Report on Visit to Queen's University Belfast by International Training Program

Department of Electronic Information System, Graduate School of Engineering, Nagoya University
Takehiro Hiraoka

In this time, I attended the International Training Program (ITP) to participate in long-term exchange for two months from January 30, 2011, and I have researched at Prof. Bill Graham group in Centre of Plasma Physics of Queen's university Belfast.

§ Queen's University Belfast

Queen's University Belfast (QUB) is located in the southern district of the capital, Belfast, Northern Ireland. There are a Ulster museum and Botanic Garden around the university, and the region done very in a relaxed manner. In surroundings of the botanical garden, we looked many students playing football or reading.

Centre of Plasma Physics is in Mathematics and Physics of QUB. Construction that newly changed old stone was done now. The nonequilibrium plasma is handled in Graham professor's group, and the plasma source is analyzed to simulate by the experiment when the atmospheric pressure plasma source and liquid plasma. Moreover, most is composed of PhD and the PhD students as for the group.

Fig. 1 Queen's University Belfast .

§ Life

I stayed in Dr. Charlie's house where Arthur who is PhD student at the QUB lived with on the introduction of Prof. Graham. There is a house at about ten minutes on foot from QUB. It was wide enough though the room was an attic, and was able to use the consumer electronic freely. Most made the sandwich and pasta, etc. from cooking for oneself in meal. Rice used the school cafeteria and the takeout in daytime. There were a lot of supermarkets and shops of the take away around the university, and were abundantly & chips and the sandwich, the curry, and pizzas, etc. Moreover, there was a menu of about five pounds also in the dining room in the student hall. The menu mainly had sausage pie and fish & chips. Appreciation of the yen influenced as prices, and I did not felt that it was too high either. Because a loaf of bread sold was one pound, and some fruit was about 40 pence in the supermarket, it bought it as much as possible in the supermarket for the saving.

I spent it at home as how after it had come home to spend it because it darkened around 18 o'clock. I watched DVD of the movie or quiz show on TV with Mr. Charlie, and I often read.

I went sightseeing in the city, and we watched the rugby match in PUB because 6 nations holding period on holiday. There is a capital of Northern Ireland, too and the central portion includes the city hall and the grand opera house, etc. in Belfast. Moreover, the region of Catholic community and the region of Protestant community divided when going to the Belfast west, and a lot of wall paintings were

seen in each region. At the Ulster museum and the Botanic Garden, a lot of tourists visited, and I often went there because entrance charge is free .

Moreover, it went to the tour that turned round Giant's Causeway in Northern Ireland that was the tourist spot when Mr. Arthur's friend came to play from Germany. This tour was turned round the Dunluce castle, the CVarrick-a-Rede Rope Brigde and the Bushmills distillery in Portrush, and this spent 25 pounds. It became very good study for me though it was not possible to understand perfectly because the guide performance in English

The parade was done in the city hall on the Cent Patrick day, March 17. This day when the entire town was dyed to one green color was able to touch the culture of Ireland, too.

§ Research Activities

During first week, Mr. Arthur introduced laboratory members for me briefly; because Prof. Graham missed I filled out the form which required the permission during my stay.

Second week, I presented about my research. I talked about master's study at Wakayama University, "Development of optical fiber type Cavity Ring-Down Spectroscopy" and "Fiber-type thermo sensor using low coherence interferometry", and in progress study, "Measurement of carbon nanowall characterization using Terahertz spectroscopy". Thus, my study theme was decided "Temperature measurement in liquid plasma emission spectroscopy", because I used spectroscopy tecnique..

The third and fourth week, I read the paper related the experiment and I learned to use of the device with Mr. Colin. There was also collaboration with the University of Ulster, I joined the meeting with professor and PhD students at the University of Ulster. In their experiments are conducted generating particles using gas-liquid plasma and they desired to measure optical emission spectroscopy of the plasma using PMT. Therefore, we read related paper and went to NIBEC of University of Ulster, for optical emission spectroscopy measurement of gas-liquid plasma. Unfortunately, we could not measure because the plasma source had poor stability to continue the discharge.

During five to eight weeks, I performed optical emission spectroscopy measurements in this report. Mr. Colin studied with PhD students in other groups, she synthesize the polymer using low temperature ablation system. Thus we measured the optical emission in order to obtain the characterization of this plasma source. Arthourcare system is medical low-temperature ablation plasma source. Firstly, we used NaCl, $BaCl_2$, $NaOCH_3$, KCl, $NaCO_3$ as a solution. They were used in her experiment. Fig. 2 is schematic diagram of optical emission spectroscopy. Here, we focused BaCl2 to calculation temperature from the emission spectrum, because Ba and Ba ions are easily excited and many peaks can be observed from the visible region. BaCl2 was 10ml of 0.5 mol. First, we measured time response of voltage, current, the emission intensity measured PMT were measured of the plasma. Voltage was 200 kHz, Vp-p was 300 V. With the current value of the plasma emission was seen change. In particular, the first part of 1μs is larger for the emission changes for the solution is heated to generate bubbles at room temperature.

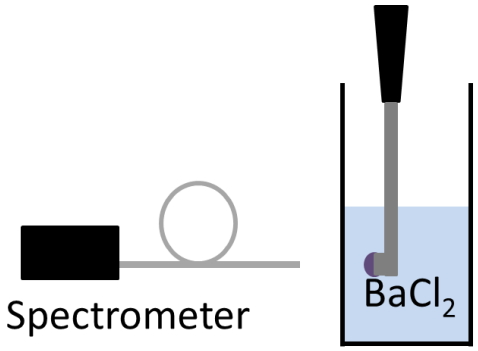

Fig. 2 Schematic diagram of optical emission spectrometry.

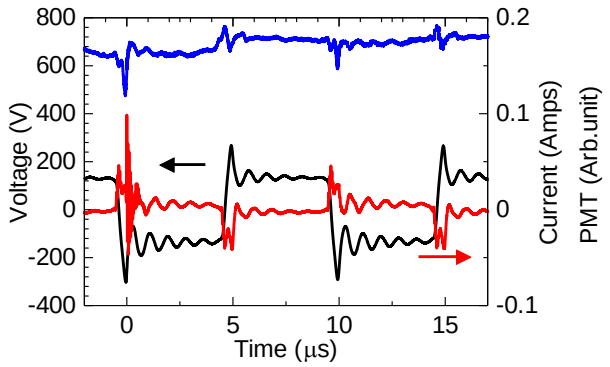

Fig. 3 time response of voltage, current, emission intensity

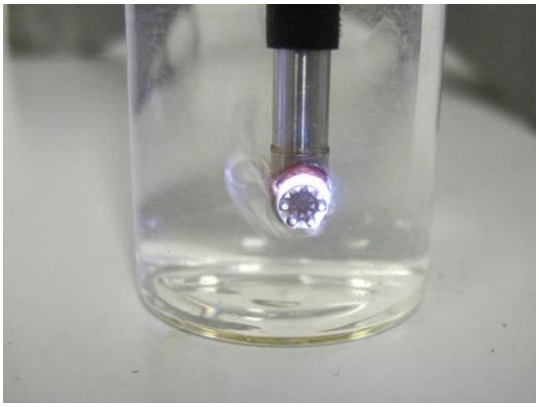

Fig. 4 optical emissions in $BaCl_2$

Fig. 4 was a state of BaCl2 during emission from the plasma source. Ba could be confirmed by the emission of lilac. The spectral measurements used a multi-channel optical fiber type spectroscope. The measurement region was 200nm ~ 1100nm. And the integration time is 300ms, and the average number was 3 times. Fig. 5 shows optical emission spectra of $BaCl_2$. Against the NIST database, I identified Ba I, Ba II lines. In this measurement, we focused on Ba lines; Hα line was able to confirm, Hβ line measurements were performed due to the short integration time. In addition, Cl emission line could not be confirmed because of the high excitation energy.

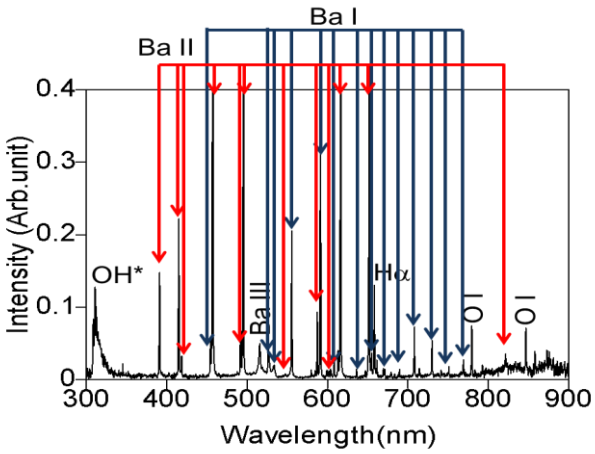

Fig. 5 shows the emission spectra of $BaCl_2$

Fig. 6 shows the Boltzmann plot of the Ba I, Ba II which obtained Fig. 5. Excited states of Ba I in the process is

$$Ba\ I + e \rightarrow Ba\ I\ *$$

Therefore, this plot can be approximated using

$$\ln\left(\frac{I\lambda}{Ag_k}\right) = -\frac{E_k}{kT} + \ln C \quad , \qquad (1)$$

where, I is the emission intensity, λ is the wavelength, A is the transition probability, g_k is the multiplicity of the upper level, E_k is the excitation energy, k is the Boltzmann constant, T is the excitation temperature, C is a constant.
In addition, Ba II excited state of the process,

$$Ba\ I + e \rightarrow Ba\ II + e \rightarrow Ba\ II\ *.$$

The two processes are possible. Therefore, this plot can be approximated

$$\ln\left(\frac{I\lambda}{Ag_k}\right) = -\frac{E_k + E_{ion}}{kT} + \ln C \quad , \qquad (2)$$

where, E_{ion} is the first ionization energy of Ba. Ba is the first ionization energy is 5.212eV. Solid lines in Fig. 6 are approximated by linear least squares using eq.1 and eq.2. And the excitation temperature

obtained from each slope, Ba I excitation temperature of 0.52eV, Ba II excitation temperature could be obtained with the 1.09eV.

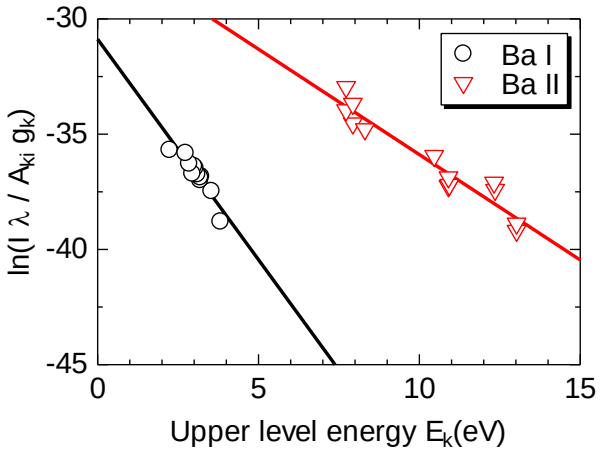

Fig. 6 Boltzmann plot

・For academic life

Laboratory meeting held on once a week, two research students gave a presentation about the status of the two slides, the format was discussed. If there are no speakers, someone report the recent study freely, sometimes to the discussion. I inspired by their willingness to study attitudes, because students, postdoctoral and professors actively discussed every time,

As mentioned above, I think that this exchange for two months was invaluable to me, because this is expected to develop research activities in the future and trigger understanding each other's culture between Japan and British through the plasma emission spectroscopy measurements of liquid plasma, exchange of students and professor in QUB, and living abroad, and two months so it was invaluable to me.

Finally, I would like to thank Prof. Masaru Hori, Prof. Hirotaka Toyoda, many professors, Plasma Nanotechnology Research Center, Nagoya University, professor and Prof. Graham, lecturers and many students of Queen's University Belfast who gave me opportunity like this.