台灣國立交通大學理學院應用化學系
雷射生物奈米科學研究室
研究成果活動報告書
民國 97 年 4 月 ～ 107 年 3 月

Laser Bio/Nano Science Laboratory
Department of Applied Chemistry, National Chiao Tung University
(NCTU)

Activity Report
(2008 April - 2018 March)

Increasing Visibility of NCTU in Science and in Japan

Preface

In the autumn of 2007 I was invited by Prof. Yuan-Pern Lee to visit NCTU (National Chiao Tung University) and exchanged our opinions on some topics of mutual interest with him and prominent scientists of Department of Applied Chemistry (DAC). Also we discussed on how to develop our science, university, and academic exchange internationally, and consequently I shifted from Osaka to Hsinchu on April 2018. Our Laser Bio/Nano Science Laboratory started smoothly and now ten years have passed away. I chose laser trapping as a central subject among my topics in the past, considering various situations and conditions about NCTU, fund, staff, my age, and of course my interest, I believed that originality and uniqueness of laser trapping dynamics and chemistry were enough high, international competitiveness was expected, and unconventional and seminal study would evolve from our laboratory.

Laser Bio/Nano Science Laboratory has been developing supported by Aiming-Top-University (ATU) project of NCTU and Ministry of Education (MOE). Now my contract of 5 years-2 terms with our presidents is ending, and we are happy to summarize our activity in this small booklet. Due to our systematic scientific contribution, we are now regarded as one of the world-level centers studying laser trapping dynamics and chemistry. Additionally we have devoted our efforts for academic exchange between Taiwan and foreign countries particularly Japan, so that not only professors and researchers but also many people including even high school students have visited to NCTU, DAC, and our Laser Bio/Nano Science. Our past ten years activity is well summarized with a concluding word “Increasing Visibility of NCTU in Science and in Japan”.

Here I would like to express my sincere thanks to my colleagues, friends, assistants, students and funding, and most importantly to President Drs. Peter Chung-Yu Wu, Yan-Hua Wu Lee, and Mau-Chung Frank Chang, Deans of College of Science Drs. Jenh-Yih Juang, Henry Horng-Shing Lu, Yaw-Kuen Li, and Yung-Fu Chen, and DAC Chairs Drs. Weng-Sheng Chung, Niann-Shiah Wang, and Chi-Shen Lee for their kind understanding and strong supports. Finally, my most sincere

thanks are dedicated to Prof. Yuan-Pern Lee for his kind and fair management based on his wonderful scientific project.

March 29, 2018

Hiroshi MASUHARA

Research Activity

98 Published Papers

96 Invited lectures

Education Activity

8 PhD Students

1 1 PhD student promoted as Professor of Japanese University

41 Master Students

4 Dual Degree Students (3 with Japanese University and 1 with Belgian University)

27 Japanese Graduate Students staying in Our Laboratory for 1~3 months

11 Our Students Studying Abroad for 1 – 2 years

Academic Exchange Activity

5 Staffs Promoted to Japanese and Brunei Universities

2 Japanese Staffs married with Taiwanese ladies

4 Japanese Postdoctoral Fellows supported by JSPS (Japan Society for Promotion of Science)

48 Japanese Professors we invited to Department Seminar

86 Japanese Professors we invited to Laboratory Seminar

723 Participants to Hsinchu Summer Course and Workshop on Single Molecule/Nanoparticle Spectroscopy and Imaging

228 Japanese Super Science High School students we received


台湾国立交通大学 竹湖
2014.6.17

Present Members

Hiroshi MASUHARA

増原 宏

Painted by
Prof. Toshitsune MIYAKE
Mathematician,
Prof. Emeritus of
Hokkaido University

Dr. Hiroshi Masuhara graduated from Tohoku University (1966) in Sendai and obtained Ph.D. degree from Osaka University (1971). He is a physical chemist working in multidisciplinary areas in departments of chemistry (Tohoku University), synthetic chemistry (Osaka University), polymer science and engineering (Kyoto Institute of Technology), applied physics (Osaka University), frontier bioscience (Osaka University), life science (Hamano Foundation), and materials science (Nara Institute of Science and Technology). In 2008 he joined Department of Applied Chemistry of National Chiao Tung University as Chair Professor. He has published about 600 papers, 160 reviews and 19 books. In Laser Bio/Nano Science Laboratory he has extended seminal researches on (1) laser trapping dynamics of nanoparticles, (2) laser trapping crystallization of molecules and proteins, and (3) application of femtosecond laser and chemical surface modification for fabricating individual cell-based devices.

Academy Member

(1) Foreign Fellow of National Academy of Sciences, India (2010 - present)
(2) Foreign Member, Flemish Academy of The Art and Sciences, Belgium (1998 - present)

Honor, Award, and Prize

(1) 2017 The Order of the Sacred Treasure, Gold Rays with Neck Ribbon (The Emperor of Japan)
(2) 2010 Mukai Prize
(3) 2010 Mizushima-Raman Lectureship (JSPS-India DST)
(4) 2010 Asian Photochemistry Association Award
(5) 2008 Outstanding Scholar Award (Foundation for the Advancement of Outstanding Scholarship, Taiwan)
(6) 2008 The Purple Ribbon Medal (The Emperor of Japan)
(7) 2006-2013 Doctor Honoris Causa de Ecole Normale Superier de Cachan, France

Society Fellow

(1) JPA (Japanese Photochemistry Association) Emeritus Member (2017~present)
(2) CSJ (Chemical Society of Japan) Fellow (2010 - present)

Journal Editor

(1) Advisory board (2008 - present)
The Chemical Record
(2) Advisory board (2005 - present)
Bulletin of the Chemical Society of Japan
(3) Editorial board (2000 - present)
ChemPhysChem
(4) Editorial board (1997 - present)
Journal of Photochemistry and Photobiology C: Photochemistry Review
(5) Asian Editor (1997 - 2011), Editorial Board (2012 - present)
Journal of Photochemistry and Photobiology A: Chemistry

President, Advisor, and Councilor

(1) Advisor (2016 - present)
Center for Excellence in Exciton Science, Australian Research Council, Australia
(2) Advisor (2016 - present)
Japan Society for Promotion of Science Project, Grant-in-Aid for Scientific Research on Innovative Area on “Nano-Material Manipulation and Structural Order Control with Photon Forces”

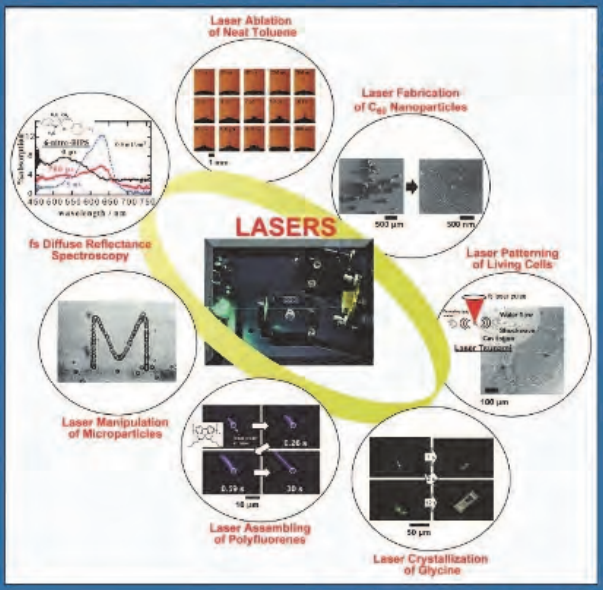
(3) Advisor (2014 - present)
Japan Society for Promotion of Science Project, Grant-in-Aid for Scientific Research on Innovative Area on “Application of Cooperative Excitation into Innovative Molecular Systems with High Order Photofunctions”
(4) Advisor (2013 - 2018)
Japan Society for Promotion of Science Project, Grant-in-Aid for Scientific Research on Innovative Area on “Dynamical ordering of biomolecular systems for creation of integrated functions”
(5) Review Committee member (2013 - 2016)
Research Center of Applied Sciences, Academia Sinica
(6) Executive Advisor (2013 - 2016)
Institute for Molecular Science, Japan
(7) President (2002 - 2004), Advisor (2005 - present)
The Asian and Oceanian Photochemistry Association
(8) International Advisor (2002 - 2016)
Interuniversity Attraction Pole Project on Supramolecular Chemistry and Catalysis, Belgian Federal Science Policy Office, Belgium
(9) Councilor and Advisor (2001 - present)
The Laser Society of Japan
(10) President (2000-2001), Advisor (2003-present)
Japanese Photochemistry Association

Masuhara Lectureship Award
Asian and Oceanian Photochemistry Conference started this award in 2012.

HIROSHI MASUHARA FESTSCHRIFT (Special Issue)
2009 Journal of Physical Chemistry C, America Chemical Society

JULY 9, 2009
VOLUME 113
NUMBER 27
pubs.acs.org/JPCC

THE JOURNAL OF PHYSICAL CHEMISTRY C



Exploration with Lasers into New Areas of Molecular Photoscience (see page XXX)

Hiroshi Masuhara Festschrift

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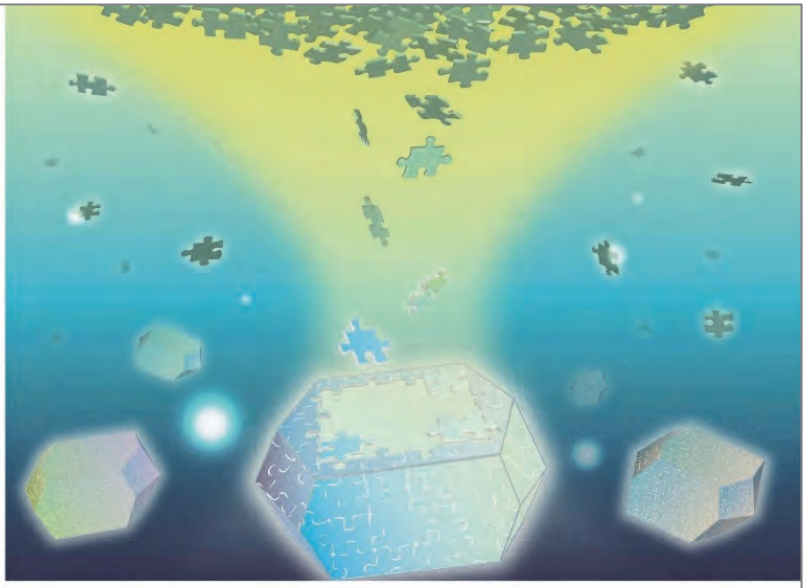
Teruki SUGIYAMA

杉山 輝樹

Dr. Teruki Sugiyama received B. Eng. degree from Shinshu University in 1994 and Ph.D. from Nankai University, P. R. China in 2002. He was Designated Instructor, Specially-Appointed Instructor, and Specially-Appointed Fellow in Department of Applied Physics at Osaka University from 2002-2007. In Osaka University, he studied the fabrication of organic and pharmaceutical nanoparticles utilizing laser ablation in solution, and succeeded in tailoring the smallest organic dye nanoparticles by the top-down method using ultrashort laser. In 2007, he became Researcher at Hamano Life Science Research Foundation, where he started his current research topic on the development of laser trapping method to crystal chemistry. From 2008 to 2011, he worked at Nara Institute of Science and Technology as Associate Professor and at Instrument Technology Research Center, National Applied Research Laboratories as Associate Researcher and Research Fellow from 2011 to 2015, when he extended his research on laser trapping chemistry. He moved to National Chiao Tung University as Associate Professor of Applied Physics in 2007. His main areas of research interest are laser nano chemistry of molecular/cluster systems for two research topics: “Laser trapping chemistry” and “Laser bio/nano application”.

Physical Chemistry Chemical Physics (Back cover)
20, 6034–6039 (2018)
“Rapid localized crystallization of lysozyme by laser trapping”



Highlighting research from Laser Bio/Nano Science Laboratory, National Chiao Tung University, Hsinchu, Taiwan

Rapid localized crystallization of lysozyme by laser trapping

This paper reports laser trapping-induced crystallization of hen egg-white lysozyme (HEWL) showing high temporal and spatial controllability. The crystallization is inhibited during laser trapping, while initiated by stopping the laser irradiation. The generation time is much shortened by 20 times compared to spontaneous nucleation. The resultant HEWL crystals are densely localized in a circle area with the diameter of a few millimetres around the focal spot. The present rapid localized crystallization method will be widely applied to many proteins.

As featured in:

See Teruki Sugiyama *et al.*, *Phys. Chem. Chem. Phys.*, 2018, **20**, 6034.

ROYAL SOCIETY OF CHEMISTRY

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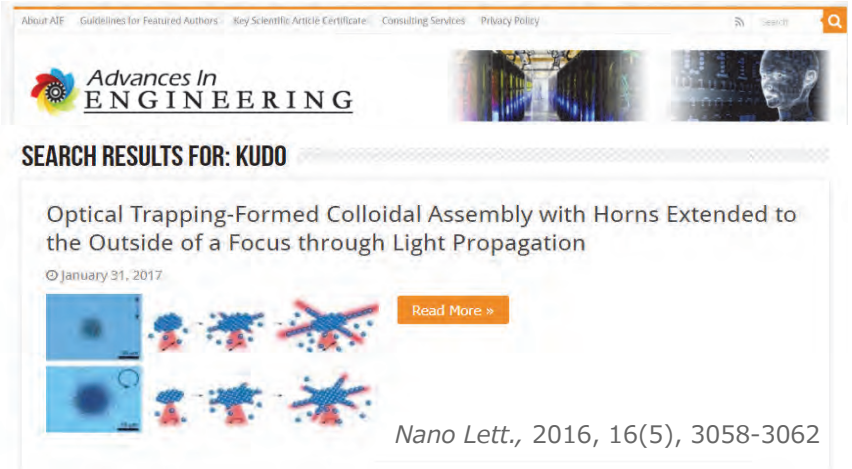
Tetsuhiro KUDO

工藤 哲弘

Dr. Tetsuhiro Kudo obtained the Ph.D. degree from Department of Physics and Electronics, Osaka Prefecture University, Japan (2014). He has worked in Department of Applied Chemistry, National Chiao Tung University in Taiwan as JSPS (Japan Society for the Promotion of Science) Overseas Research Fellow and Post-doc (2014-2016). He is currently working as Assistant Research Fellow from 2017. He is a theoretical and experimental physicist starting academic career in Taiwan, and recently discovering and investigating the novel laser trapping phenomena of nanoparticles based on light propagation and scattering at an interface. He has received 2016 Inoue Research Award for Young Scientists in Japan, EXCON2012 Young Scientist Award in Netherlands, and Poster award at 2017 Spring Symposium of The Asian and Oceanian Photochemistry Association in Taiwan.

Our *Nono Letters* is cited as a key scientific article in Advances in Engineering. (https://advanceseng.com/)



Laboratory Staffs

Hiroshi Masuhara 増原宏	Chair Professor	2008.04 - present
Teruki Sugiyama 杉山輝樹	Associate Professor	2015.08 - present
Atsushi Miura	Assistant Professor	2009.09 - 2014.04
三浦篤士	Associate Researcher	2008.04 - 2009.08
Takayuki Uwada	Assistant Researcher	2008.04 - 2012.03
宇和田貴之		
Anwar Usman	Post Doctoral fellow	2009.06 - 2013.06
吳安華		
Kenichi Yuyama	Assistant Researcher	2014.01 - 2016.09
柚山建一	Post Doctoral Fellow	2011.04 - 2013.12
Kazunori Okano	Assistant Researcher	2013.06 - 2015.12
岡野和宣	Post Doctoral Fellow	2012.08 - 2013.05
Masayasu Muramatsu	Post Doctoral Fellow	2014.04 - 2015.10
村松正康	JSPS Overseas Research Fellow	
		2012.04 - 2013.03
Tetsuhiro Kudo	Assistant Researcher	2017.01 - present
工藤哲弘	Post Doctoral Fellow	2016.04 - 2016.12
	JSPS Overseas Research Fellow	
		2014.04 - 2016.03
Shun-Fa Wang	Post Doctoral Fellow	2017.02 - 2017.07
王順発		
Yugo Hayashi	JSPS Overseas Research Fellow	
林有吾		2015.06 - 2015.08
		2016.02 - 2016.03
Morihiko Hamada	JSPS Overseas Research Fellow	
濱田守彦		2015.04 - 2016.03
Wen-Yu Lee	Assistant	2008.04 - present
李文郁		
Yi-Chun Lee	Assistant for Research	2009.08 - 2010.0
李依純		

JSPS Overseas Research Fellows

1.	Masayasu Muramatsu	村松正康	2012.04 - 2013.03
2.	Tetsuhiro Kudo	工藤哲弘	2014.04 - 2016.03
3.	Morihiko Hamada	濱田守彦	2015.04 - 2016.03
4.	Yugo Hayashi	林有吾	2015.06 - 2015.08 2016.02 - 2016.03

Students

1.	Ping-Yu Hsu	許平諭	(PhD)	2009.08 - 2015.01
2.	Jing-Ru Tu	杜靜如	(PhD)	2009.08 - 2016.01
3.	Tsung-Han Liu	劉宗翰	(MS, PhD)	2009.08 - 2017.08
4.	Chun-Wei Huang	黃重維	(MS)	2010.02 - 2011.11
5.	Wei-Yi Chiang	江威逸	(MS, PhD)	2010.08 - 2017.11
6.	Shun-Fa Wang	王順發	(MS, PhD)	2010.08 - 2017.01
7.	Ching-Shu Tseng	曾綮續	(MS)	2010.08 - 2013.08
8.	Zu-Wei Hsu	許孜瑋	(MS)	2010.08 - 2013.08
9.	Yen-Hwa Huang	黃彥樺	(MS)	2010.08 - 2013.08
10.	Ling-Ting Huang	黃鈴婷	(MS)	2010.08 - 2013.08
11.	Chi-Shuen Wu	吳奇勳	(MS, PhD)	2011.08 - present
12.	Chun-Shen Wu	吳峻陞	(MS)	2012.08 - 2015.02
13.	Po-Yu Lin	林柏宇	(MS)	2012.08 - 2014.07
14.	Ding-Wen Jian	簡鼎文	(MS)	2013.07 - 2015.07
15.	Chun-Han Wang	王崇翰	(MS)	2013.07 - 2015.07
16.	Pei-Yun Hseh	謝沛芸	(MS)	2013.07 - 2015.07
17.	Jen-Lian Shu	徐禎蓮	(MS)	2013.07 - 2015.09
18.	Po-Ren Chen	陳伯任	(MS)	2013.08 - 2015.07
19.	Kai-Di Chang	張凱迪	(MS)	2013.08 - 2015.07
20.	Lin-Li Liu	劉林禮	(MS)	2013.08 - 2016.01
21.	Tse-Fu Hsen	沈則甫	(MS)	2013.09 - 2015.07
22.	Yuan-Lin Yi	易宛霖	(MS)	2014.04 - 2015.12
23.	Ping-Shun Peng	彭炳順	(MS)	2014.08 - 2016.10
24.	Mong-Wei Chou	卓孟瑋	(MS)	2014.08 - 2015.07
25.	Ray-Kai Chen	陳睿凱	(BS, MS)	2014.08 - present
26.	Yung-Lun Lin	林詠倫	(MS)	2015.02 - 2017.08
27.	Shang-Wei Lou	劉上瑋	(MS)	2015.08 - 2016.09

28.	Chi-Lung Wu	吳奇隆	(MS)	2015.08 - 2017.08
29.	Shang-Jan yang	楊尚展	(MS)	2015.08 - 2017.10
30.	An-Chieh Cheng	鄭安婕	(MS, PhD)	2015.08 - present
31.	Tsung-Wei Shieh	施宗緯	(MS, PhD)	2015.08 - present
32.	Chieh-Ju Chang	張傑茹	(MS)	2015.09 - 2017.08
33.	Ting-Shiang Chiou	邱鼎翔	(BS, MS)	2015.03 - present
34.	Ching-Shiang Tseng	曾靖翔	(MS)	2016.07 - present
35.	Yang-Hsin Shieh	施仰欣	(MS)	2016.02 - present
36.	Jhao-Rong Lin	林昭容	(MS)	2016.06 - present
37.	Pei-Hua Lo	羅珮華	(MS)	2016.07 - present
38.	Jia-Syun Lu	呂佳勳	(MS)	2017.07 - present
39.	Hao-Tse Su	蘇浩澤	(MS)	2017.07 - present
40.	Zhi-Hao Huang	黃之灝	(MS)	2017.07 - present
41.	Yu-Ming Wang	王裕明	(MS)	2017.07 - present
42.	Chia-Ying Tsai	蔡佳穎	(MS)	2017.09 - present
43.	Abdullah Kamit	卡蜜濤	(MS)	2018.02 - present
44.	Yen-Ling Chiou	邱彥苓	(BS)	2013.08 - 2015.06
45.	Yen-En Liu	劉言恩	(BS)	2015.07 - 2017.08
46.	Yi-Ju Wu	吳奕儒	(BS)	2016.07 - present
47.	Hsuan-Yin Wang	王暄尹	(BS)	2017.07 - present
48.	Wen-Chi Wang	王玟淇	(BS)	2017.07 - present

Dual Degree Program Students

1. Shinpei Nishimura (Saitama University - NCTU)
   西村晋平 2012.08 - 2015.09
2. Kazuki Okano (Saitama University - NCTU)
   岡野和希 2017.10 - 2018.03
3. Chiang Wei.-Yi. (NCTU - Katholieke Universiteit Leuven)
   江威逸 2014.09 - 2017.11
4. Chi-Shuen Wu (NCTU - Saitama University)
   吳奇勳 2016.10 - 2017.09

Financial Support by NCTU, NSC (National Science Council) and MOST (Ministry of Science and Technology)

1. Hiroshi Masuhara, 2008, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
2. Hiroshi Masuhara, 2009, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
3. Hiroshi Masuhara, 2010, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
4. Hiroshi Masuhara, 2011, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
5. Hiroshi Masuhara, 2011, President of NCTU
   Title: 雷射生物奈米科學研究室
6. Hiroshi Masuhara, 2012, President of NCTU
   Title: 雷射生物奈米科學研究室
7. Hiroshi Masuhara, 2012, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
8. Hiroshi Masuhara, 2013, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
9. Hiroshi Masuhara, 2014, ATU Project of NCTU
   Title: 雷射生物奈米科學研究室
10. Hiroshi Masuhara, 2015, ATU Project of NCTU
    Title: 雷射生物奈米科學研究室
11. Hiroshi Masuhara, 2016, ATU Project of NCTU
    Title: 雷射生物奈米科學研究室
12. Hiroshi Masuhara, 2017, ATU Project of NCTU
    Title: 雷射生物奈米科學研究室
13. Hiroshi Masuhara, 2018, President of NCTU
    Title: 雷射生物奈米科學研究室
14. Hiroshi Masuhara, 2008.04 ~ 2009.03, NSC
    Title: 雷射補陷結晶法之研究(1/3)

15. Hiroshi Masuhara, 2009.04 ~ 2010.03, NSC
    Title: 雷射補陷結晶法之研究(2/3)
16. Takayuki Uwada, 2009.08 ~ 2011.07, NSC
    Title: 開發廣場雷利散射顯微影像技術用於探討蛋白質結晶的基本過程
17. Hiroshi Masuhara, 2010.04 ~ 2011.03, NSC
    Title: 雷射補陷結晶法之研究(3/3)
18. Hiroshi Masuhara, 2011.04 ~ 2012.03, NSC
    Title: 純有機化合物液體中的雷射捕捉及結構組成(1/3)
19. Hiroshi Masuhara, 2012.04 ~ 2013.03, NSC
    Title: 純有機化合物液體中的雷射捕捉及結構組成(2/3)
20. Atsushi Miura, 2012.08 ~ 2014.07, NSC
    Title: 螢光蛋白雷射捕陷結晶化動力學：藉由非線性顯微成像研究光壓誘發相分離及晶核形成
21. Hiroshi Masuhara, 2013.04 ~ 2014.03, NSC
    Title: 純有機化合物液體中的雷射捕捉及結構組成(3/3)
22. Hiroshi Masuhara, 2014.05 ~ 2015.11, NSC
    Title: 藉由三維觀測分析闡明奈米糰簇和奈米粒子的雷射捕捉, 散射及緊合動力學
23. Kazuhiro Okano, 2014.01 ~ 2015.12, NSC
    Title: 藉由在培養基片上的局部設計固定誘導分化因子達成細胞分化在時空上的控制
24. Kenichi Yuyama, 2014.08 ~ 2016.07, NSC
    Title: 雷射捕陷誘發分子與膠體晶體動態成長機制之反射影像光譜解析
25. Teruki Sugiyama, 2015.08 ~ 2016.07, MOST
    Title: 雷射捕陷誘發叢集聚合區域之蛋白質結晶調控
26. Hiroshi Masuhara, 2016.04 ~ 2017.03, MOST
    Title: 雷射捕陷與雷射燒蝕誘發類澱粉蛋白之纖維化
27. Teruki Sugiyama, 2017.08 ~ 2018.07, MOST
    Title: 藉由雷射捕陷技術控制結晶之對映現象(1/2)
28. Hiroshi Masuhara, 2017.08 ~ 2018.07, MOST

Title: 雷射捕陷與雷射燒蝕誘發類澱粉蛋白之纖維化

29. Tetsuhiro Kudo, 2017.10 ~ 2019.07, MOST
Title: 光傳遞及光散射促成之光捕陷誘發聚集

Academic Exchange Activity

Collaborative Publication with Taiwanese Professors

LANGMUIR

Article

pubs.acs.org/Langmuir

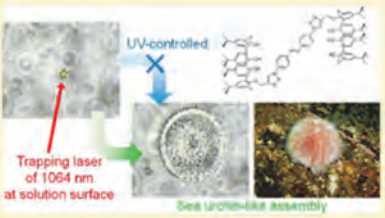
Photocontrolled Supramolecular Assembling of Azobenzene-Based Biscalix[4]arenes upon Starting and Stopping Laser Trapping

Ken-ichi Yuyama,† Lionel Marcelis, Pei-Mei Su, Wen-Sheng Chung,* and Hiroshi Masuhara*

Department of Applied Chemistry and Institute of Molecular Science, National Chiao Tung University, Hsinchu 30010, Taiwan

Supporting Information

ABSTRACT: Laser trapping in chemistry covers various studies ranging from single molecules, nanoparticles, and quantum dots to crystallization and liquid−liquid phase separation of amino acids. In this work, a supramolecular assembly of azobenzene-based biscalix[4]arene is generated in ethyl acetate using laser trapping; its nucleation and growth are elucidated. No trapping behavior was observed when a 1064 nm laser beam was focused inside of the solution; however, interesting assembling phenomena were induced when it was shined at the air/solution interface. A single disk having two layers was first prepared at the focal point of ~1 μm and then expanded to the size of a few tens of micrometers, although no optical force was exerted outside of the focal volume. Upon switching the trapping laser off, needles were generated at the outer layer of the assembly, giving a stable sea urchin-like morphology to the generated assembly. At a 30−50% dilution of the initial solution in ethyl acetate, a mushroom-like morphology was also observed. Laser trapping-induced assembly of azobenzene-based biscalix[4]arene was quite different from the sharp-ellipsoidal aggregates obtained by the spontaneous evaporation of the solution. These trapping phenomena were specifically observed for biscalix[4]arene in the *trans* conformation of azo-benzene moiety but not for the *cis*-form, suggesting that the laser trapping of this azobenzene-based biscalix[4]arene is photocontrollable. Dynamics and mechanism of the supramolecular assembling are considered, referring to laser trapping-induced nucleation and liquid−liquid phase separation of amino acids.



Langmuir, 2017, 33, 755-763

RSC Advances

PAPER

View Article Online
View Journal | View Issue

Cite this: RSC Adv., 2017, 7, 42606

Enhanced optical confinement of dielectric nanoparticles by two-photon resonance transition†

Aungtinee Kittiravechote, Anwar Usman,‡ Hiroshi Masuhara* and Ian Liau *

Despite a tremendous success in the optical manipulation of microscopic particles, it remains a challenge to manipulate nanoparticles especially as the polarizability of the particles is small. With a picosecond-pulsed near-infrared laser, we demonstrated recently that the confinement of dye-doped polystyrene nanobeads is significantly enhanced relative to bare nanobeads of the same dimension. We attributed the enhancement to an additional term of the refractive index, which results from two-photon resonance between the dopant and the optical field. The optical confinement is profoundly enhanced as the half-wavelength of the laser falls either on the red side, or slightly away from the blue side, of the absorption band of the dopant. In contrast, the ability to confine the nanobeads is significantly diminished as the half-wavelength of the laser locates either at the peak, or on the blue side, of the absorption band. We suggest that the dispersively shaped polarizability of the dopant near the resonance is responsible to the distinctive spectral dependence of the optical confinement of nanobeads. This work advances our understanding of the underlying mechanism of the enhanced optical confinement of doped nanoparticles with a near-infrared pulsed laser, and might facilitate future research that benefits from effective sorting of selected nanoparticles beyond the limitations of previous approaches.

Received 30th May 2017
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DOI: 10.1039/c7ra06031a

rsc.li/rsc-advances

Journal of Materials Chemistry C

PAPER

View Article Online
View Journal | View Issue

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Highly-integrated, laser manipulable aqueous metal carbonyl vesicles (MCsomes) with aggregation-induced emission (AIE) and aggregation-enhanced IR absorption (AEIRA)†

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A highly-integrated, laser manipulable multi-functional metal carbonyl nanovesicle (MCsome) with aggregation-induced emission (AIE) and aggregation-enhanced IR absorption (AEIRA) is created via the self-assembly of a bithiophene tethered-Fp acyl derivative (Fp: $CpFe(CO)_2$) (**1**). Although **1** is hydrophobic and non-surface-active, the molecule can self-assemble in water into vesicles without detectable critical aggregation concentration (CAC). The water–carbonyl interaction (WCI) is responsible for the colloidal stability. The bilayer membrane structure with the bithiophene moieties associated within the inner wall and the iron-carbonyl units exposed to water is confirmed by transmission electron microscopy (TEM), atomic force microscopy (AFM), and cyclic voltammetry (CV) experiments. The synchrotron small-angle X-ray scattering (SAXS) experiment suggests that the bithiophene groups are interdigitated within the membrane. The spatial segregation of the AIE-active bithiophene domain from the iron-carbonyl units by the butanoyl spacers prevents the quenching effect of the iron and renders the MCsome photoluminescent. The polarizable iron-carbonyl groups on the surface of the MCsome create an enhanced optical field upon infrared (IR) irradiation, resulting in an enhancement (ca. 100-fold) in IR absorption for the carbonyl groups as compared to the same concentration of molecule **1** in THF. When the MCsome interacts with a focused continuous-wave near-IR (NIR) laser beam, a strong gradient (trapping) force is generated allowing the laser trapping of the MCsome without using additives. A sharp contrast in the refractive index (RI) of **1** (RI = 1.71) with water (RI = 1.33) accounts for this laser manipulability that is difficult to be achieved for nanosized liposomes (RI = 1.46). As illustrated, the MCsome of **1** represents a novel group of vesicular colloids, which is amenable to functional materials complementary to extensively studied liposomes and polymersomes.

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Review

In situ patterning and controlling living cells by utilizing femtosecond laser

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ABSTRACT

Photo-induced processes have high potential in *in situ* patterning and controlling living cells, whose developments are introduced and recent progresses by utilizing femtosecond laser are described. Photochemical and photothermal surface modification performed by conventional light and nanosecond laser irradiation is summarized and their applicability is considered. Femtosecond laser ablation has superior features due to its photomechanical mechanism, which is confirmed by ultrafast spectroscopy and imaging of a model film under laser ablation. Femtosecond laser ablation of physiological solutions generates shockwave and cavitation bubbles, which is employed for patterning and manipulating living cells. Femtosecond laser ablation fabricating cytophobic and cytophilic domains enable us to form living cell patterns and to study cell migration and cell–cell interaction. Finally summary and perspective are presented.

Enhanced optical confinement of dye-doped dielectric nanoparticles using a picosecond-pulsed near-infrared laser

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Abstract

We demonstrate a novel strategy to increase the capability of confining numerous dye-doped polymeric nanobeads (diameter 100 nm) with laser trapping. Unlike most classical works of optical trapping that address mainly the stiffness of the optical trap, our work concerns an increase in the number of particles confined near the laser focus. We developed an imaging system of light scattering in which a condenser lamp was employed to illuminate the focal plane of the objective lens, and the scattering of the incoherent light was specifically measured to determine the number of confined nanobeads. In contrast to preceding work that used mainly continuous-wave or femtosecond-pulsed lasers, we employed a picosecond-pulsed laser with the half-wavelength of the laser particularly falling within the absorption band of the dopant. Our results show that the number of doped nanobeads held by the laser is significantly greater than that of the bare nanobeads of the same dimension. In striking contrast, the confinement of the nanobeads of the two types was comparable when a continuous-wave laser of the same wavelength and power was employed. The number of confined dye-doped nanobeads increased nonlinearly with the power of the pulsed laser; this dependence was fitted satisfactorily with a second-order polynomial. Supported by theoretical analysis, we attribute the enhanced confinement of doped nanobeads in part to an increased effective refractive index resulting from two-photon resonance between the optical field of the laser and the dopant of the nanobead. We envisage that our findings would evoke applications that benefit from controlled confinement or aggregation of nanomaterials with the employment of near-infrared pulsed lasers.

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Metabolic variation of HeLa cells migrating on microfabricated cytophilic channels studied by the fluorescence lifetime of NADH†

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We report a novel method for studying cellular migration *in vitro*. Cytophilic microdomains were formed on a cytophobic substrate by laser ablation. HeLa cells were grown on those domains until confluence, and then channels were formed to guide cellular migration. Two-photon excitation fluorescence-lifetime imaging of NADH revealed metabolic variation among migrating and nonmigrating cells.

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Single femtosecond laser pulse-single crystal formation of glycine at the solution surface

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ABSTRACT

We demonstrate femtosecond laser-induced crystallization of glycine from its supersaturated solution depending on laser tunable parameters (pulse energy and repetition rate) and focal position, and examine the crystallization probability, crystal morphology, and crystal polymorph. The generation of cavitation bubble through multiphoton absorption of water depends on input laser pulse energy and repetition rate, which strongly determine morphology and number of the obtained crystals. Significant increase in the crystallization probability is observed by irradiating the femtosecond laser pulses to the air/solution interface, and single pulse-induced single crystal formation is successfully achieved. The crystallization mechanism is discussed in view of inhomogeneous mechanical stress induced by cavitation bubble generation and molecular assembly characteristics of the surface.

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In situ laser micropatterning of proteins for dynamically arranging living cells

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This study shows the modification of the surface of polymer-layered glass substrates to form biofunctional micropatterns through femtosecond laser ablation in an aqueous solution. Domains of micrometer size on a substrate can be selectively converted from proteinphobic (resistant to protein adsorption) to proteinphilic, allowing patterning of protein features under physiological aqueous conditions. When femtosecond laser pulses (800 nm, 1 kHz, 200–500 nJ per pulse) were focused on and scanned on the substrate, which was glass covered with the proteinphobic polymer 2-methacryloyloxyethylphosphorylcholine (MPC), the surface became proteinphilic. Surface analysis by X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM) reveals that the laser ablates the MPC polymer. Extracellular matrix (ECM) proteins were bound to the laser-ablated surface by physisorption. Since femtosecond laser ablation is induced under physiological aqueous conditions, this approach can form micropatterns of functional ECM proteins with minimal damage. This method was applied to pattern collagen, laminin, and gelatin on the substrate. Removal of an ECM protein from the substrate followed by replacement with another ECM protein was achieved on demand at a specific location and time by the same laser ablation method. Living cells adhered to the fabricated domains where ECM proteins were arranged. The modification of patterning during cell culture was used to control cell migration and form arrays of different cells.

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FULL PAPERS

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Induction of Cell–Cell Connections by Using in situ Laser Lithography on a Perfluoroalkyl-Coated Cultivation Platform

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This article describes a novel laser-directed microfabrication method carried out in aqueous solution for the organization of cell networks on a platform. A femtosecond (fs) laser was applied to a platform culturing PC12, HeLa, or normal human astrocyte (NHA) cells to manipulate them and to facilitate mutual connections. By applying an fs-laser-induced impulsive force, cells were detached from their original location on the plate, and translocated onto microfabricated cell-adhesive domains that were surrounded with a cell-repellent perfluoroalkyl (R_f) polymer. Then the fs-laser pulse-train was applied to the R_f polymer surface to modify the cell-repellent surface, and to make cell-adhesive channels of several μm in width between each cell-adhesive domain. PC12 cells elongated along the channels and made contact with others cells. HeLa and NHA cells also migrated along the channels and connected to the other cells. Surface analysis by X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM) confirmed that the R_f polymer was partially decomposed. The method presented here could contribute not only to the study of developing networks of neuronal, glial, and capillary cells, but also to the quantitative analysis of nerve function.

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Local stimulation of cultured myocyte cells by femtosecond laser-induced stress wave

Yung-En Kuo · Cheng-Chi Wu · Yoichiroh Hosokawa · Yasuyo Maezawa · Kazunori Okano · Hiroshi Masuhara · Fu-Jen Kao

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Abstract When an 800 nm femtosecond laser is tightly focused into cell culture medium a stress wave is generated at the laser focal point. Since the stress wave localizes in a few tens of μm, it is possible to locally stimulate single cells in vitro. In this work, several kinds of cultured mammalian cells, HeLa, PC12, P19CL6, and C2C12, were stimulated by the stress wave and the cell growth after the stress loading with the laser irradiation was investigated. In comparison with the control conditions, cell growth after the laser irradiation was enhanced for the cells of C2C12 and P19CL6, which can differentiate into myocytes, and suppressed for PC12 and HeLa cell lines. These results suggest a possibility of cell growth enhancement due to myogenic cells response to the femtosecond laser-induced stress.