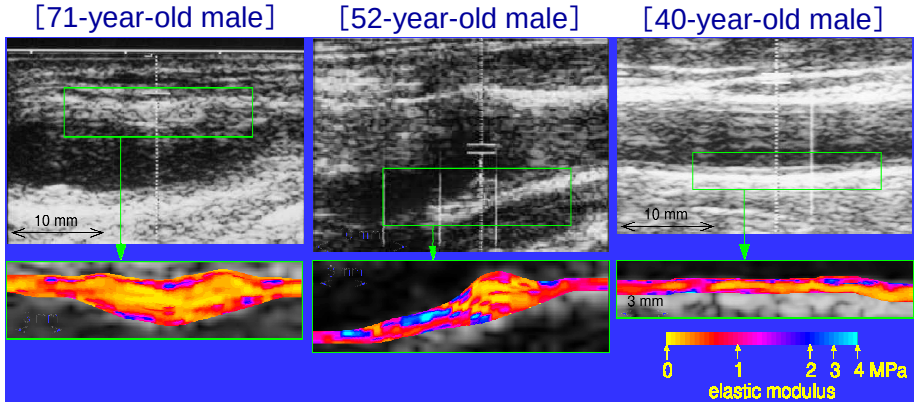


【Elasticity Imaging】

by measuring spatial distribution of changes in thickness (strain) and systolic/diastolic blood pressure measured with cuff at brachial artery



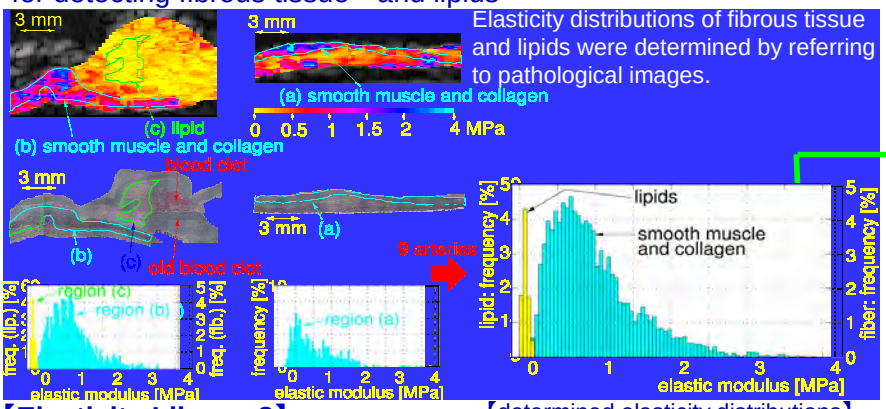
【Transcutaneously Measured Carotid Elasticity Images】



【Elasticity Library 1】

※fibrous tissue=mixture of collagen and smooth muscle

for detecting fibrous tissue※ and lipids

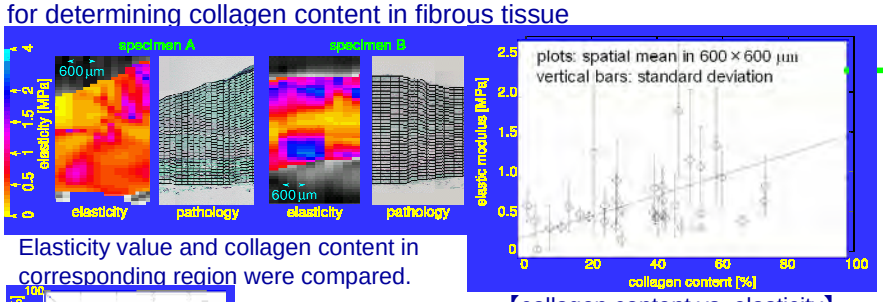


Elasticity distributions of fibrous tissue and lipids were determined by referring to pathological images.

【determined elasticity distributions】

【Elasticity Library 2】

for determining collagen content in fibrous tissue

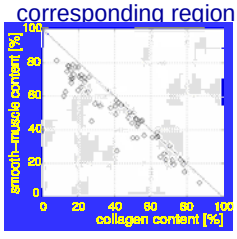


Elasticity value and collagen content in corresponding region were compared.

【collagen content vs. elasticity】

regression line: E=0.013·CC+1.5 [MPa]

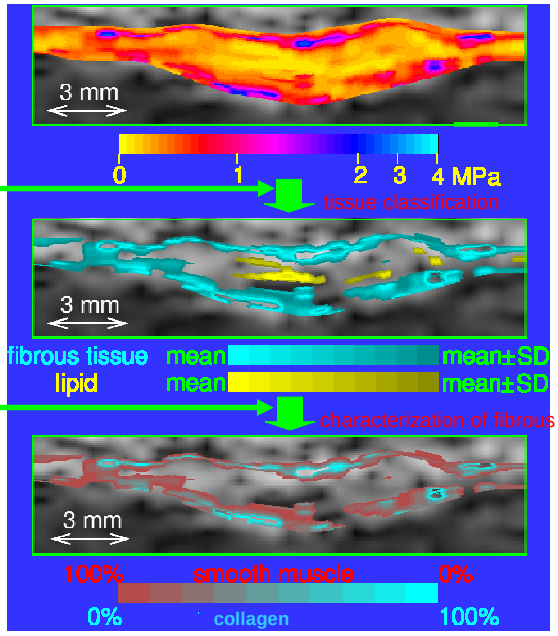
(E: elasticity, CC: collagen content)



←【collagen vs. smooth muscle】

Fibrous tissue almost consist of fibrous tissue and smooth muscle.

【Transcutaneous Tissue Characterization】



【Patent Status & Patent Owner Contact】

patent No.: WO2003/015635

patent owner contact: Yoshihiro MURAI (JST)

Tel:+81-3-5214-8486

E-mail: license@jst.go.jp

【References】

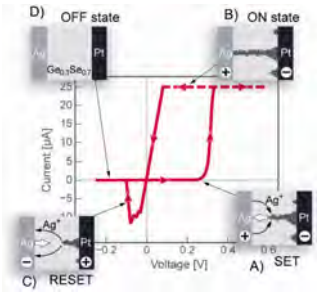
1) H. Kanai, et al.: IEEE Trans. UFFC, 1996, 1997, 1999.
2) H. Kanai, et al.: Circulation, 108, 3018-3021, 2003.
3) J. Inagaki, et al.: Jpn. J. Appl. Phys., 2005, 2006.
4) K. Tsuzuki, et al.: Ultrasound Med. Biol., 2008.
5) K. Tsuzuki, et al.: Jpn. J. Appl. Phys., 2008.
6) H. Hasegawa, et al: IEEE Trans. UFFC, 2004, 2006, 2008.

Atomic Switch Arrays for Memory and Logic Circuits

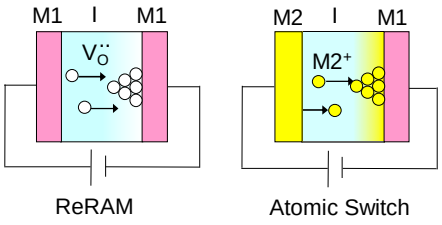
Dr. Tsuyoshi HASEGAWA (National Institute for Material Science)

1. Nanoionic Devices

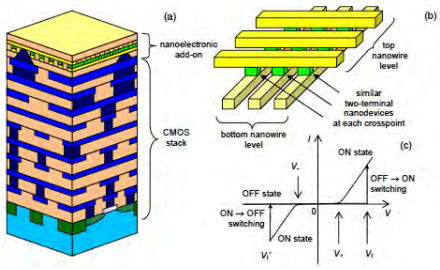
- Nonvoaltile switches for memory and logic operations in the beyond 16nm generation.



Filament formation and annihilation



ReRAM : Anion-based resistive switch
Atomic Switch: Cation-based resistive switch

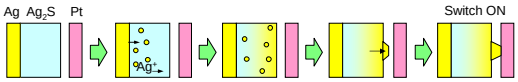


Hybrid CMOS/Nanoelectronic circuit

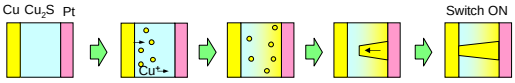
2. Cation-based resistive switch: Atomic switches

- Two types of atomic switches.

Gap-type atomic switch

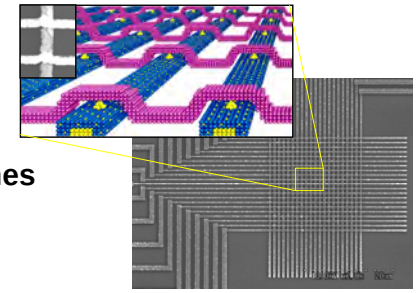


Gapless-type atomic switch



- Specifications

Retention time: 10 years
Scalability: 10 nm
Switching time: 1 ns.
Cyclic endurance: 10^5 times

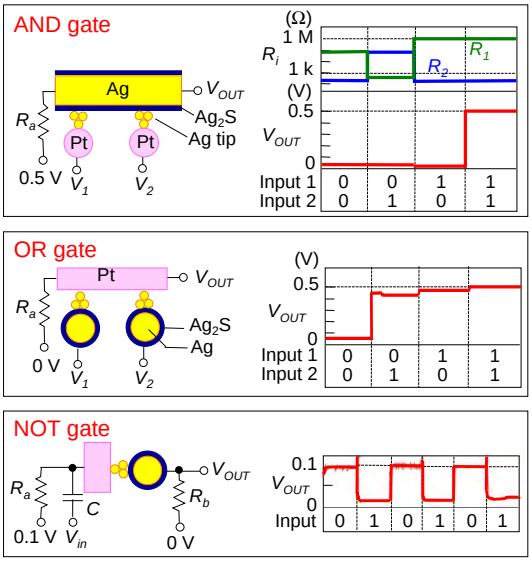


- Materials

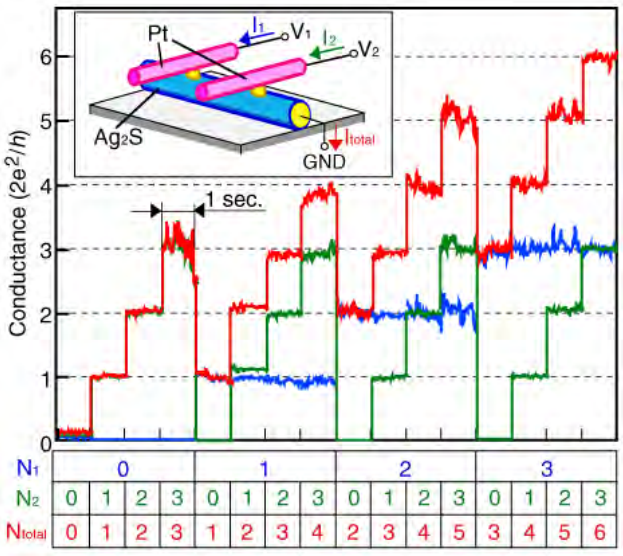
Active Electrode: Cu, Ag
Ionic conductor: Ag_2S, Cu_2S, Ta_2O_5, HfO_2, SiO_2,

3. Application of atomic switches

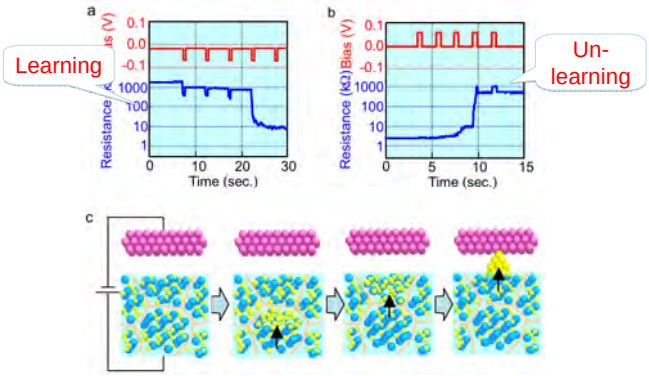
- Logic gates



- Multi-state memories, adder circuit, etc.



- Learning abilities



4. Patent status & Patent owner contact

- **Patent license is available.**

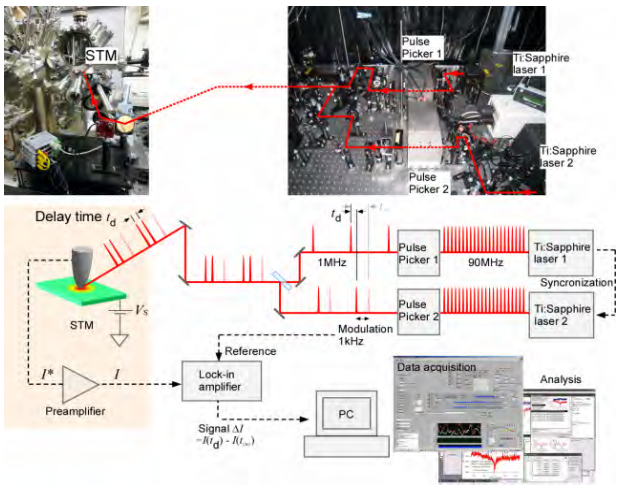
Patent No. : WO2002-037572
Apply country : JP,US,TW,EP,KR
Patent owner contact: Hisahiro Moriuchi (JST)
Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

New Pump-probe Technique providing a Wide Range Time-scale and Nanoscale Measurement

Prof. Hidemi SHIGEKAWA (University of Tsukuba)

1. New pump-probe technique

Delay Time Modulation Femtosecond Time-resolved Scanning Probe Microscope

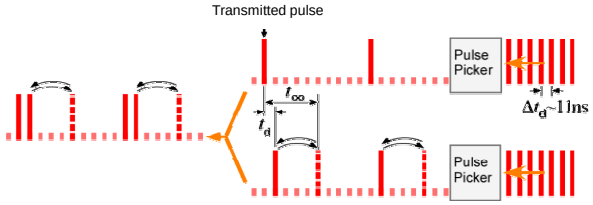


(1)Conventional optical intensity modulation causes the tunnelling current change by the thermal effect.
(2)Delay time modulation using pulse pickers gives:
①wide time rage measurement **(femtosecond ～microsecond)**
②overcome of the thermal effect
③temporal resolution deternined by pulse width and spatial resolution determined by STM

2. new key method

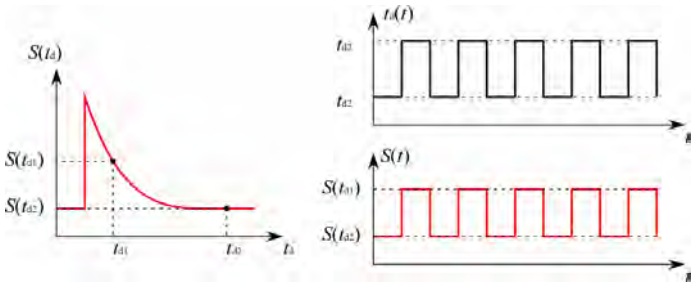
2-1. new delay-time modulation

Delay time is controlled in a digital form using pulse pickers.



2-2. New Lock-in measurement

Delay time t_d is modulated between t_{d1} (measurement point) and a large value of t_{d2}. The signal S(t_d) is measured by lock-in detection technique.
The output of the lock-in amplifier directly provides S(t_{d1}).

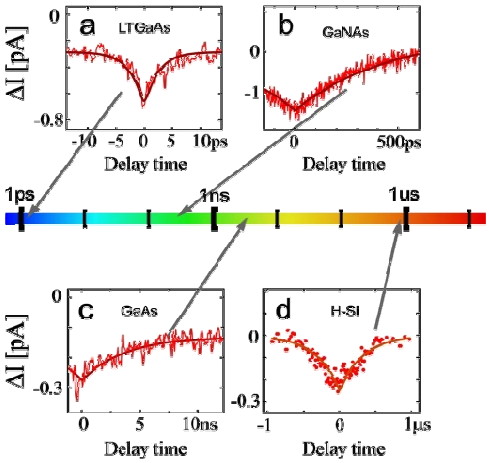


3. Examples by nanoscale pump-probe

Real space imaging of transient carrier dynamics in the nanostructures with a wide variety of lifetimes

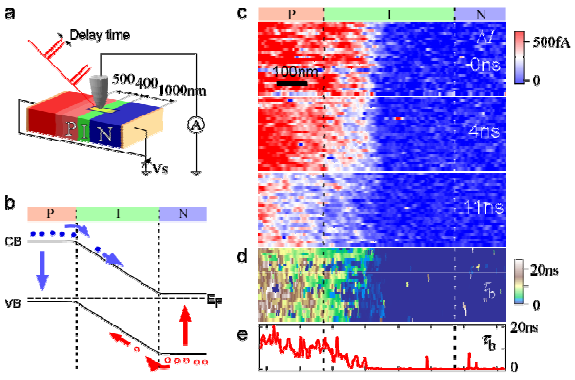
3-1. Carrier lifetimes measured by STM

・Time-dependent STM signals can be obtained for various materials
・Decay times of photoexcited carriers are consistent with the lifetimes measured by conventional optical pump-probe method.



3-2. Imaging nanoscale carrier dynamics

Observation of diffusion and drift on carrier recombination processes in an inner potential of GaAs PIN structure:
Decay of photocarrier density is apparently accelerated in the I-region.
a: measuring method. b: band structure.
c: a series of time-dependent carrier density images.
d: mapping of decay time obtained from the full series of the time-dependent STM images.
e: decay time τ_d (cross section along the line in d.)



6. Patent status & Patent owner contact

Patent license is available.

Patent No. :①WO 2008/066090,②WO 2003/046519
Apply country :①JP,US,EP,CA,CN,KR②JP,US,EP
Patent owner contact: Hisahiro Moriuchi (JST)
Tel:+81-3-5214-8486
e-mail: license@jst.go.jp

Electronic State Calculation Method, Computer Program, by Fluctuation-Referenced Multi-Reference DFT

Prof. Dr. Koichi KUSAKABE (Osaka University)

1. What is MR-DFT?

Our MR-DFT realizes

- Inclusion of quantum fluctuation,
- Systematic improvement of LDA, etc.

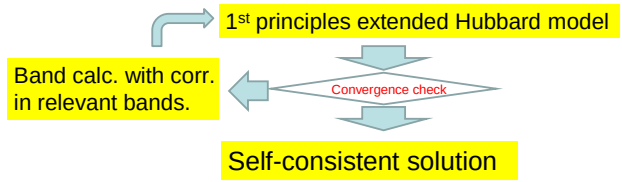
	Single-referenced Kohn-Sham DFT-LDA	Multi-referenced extended KS DFT
Reference	W. Kohn and L.J. Sham, Phys. Rev. **140** (1965) A1133.	K. Kusakabe, JPSJ **70** (2001) 2038; *ibid* **78** (2009) 114716.
Formal self-consistency in calculation scheme	○	○
Ab-initio determination of model functionals	Extrapolation	○
Variational principle for model functionals	×	○

2. How MR-DFT is given?

- Based on an energy functional,

$$F_{X_i}[n] = \min_{\Psi \to n(\mathbf{r})} \left\langle \Psi \middle| \hat{T} + \sum_n \Xi_n^{(i)} \left(\hat{Y}_n^{(i)} - \left\langle \hat{Y}_n^{(i)} \right\rangle, \hat{Z}_n^{(i)} - \left\langle \hat{Z}_n^{(i)} \right\rangle \right) \middle| \Psi \right\rangle.$$

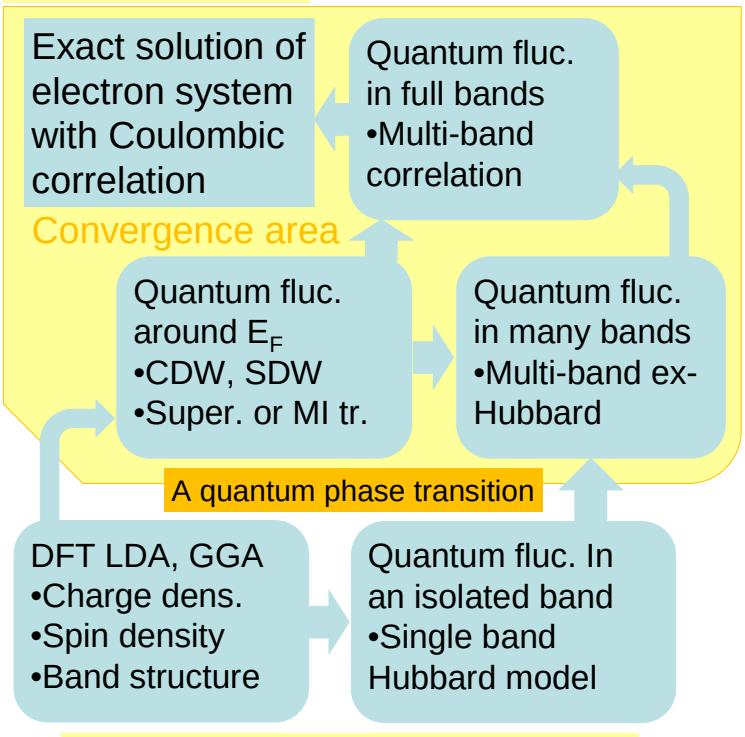
  - JPSJ 70 (2001) 2038.
- Variational principle is given.
  - JPSJ 78 (2009) 114716.



3. New technique developed!

Production of a model sequence in the model space (a Banach space).

A schematic example

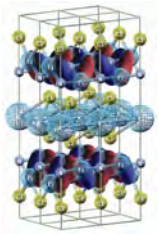


Convergence w.r.t. charge distance
⇒ a converged model in the model space.

Theorems: J. Phys. Math. Theor. **44** (2011) 135305.
K. K. & I. Maruyama: Japan patent submitted : JP 2010-183375.

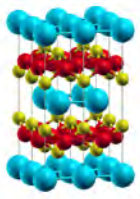
4. Applications

Layered superconductors with high T_c



Super pair-hopping[1] by V_{ee}

Applied to MNX[2], Fe-pnictide[1], Fe-selenide. ⇒ Designed Super.



1) K.K. JPSJ 78 (2009) 114716.
2) K.K. J. Phys. Chem. Solid in press.

Material	$K_{0.5}TiNCl$	$K_{0.5}ZrNCl$	$K_{0.5}HfNCl$	$K_{0.5}FeSe$
DE in z-direct	1.0 meV	0.3 meV	0.4 meV	14.4 meV
|J'| upper only	56.5 meV	26.4 meV	20.7 meV	74.8 meV
|J'| total	65.6 meV	34.7 meV	26.4 meV	164 meV

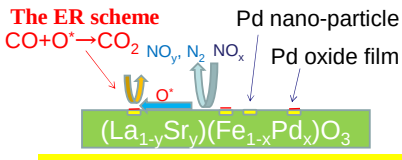
$$F_{n_1,\mathbf{k}_1,n_2,\mathbf{k}_2} = \left\langle \phi_{n_1,\mathbf{k}_1} \phi_{n_2,\mathbf{k}_2} \middle| \hat{V}_{ee} \middle| \varphi_{n_c,(\mathbf{k}_c,l=0)} \varphi_{n_c,(-\mathbf{k}_c,l=0)} \right\rangle$$

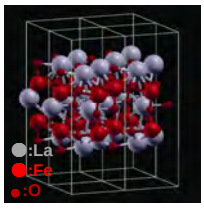
$$J' = -\sum_{n_1 \neq n_c, \mathbf{k}_1} \frac{\left| F_{n_1,\mathbf{k}_1,n_1,-\mathbf{k}_1} \right|^2}{\left| \varepsilon_{n_1,\mathbf{k}_1,n_1,-\mathbf{k}_1} - \varepsilon_{n_c,(\mathbf{k}_c,k_z)} \right|}.$$

Convergence certified by our patent.

New 3-way catalytic reaction

NO_x reduction on $LaO/LaFeO_3$.
(H. Kizaki & K.K., Surf. Sci. in press.)

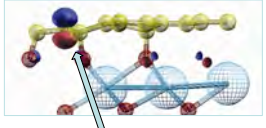




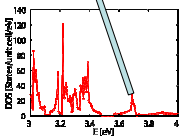
K.K. & H.Kizaki: Japan patent submitted : JP 2009-204665.

A solution for the element science & technology.

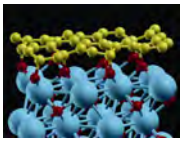
Design of graphene devices



The array of Quantum dots in 200Tbit/cm^2 is expected!



A localized orbital = a quantum dot



: Periodic Anderson model

Convergence certified by our patent.

5. Patent status & Patent owner contact

- **Patent license is available.**

Patent No. : WO2010-023943
Apply country : JP, US(allowed)
Patent owner contact: Hisahiro Moriuchi (JST)
Tel:+81-3-5214-8486
e-mail: h2moric@jst.go.jp

Lignin-based Solar Cell

Prof. Masamitsu FUNAOKA (Mie University)

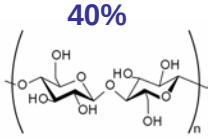
1. Utilization of Forest Resources

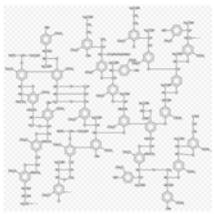
- Lignin has never been utilized sufficiently as industrial material.

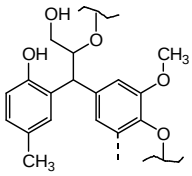
Wood = Carbohydrate + Organic Material

Cellulose & Hemicellulose 40% + 30%

Lignin 30%







- high temp. & pressure
- NaOH

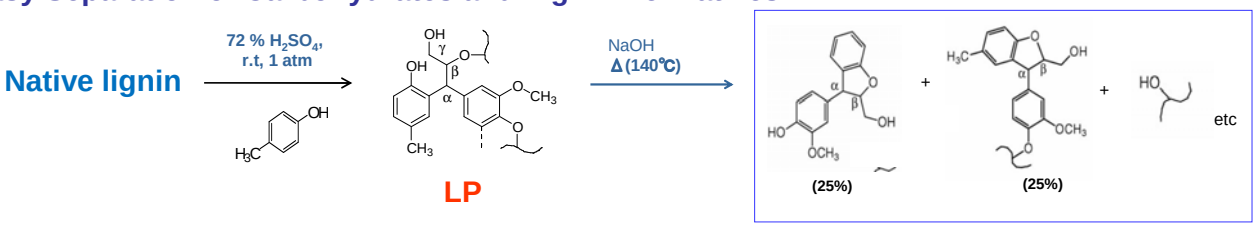
Pulp & Paper

Phase-separation method

Lignophenol (LP)
(*p*-cresol type)

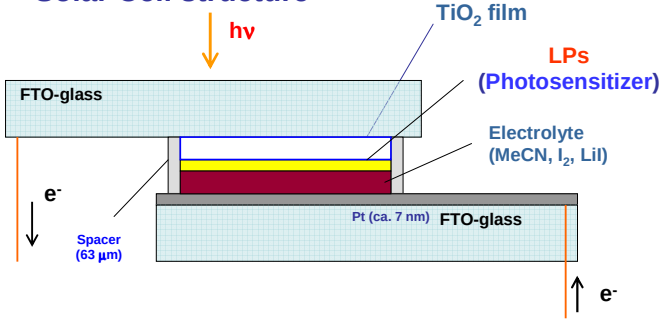
2. Phase-separation Method

- Easy Separation of Carbohydrates and Lignin Derivatives

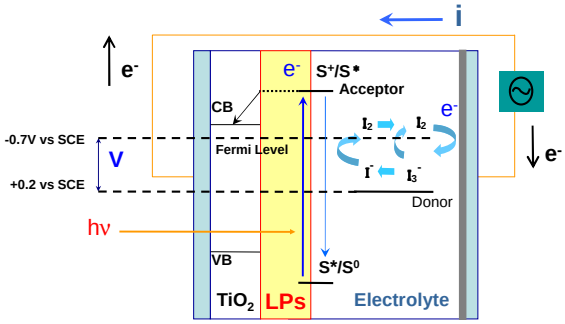


3. Lignin-based Solar Cell Structure

- Solar Cell structure



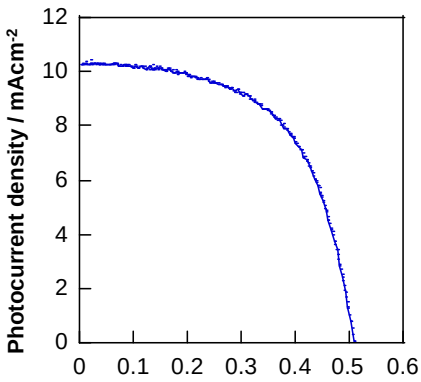
- Energy diagram



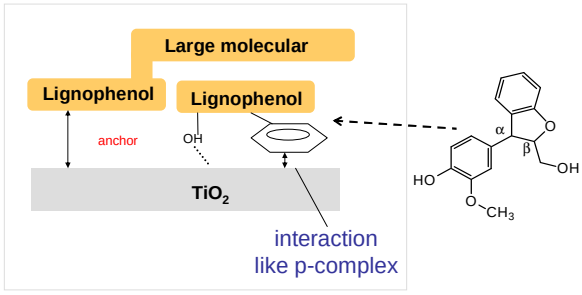
- **Solar Cell Efficiency**

V_{oc} = 0.51 V
I_{sc} = 10.23 mAcm^{-2}
W_{max} = 3.1 mWcm^{-2}
ff = 0.59
η = 3.6 %

Under visible and Infrared light
(85.0 mWcm^{-2}, > 400 nm)



- Proposed mechanism



4. Patent status & Patent owner contact

- Patent license is available.

Patent No. : WO2004/070868, JP3934068
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