國立交通大學
National Chiao Tung University

出國報告（出國類別：國際會議、學研訪問）

赴北海道大學、理研研究所參訪暨2014光化學會議

Collaboration Work with Hokkaido Univ. /Prof. Maeda in Riken and attending "The Annual Meeting on Photochemistry 2014"

服務機關：應用化學系 及 分子科學研究所
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摘要

The purpose of my business trip is to enhance the collaboration works with associate professor Miura's group in Hokkaido University (Sapporo city) and professor Maeda's group in Riken (Wako city). Associate professor Miura was an assistant professor of our laboratory in NCTU until April in 2014, and then promoted to the present position in Hokkaido University. In NCTU, we have worked together on the research topic of laser trapping-induced molecular assembly. He is still studying this topic in the new laboratory in Hokkaido University. We have a common problem to develop this topic. In order to overcome this common difficulty, I visited his laboratory in Hokkaido University and worked together for 3 days. Professor Maeda in Riken was one of lecturers in the summer course that we organized in July in this year. NCTU and Riken are cooperation partners, and we are strongly encouraged to enhance collaboration works. In the summer course, we found that his nanoparticles modified with DNA are very interesting in our trapping experiments. In order to start our collaboration, I visited his laboratory in Riken and discussed with several researchers. During my trip, I fortunately delivered an oral presentation in "Annual Meeting on Photochemistry 2014" held in Hokkaido University, which is the largest photochemistry conference in Asia.

這次行程目的主要是與在北海道大學（札幌市）的副教授三浦 Prof. Miura 及在理化學研究所（和光市）的前田教授 Prof. Maeda 研究小組加強合作的工作。副教授三浦 Prof. Miura 曾在交通大學擔任我們實驗室的助理教授直到 2014 年 4 月，然後晉升為北海道大學的副教授。在交大，我們一起做有關雷射激發光捕捉誘導分子組裝的研究。他目前也仍然在北海道大學新的實驗室從事這個課題的研究。我們在研究這個課題都擁有一個共同的問題。為了克服這個難題，我拜訪他北海道大學的實驗室且一起工作三天。在理化學研究所（和光市）的前田教授 Prof. Maeda 是我們在七月時所舉辦的暑期演講課程邀請的其中一位教授。交通

大學和理化學研究所是合作夥伴，我們也強烈地鼓勵加強合作的工作。在暑期課程中，我們發現他的 DNA 奈米分子修飾研究對我們做雷射捕捉實驗的來說很有興趣。為了開始我們的合作，我拜訪他在理化學研究所的實驗室與許多研究者討論。在我的行程中，我幸運地參加了北海道大學所舉行的“2014 年國際光化學操作會議”，這是亞洲最大的光化學會議。

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本文

一、目的

The purposes of this business trip are (1) to start collaboration work with associate professor Miura's group in Hokkaido University, (2) to start collaboration work with professor Maeda's group in Riken, and (3) to deliver an oral presentation in “Annual Meeting on Photochemistry 2014”. The details are described below.

這次的行程目標主要為 (1)和在北海道大學的副教授三浦 Prof. Miura 團隊合作(2) 和在理化學研究所（和光市）的前田教授 Prof. Maeda 團隊合作(3)參加“2014 年度國際光化學會議”(Annual Meeting on Photochemistry 2014)主要描述細節為下：

(1) Collaboration work with associate professor Miura’s group

In our laboratory, we have succeeded in crystallization and crystal growth of amino acids and protein by laser trapping technique (Figure 1-1). Resent research made clear that laser trapping-induced crystallization and crystal growth are accompanied with the formation of a large-volume, high-concentration domain, as shown in Figure 1-2. The domain is millimeter-scale and much larger compared to the focal volume. Therefore, the domain plays an important role for crystallization and crystal growth at the outside of the focal volume. Actually, thanks to the dense domain, the crystal growth rate could be controlled by optimizing the laser power. Associate professor Miura’s group in Hokkaido University has also interested in this domain formed by laser trapping. His group is now analyzing the dense domain of hen egg white lysozyme (HEWL) using Raman spectroscopic measurement. The Raman measurement can give us the information on mutual molecular interactions in the domain. But it is difficult to understand the whole information of the millimeter-scale

dense domain, because the measurement can be applied to investigate only the small area with a few micrometers. Therefore, we start the collaboration to construct a new optical system which enables us to examine the domain size and the concentration.

(1)與副教授三浦 Prof. Miura 團隊的合作：

目前本實驗室成功的利用雷射捕捉技術生成長蛋白質及胺基酸的結晶，如下圖(圖 1-1)。下圖(圖 1-2)為目前最近的新發展，藉由雷射捕捉技術成長結晶，而結晶的形成通常伴隨著高濃度及大量體積的區域。而這個區域在生長結晶的過程中扮演著一個很重要的角色，探討這類型的物理性質對於未來在雷射捕捉技術內生成結晶及結晶化是一個相當重要的主題。實際上，由於此緻密的區域，晶體生長速率可以通過優化激光功率控制。在北海道大學的副教授三浦團隊也有興趣於透過雷射捕捉所形成的這個區域。他的研究團隊正在分析利用拉曼光譜測量雞蛋清溶菌酶（HEWL）密集的區域。拉曼測量可以給我們在此區域中相互分子間相互作用的信息。但它是很難理解奈米級緻密區域的整個信息，因為測量可以應用於調查僅幾微米的小區域。因此，我們開始合作建立一個新的光學系統，使我們能夠計算區域的大小和濃度。

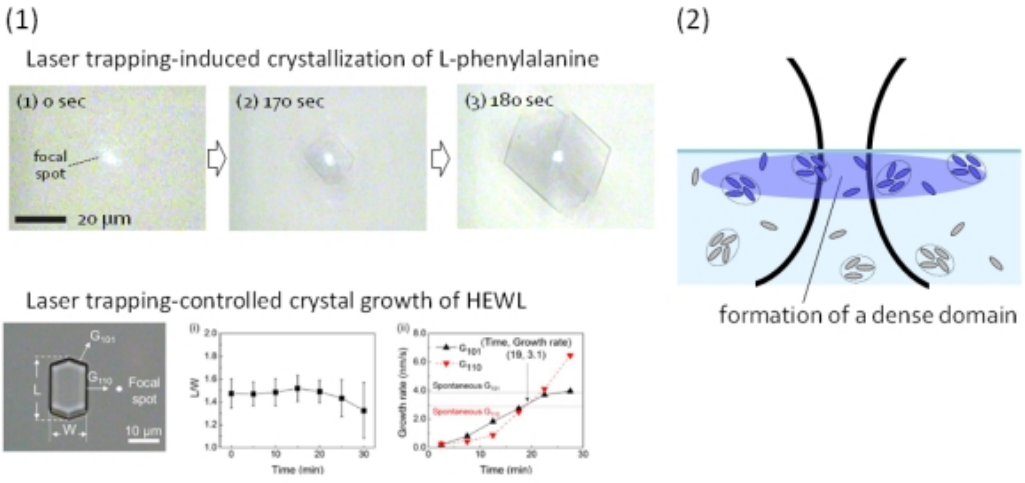

Figure 1. (1) Representative results on laser trapping-induced crystallization and crystal growth. (2) A schematic illustration of the formation of a dense domain induced by laser trapping.
圖 1.(1)在雷射激發光捕捉誘導下結晶與晶體成長的過程與分析圖。(2)在雷射激發光捕捉誘導下緻密區域的形成示意圖。

(2) Collaboration work with professor Maeda's group

In our laboratory, we have succeeded in the formation of a nanoparticle assembly with an ordered structure by using laser trapping technique. This nanoparticle assembly like a colloidal crystal is very interesting, because its ordered structure is dynamically balanced between attractive trapping force and repulsive force due to electric charge at a particle surface (Figure 2-1). The former attractive force can be easily changed by optimizing the irradiation condition. We can do it by ourselves. But, the latter repulsive force is difficult to be controlled in our laboratory. Professor Maeda's group can prepare nanoparticles coated with DNA (Figure 2-2). The central seed particles are gold, polystyrene, and polymer (PINIPAM：temperature-responsive polymer). All nanoparticles are very good samples for our laser trapping experiments. The most important point is DNA bound at a surface of their nanoparticles. DNA can form a double helix structure, if constitutive bases are complementally coupled with each other. On the other hand, in the case that mismatched bases are included in DNA strand, they are not coupled, and the repulsive force is generated. That means, we can control repulsive force among particles in molecular level by changing bases in DNA. The purpose of my visit to Riken is to discuss our future collaboration work combined with their samples and our laser trapping technique.

(2)與在理化學研究所的前田教授 Prof. Maeda 團隊的合作：

目前本實驗室成功的利用雷射捕捉技術形成奈米分子組裝的有序結構。此奈米分子組裝的結構就像是膠體結晶是非常有趣的，因為它的有序結構是由於電荷存在於分子表面光鉗力與排斥力互相達動態平衡(圖 2-1)。前者的吸引力可以藉由優化照射條件可容易地改變。我們可以自己去做調整。但是後者的排斥力在我們實驗室是很難去控制的。Prof. Maeda 團隊能夠製備出將 DNA 附著於奈米分子上。(圖 2-2)。它主要的分子由金、聚苯乙烯和高分子(PINIPAM：易受溫度影響

的高分子)。對於我們雷射捕捉實驗所有的奈米分子都是很好的例子。重點是他們的 DNA 能夠鍵結於奈米分子表面上。如果構成鹼基會互相耦合，DNA 可形成雙股螺旋結構。在另一方面，在 DNA 鏈中含錯配鹼基的情況下，它們不耦合，並產生排斥力。這代表我們能夠藉由改變 DNA 的鹼基來控制分子間的排斥力。此次拜訪理化學研究所的目的是去討論未來結合我們雷射捕捉技術與他們的樣本之合作工作。

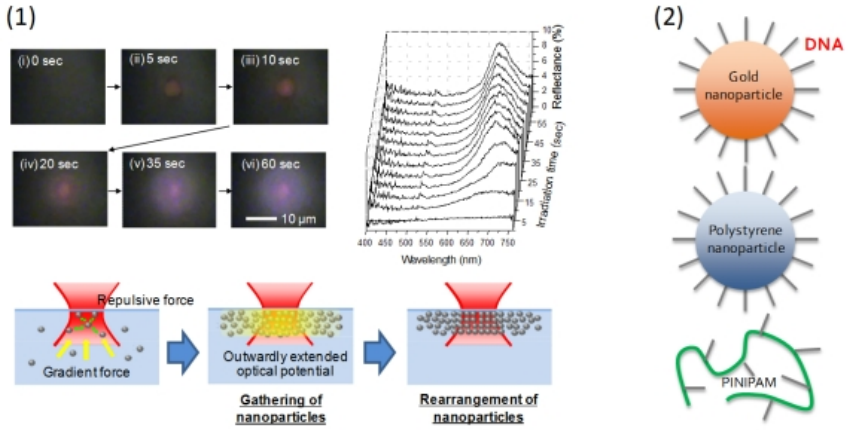

Figure 2. (1) Representative results on the formation of a nanoparticle assembly with an ordered structure by laser trapping. (2) Nanoparticles covered with DNA in professor Maeda's laboratory.

圖 2.(1) 利用雷射捕捉技術形成奈米分子組裝的有序結構之示意圖。(2)Prof. Maeda 團隊製備的 DNA 附著於奈米分子上之示意圖。

(3) Oral presentation in "Annual Meeting on Photochemistry 2014"

This international meeting held annually is the largest photochemistry conference in Asia. Based on the program, we had 170 oral presentations and 334 posters in the conference. In addition, two special sessions were organized：[1] New Photochemistry Opened by Photofunctional Inorganic-Organic Hybrids, and [2] Frontier of Single Molecule Detection. My presentation title was "Laser Trapping Controlled-Crystal Growth of L-Phenylalanine at a Solution Surface". I talked about 12 min and discussed with audiences for 8 min.

(3)於 2014 年度國際光化學會議口頭演講：

這次的國際會議每年舉辦為亞洲最大型的光化學會議。在這個會議中有 170 位口頭演講者與 334 為海報報告者參與。此外，我們將策畫兩個特別的部分；[1]開啟新的光化學議題—光官能基之無機與有機的結合及[2]單分子偵測的前沿。我演講的題目是“在溶液表面利用雷射捕捉技術控制 L-Phenylalanine 的晶體成長”(Laser Trapping Controlled-Crystal Growth of L-Phenylalanine at a Solution Surface)。我口頭演講 12 分鐘，討論 8 分鐘。

二、過程

10/10：Arrive in Sapporo, Hokkaido, Japan

Taipei Songshan Airport => Haneda International Airport (by air)

Haneda International Airport => Shin-Chitose Airport (by air)

10/10：抵達札幌市，北海道，日本

●臺北松山機場=>東京羽田國際機場（空運）

●東京羽田國際機場=>新千歲機場（空運）

10/11：Oral presentation in the conference

Annual Meeting on Photochemistry in 2014 (Oral presentation for 20 min including discussion)

10/11：口頭報告在會議中

2014 年度國際光化學會議(Annual Meeting on Photochemistry in 2014)（口頭報告中，包括討論 20 分鐘）

10/12–14 Stay in Associate Prof. Miura’s lab (Hokkaido University)

Discussion and simple experiments (construction of new optical setup)

10/12–14 停留 Associate Prof. Miura 的實驗室(北海道大學)

討論和一般的實驗

10/14 night：Arrive in Tokyo

Shin-Chitose Airport => Haneda International Airport (by air)

10/14 晚上，抵達東京

●新千歲機場=>東京羽田國際機場（空運）

10/15：Stay in Prof. Maeda's lab (Riken)

Seminar, lab tour, and discussion

10/15：停留 Prof. Maeda 的實驗室

研討會，實驗室參觀和討論

10/16 Arrive in Taiwan

Tokyo Narita International Airport => Taiwan Taoyuan International Airport (by air)

10/16 抵達臺灣

●東京成田國際機場=>臺灣桃園國際機場（空運）

三、心得及建議

10/11 Oral presentation in the conference

I presented our recent results on crystallization and crystal growth of L-phenylalanine by laser trapping. Figure 3 shows some slides which were used in my oral presentation entitled "Laser trapping controlled-crystal growth of L-phenylalanine at a solution surface". Our results were well accepted from audiences. I received 5 questions from 4 professors.

<Questions>

(1) How molecules/clusters are gathered around the focal spot? You can examine the gathering dynamics by using optical methods?

(2) Why a dense region can be extended outward from the focal spot?

(3) Initially the crystallization of glycine was demonstrated, because it has strong electrostatic molecular interactions. Other amino acids have also the similar interactions?

(4) The mechanism of trapping at the crystal edge is still unclear.

(5) Convection flow can influence the trapping behavior?

After the presentation, I talked with professor Okutsu in Gunma University. He is preparing to organize “Crystal Growth Conference” in the next year. I was asked to deliver an invited talk in the special session on "photo-induced crystallization and crystal growth" that he will organize.

10/11 口頭報告在會議中

我報告目前利用雷射捕捉技術控制 L-Phenylalanine 的晶體成長及結晶的結果。圖 3.顯示我的題目“在溶液表面利用雷射捕捉技術控制 L-Phenylalanine 的晶體成長”(Laser Trapping Controlled-Crystal Growth of L-Phenylalanine at a Solution Surface)是在口頭演講所用到的一些投影片。我們的結果廣受聽眾的接受。我收到來自四個教授的 5 個問題。

<問題>

(1)這些分子是如何聚集在焦點周圍?你能運用光學方法來檢查聚集的動力學嗎?

(2)為何緻密區域可以自焦點向外延伸?

(3)一開始顯示甘氨酸的結晶形成是因為分子間交互作用形成強大的靜電力。其他的氨酸分子也有相似的交互作用力嗎?

(4)雷射捕捉行為在晶體邊緣的機制仍然不清楚。

(5)對流會影響到雷射捕捉的行為嗎?

演講之後，我和在群馬大學的 Prof. Okutsu 討論。他正準備在明年舉辦“結晶成長會議”。我被邀請參加他策畫的特別部分“光激發結晶及晶體成長”。

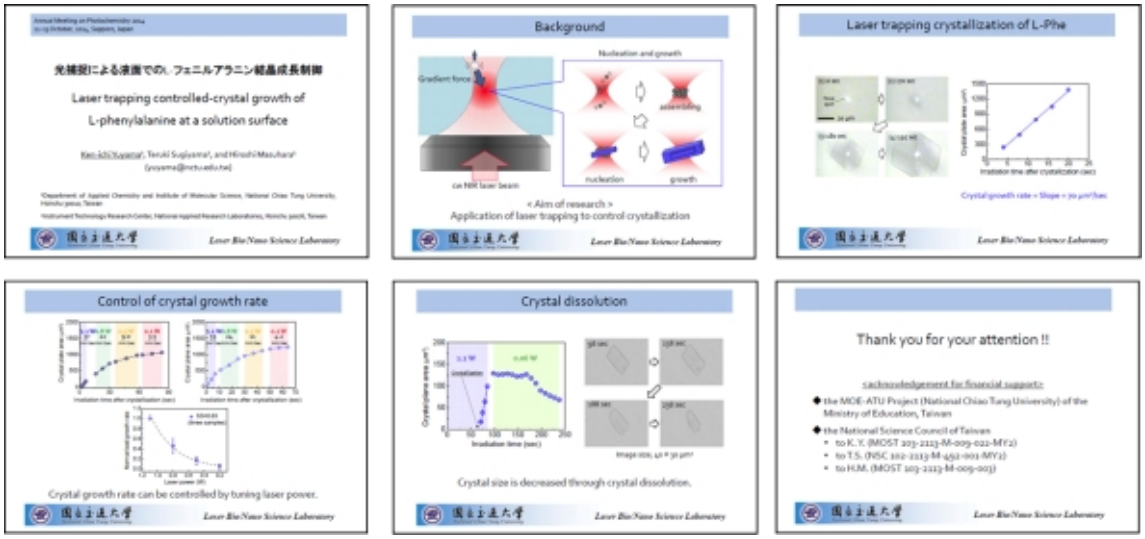

Figure 3. Some slides used for the oral presentation in the conference.
圖 3.在會議中口頭演講所用到的一些投影片。

10/12–14：Stay in Associate Prof. Miura’s lab (Hokkaido University)

First of all, I discussed our recent results with associate professor Miura in his office (Figure 4-1). I explained our recent results on laser trapping-induced crystallization of L-phenylalanine. He showed the results of ongoing research of laser trapping-induced formation of a dense domain of HEWL. We understood that, in both cases, a dense domain is formed from the focal spot and it plays an important role for crystallization and crystal growth. The common problem is that we cannot measure its size and concentration in the conventional laser trapping system. In order to solve this problem, we concluded that a new optical system should be coupled with the conventional laser trapping setup. We had two ideas schematically illustrated in Figure 4-2. We will set another objective lens at the position above the sample (Figure 4-2 left). This system will enable us to estimate the size of a dense domain through

direct observation. In the second idea, we will detect the diffraction angle of light passing through the sample (Figure 4-2 right). Because the diffraction angle strongly depends on solution concentration, we can estimate the concentration change during laser trapping. It takes time to start the first idea, because we have to buy some optical items. So, we decided to start the second idea in Hokkaido University.

For two days, I and associate professor Miura tried to construct the new system for the measurement of the domain concentration (Figure 5). In their microscope, two lasers were already introduced. One is the trapping laser of 1064 nm, and the other is 488 nm. The latter laser was originally used for the Raman measurement. The latter laser was used as probe light to monitor the concentration change during the laser irradiation. The important point is that we have to introduce the probe light as parallel light ray. This was a more serious problem than expected. Usually, laser light passing through an objective lens is tightly focused into a small area. So, we put one lens in front of the objective lens. The lens was set on a micrometer-stage, so that we could change its position manually and change the incident angle of light after the objective lens. We took the remaining days for this adjustment and could not start the measurement of the concentration change during laser trapping. But, I think that associate professor Miura's group can develop this new system in the near future.

10/12–14：待在助理教授 Prof. Miura 的實驗室 (北海道大學)

首先，我與副教授三浦在他的辦公室介紹我們的最新研究成果 (圖 4-1)。我報告在雷射誘導捕捉 L-phenylalanine 結晶的最新研究成果。他介紹即將發表的研究—利用雷射誘導捕捉技術形成雞蛋清溶菌酶（HEWL）密集的區域。我們了解到，在這兩個情況下，密集的區域都會自焦點形成且在結晶與晶體成長中扮演很重要的角色。相同的問題是我們無法在雷射捕捉系統下測量它的大小和濃度。為了解決這個問題，我們總結出一個新的光學系統應該要加上傳統雷射捕捉設置。我們有兩個想法之示意圖(圖 4-2)。我們將設置其他的物鏡在樣本上方的位置(圖

4-2 左)。這個系統將經過直接觀察使我們能夠估計出緻密區域的大小。第二個想法，我們將偵測光通過樣本之衍射角(圖 4-2 右)。因為衍射角和溶液中濃度有強烈的關係，我們在雷射捕捉時可以估計濃度的改變。第一個想法是很花時間的，因為我們必須買一些光學產品。所以我們決定在北海道大學採用第二個想法。

這兩天，我和助理教授 Prof.Miura 為了測量區域的濃度試著設置新的系統(圖 5)。我們介紹他們顯微鏡下的兩個雷射光。一個是波長 1064 奈米光束，而另一個是波長 488 奈米的光束。後者雷射光束是用拉曼儀器測量。後者雷射光束作為探測光來監控雷射光照射過程中的濃度變化。重點是我們必須介紹探測光為平行光。這是非常嚴重的問題超越我們所預期的。通常雷射光經過物鏡是緊密地聚焦於一塊小區域。所以我們放置一面鏡子在物鏡的前方，物鏡設定為微米級，因此我們能夠用手動的方式改變它的位置及在物鏡之後改變入射角。我們持續幾天做調整而尚未開始在雷射捕捉時測量濃度的變化。但是我想助理教授 Prof.Miura 在不久之後能夠建立一個新的系統。

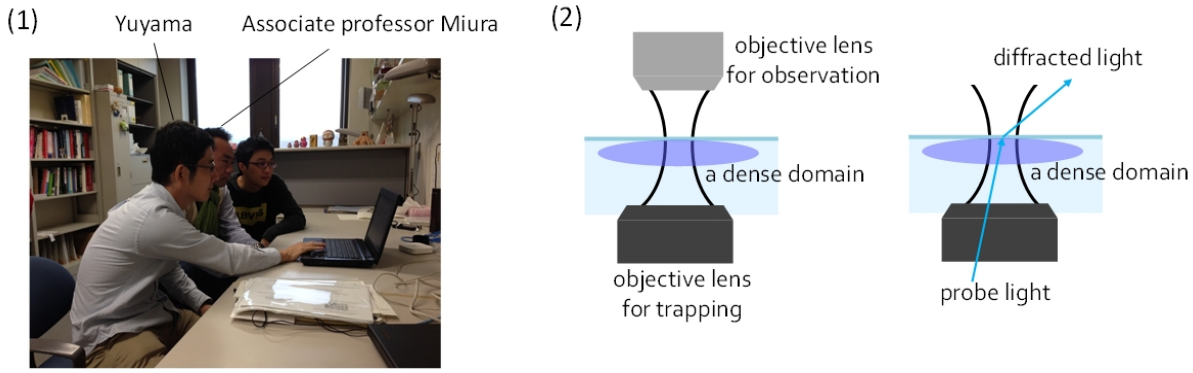

Figure 4. (1) A photo of discussion with associate professor Miura. (2) Two ideas to measure size and concentration of the domain.

圖 4.(1) 和助理教授 Prof. Miura 討論的照片(2)兩個想法去測量區域的大小與濃度。

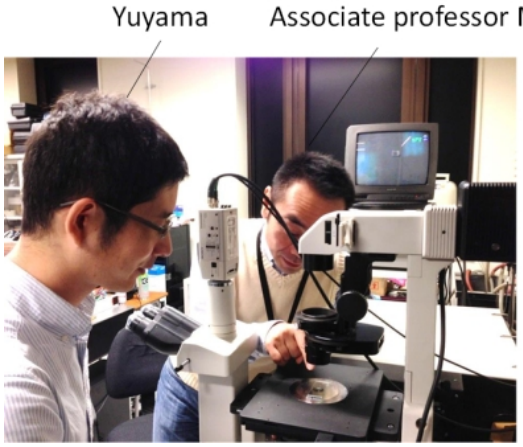

Figure 5. A photo of a simple experiment with associate professor Miura.
圖 5.和助理教授 Prof. Miura 一起做一個簡單實驗的照片。

10/15：Stay in Prof. Maeda's lab (Riken)

Figure 6-1 shows my schedule in Riken. In the morning, I had the closed-seminar in professor Maeda's group. I talked about 45 minutes. The presentation tropics were three laser trapping-induced phenomena：[1] crystallization and crystal growth, [2] formation of a nanoparticle assembly, and [3] amyloid formation. Some slides used in my seminar are shown in Figure 6-2. All results attracted much attention from audiences. Especially, the second topic was closely related to their research. After my seminar, we discussed our results for about 1 hour.

In the afternoon, 5 researchers presented the results of their ongoing works. The contents are shown below.

(1) Dr. Takarada：The history of DNA coated nanoparticles.

(2) Dr. Fujita：The structural analysis of DNA coated nanoparticles using synchrotron radiation facility (Spring 8 in Japan).

(3) Dr. Wang：Toward plasmonic coupling of DNA coated gold nanoparticles.

(4) Dr. Akiyama：The formation of oligomers of DNA coated gold nanoparticles.

(5) Dr. Kanayama：[1] Chemical sensor using DNA coated nanoparticles, [2] force analysis between DNA coated nanoparticles.

Incidentally, Dr. Akiyama has visited NCTU last year and had a seminar. He is an important scientist for the collaboration between professor Maeda's group and professor Y.-K. Li's group. A photo with professor Maeda is shown in Figure 6-3.

Though all activities, we decided to start the collaboration work using their DNA coated polystyrene nanoparticles. We will gather them at a solution surface by laser trapping technique and compare their trapping behavior with that of non-coated particles. We will again check our experimental conditions in details and order necessary particles to professor Maeda's group in the near future.

10/15：待在 Prof. Maeda 的實驗室(理化學研究所)

圖 6-1 顯示我在理化學研究所的行程。在早上，我在 Prof. Maeda 團隊有一個緊密的研討會。我演講約 45 分鐘。演講主要內容為三個雷射捕捉誘發現象；[1]結晶和結晶成長，[2]奈米分子組裝的形成及[3] 澱粉樣蛋白的形成。在圖 6-2 中為此研討會中所用到的一些投影片。實驗結果內容引起聽眾注目。特別是，第二個主題非常接近他們的研究。在研討會之後我們討論約 1 小時關於我們實驗結果。

下午五位研究生報告他們目前的實驗結果。內容將顯示在下面

(1) Dr. Takarada：DNA 附著在奈米分子的歷史.。

(2) Dr. Fujita：DNA 附著在奈米分子的結構分析利用同步輻射裝置。

(3) Dr. Wang：DNA 附著在金奈米分子的對電漿耦。

(4) Dr. Akiyama：DNA 附著在奈米分子之寡合物形成。

(5) Dr. Kanayama：[1]用 DNA 附著在金奈米分子作為化學感測器, [2]利用 DNA 附著在金奈米分子作動力分析。

順帶一提, 去年 Dr. Akiyama 曾拜訪交通大學且有一個研討會。他是一個重要的科學家在 Prof. Maeda 的團隊和 Prof. Y.-K. Li 的團隊之間合作。圖 6-3 為和 Prof. Maeda 的合照。

因此我們決定開始一起合作利用他們 DNA 附著在聚苯乙烯奈米分子的技

術。我們將利用雷射捕捉技術聚集他們在溶液中的表面及比較他們與非附著分子之捕捉行為。我們不久之後將仔細地再次檢查我們的實驗情況及向 Prof. Maeda 的團隊訂購所需的分子。

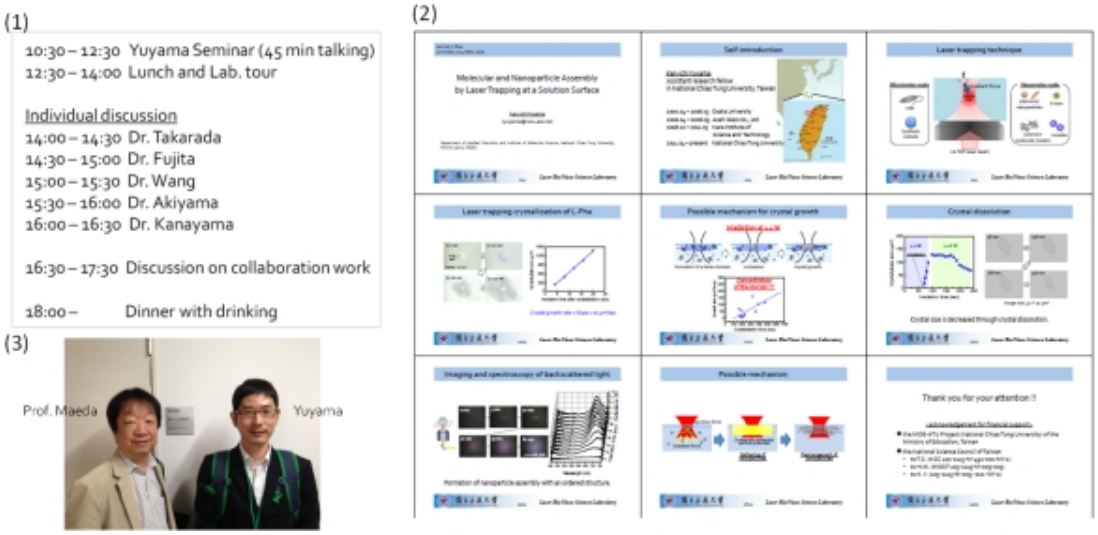

Figure 6. (1) My schedule in Riken. (2) Some slides used for the seminar in Riken. (3) A photo with professor Maeda.

圖 6.(1)在理化學研究所時我的行程表(2)在理化學研究所參加研討會時所用的投影片 。