Global Engineering for Development, Environment and Society
Internship Report

TAIST Exchange Program for NSTDA

2016/8/15 ～ 2016/9/19

Masaya Kobayashi
Hanaoka Lab

-Introduction-

I took part in the TAIST-Tokyo tech exchange program during this summer vacation. TAIST is established as international cooperation between NSTDA(National Science and Technology Development Agency) is the Thailand of advanced research institutions, Thai university groups and Tokyo institute of Technology.

TAIST has three programs for students.

1. Automotive Engineering(AE)
2. Information and Communication Technology for Embedded Systems(ICTES)
3. Advanced and Sustainable Environmental Engineering(EnvE)

I participated EnvE program. Thai student can get master degree from these programs. Also, Tokyo-tech students can take part in these program partially.

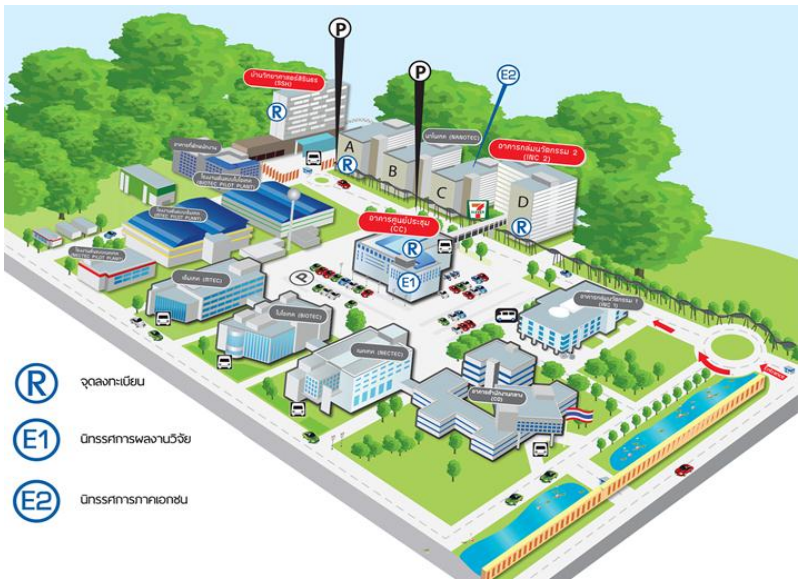


Figure1: Map of Thailand Science Park

NSTDA is placed in Thailand Science Park. NSTDA has four departments. These are NECTEC(Electronics and Computer science), BIOTEC(Biotechnology), MTEC(Metal materials) and NANOTEC(Nanotechnology). I studied in NANOTEC.

The reason why I take part in this internship, I have the background of physics field, I want to challenge for internship to research agency. Actually, I graduated from faculty of science. Also, in current laboratory, I don't have any chances to do experiment. I guessed this is the rare opportunity for me. I wanted to learn the application of nanotechnology and improve my English skills through this internship.

Figure2: Instructors (Dr.Paiboon, Dr.Jedsada) and me

They are instructors. Dr.Jedsada is my main instructor. He always conducted experiment with me. Dr.Jedsada research about Graphene/MnO2 materials for Super-capacitor electrode. He has already known some making methods, but he hasn't try it yet. I partially contributed to his research. My mission is "Making the electrode using GO/MnO2" and "Using some analysis methods of electrode materials".

-Internship-

By the way, I have to explain about Super-capacitor. It is Eco-friendly electrical storage device. It has construction using electrolyte and aluminum/carbon as materials.

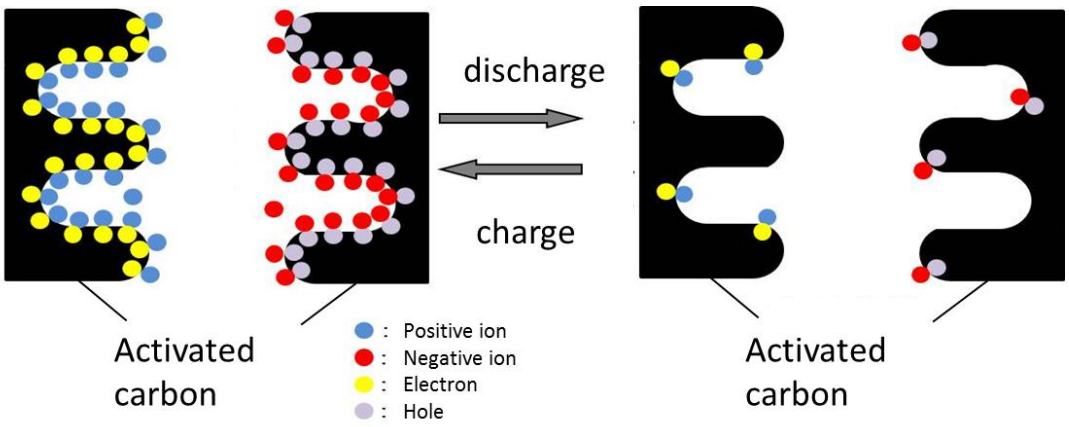


Figure3: Principle of Super-capacitor

There is some particles, such as Positive ion, Negative ion, Electron and Hole on the surface of Super-capacitor. They made the double layers like Figure3. This is the same

situation with the series of two capacitors. In this double layers, electric charge is accumulated. Then, we can see the charge and discharge. Super-capacitor has some characteristics. Merit is that it has quicker charge and discharge and longer life than normal capacitor. In other hands, Super-capacitor is weak to high voltage. And it's too expensive.

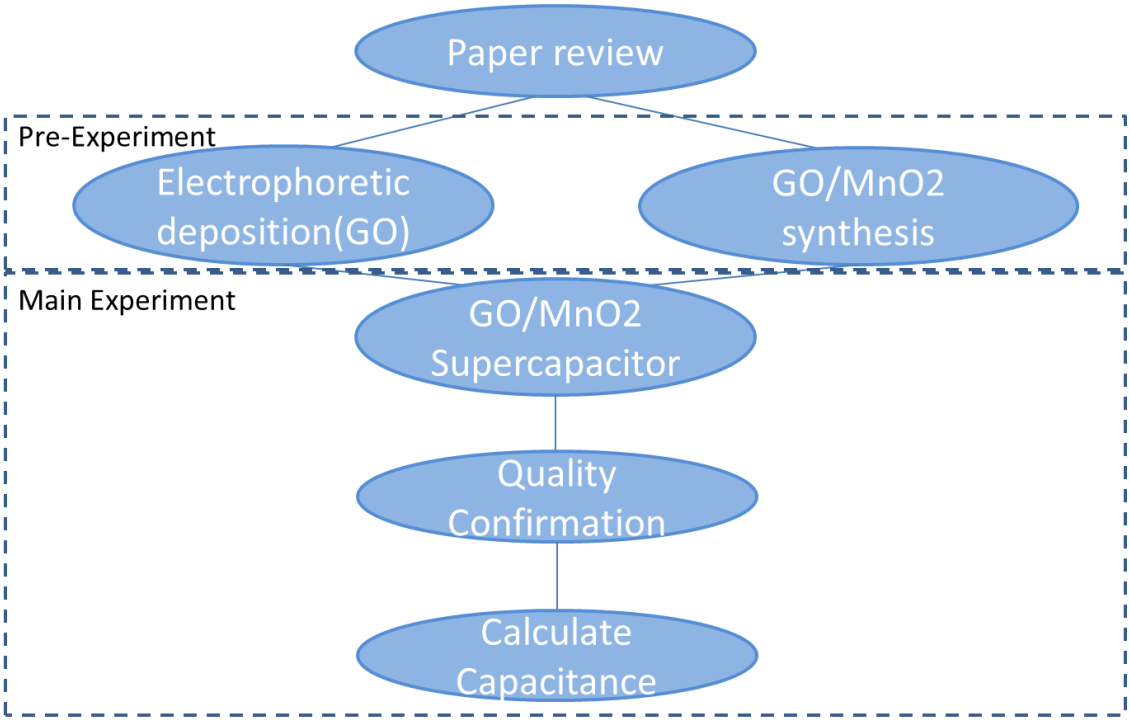


Figure4: Outline of my research process

At first, we read some papers as reference. From these papers, we decided methods of experiment for Super-capacitor. Pre-Experiment is Electrophoretic deposition and GO/MnO2 synthesis. Using Pre-experiment result, finally we made electrode materials for super-capacitor. After that, we confirmed quality of our sample and calculated capacitance.

-Experiment-

As pre-experiment in order to decide materials for synthesis GO/MnO2, we prepared two sets. Set 1 is ①*GO(0.4 mg/mL) + KMnO4(1.968g)* and ②*GO(0.4 mg/mL) + KMnO4(1.968g)+Mn(CH3COO)2(1.408g).* I warmed up this composite in the hydrothermal on 160℃ during 12 hours. After centrifuge, we could get powders.

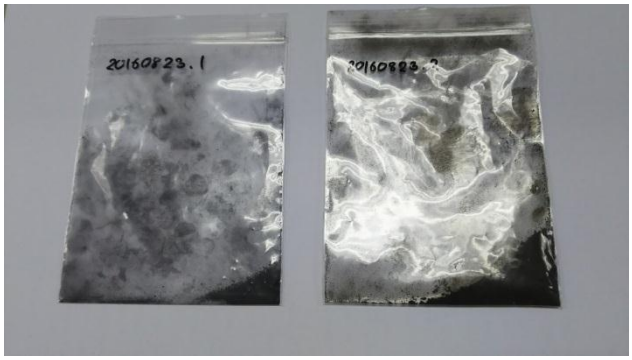


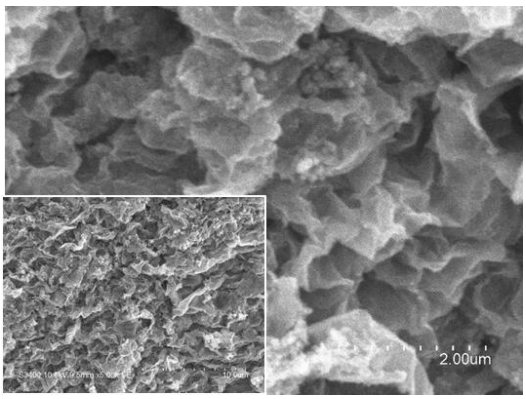
Figure5: ①&② powder

Set 2 is ③*GO(0.4mg/mL) + KMnO4(20mM)* and ④*GO(0.4mg/mL) + KMnO4(10mM)*. The difference between ③ and ④ is concentration of *KMnO4*. In the same way with Set 1, we made the powder and suspension.

Figure6: ③&④ powder

Figure7: ③&④ suspension

I analyzed samples ① to ④ using some analysis device. At first, we observed surface of ① and ② powders using SEM. SEM means Scanning Electron Microscope. We can focus on smaller nano-level materials on the surface. From SEM results, we can investigate morphology if the composite.



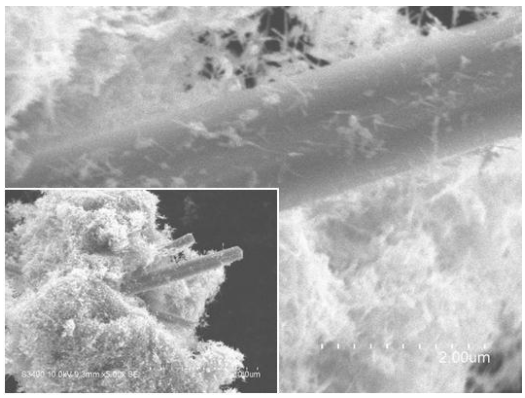


Figure8&9: SEM image of ①&② powder

SEM image of ① shows 2-D surface. ② shows nanorod. Existence of nanostructure is better for high conductivity. Also, we conducted XRD analysis. XRD means X-ray diffraction. We used XRD method to investigate structure of composite.

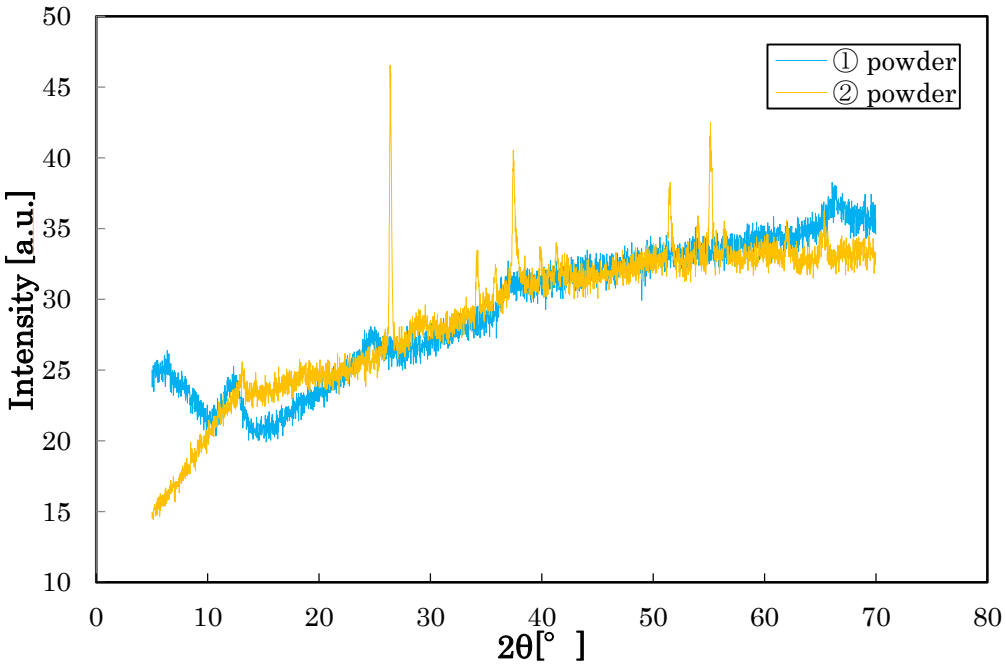


Figure10: XRD result of ①&② powder

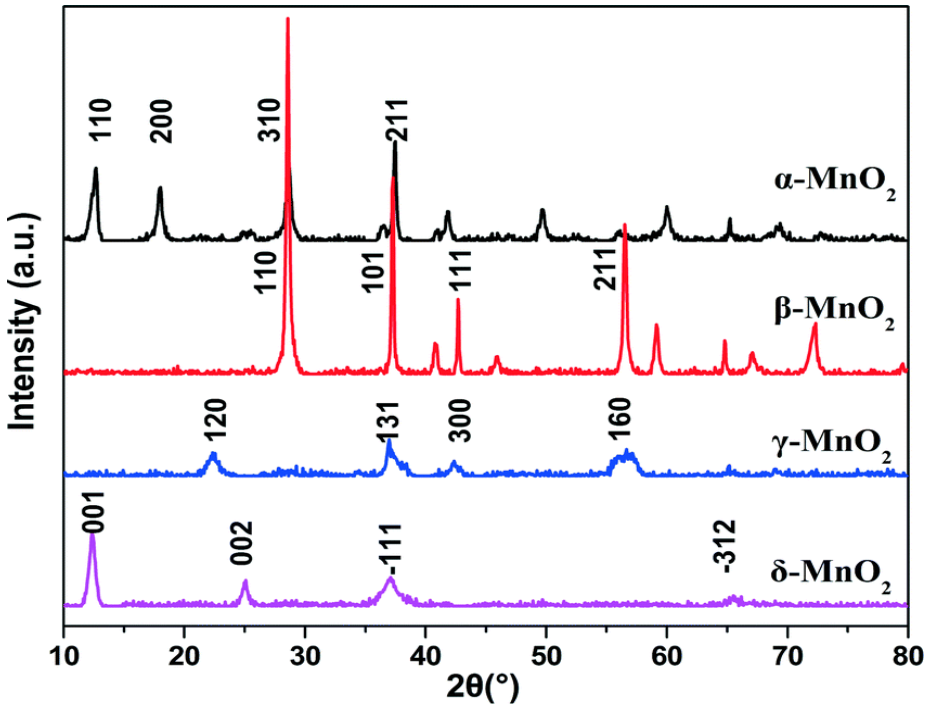
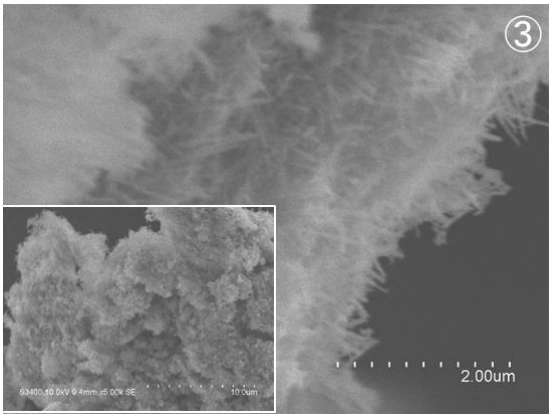


Figure11: Reference of XRD peak(GO/MnO2)

In Figure10, we can recognize structure of *GO/MnO2* using Figure11 reference. β & δ face is usually observed recent research of Super-capacitor.



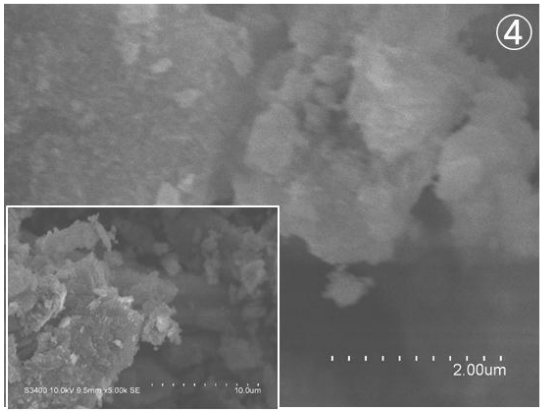
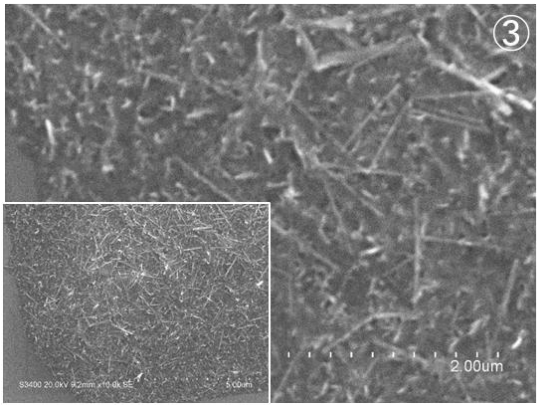


Figure12&13: SEM image of ③&④ powder



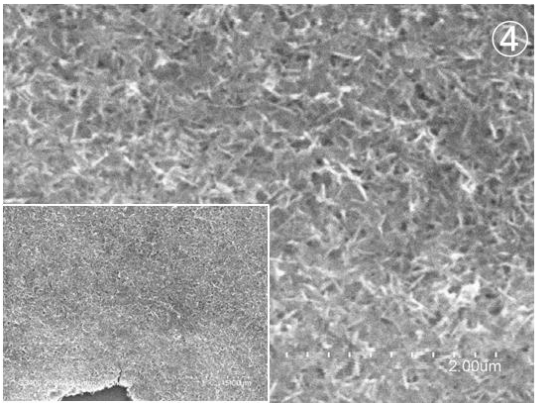


Figure14&15: SEM image of ③&④ suspension

Figure12 shows nanostructures as well as Figure9. It is called nanowire. The difference between nanowire and nanorod is length of structure. Figure13 is difficult to maintain what it is. Because it usually shows nanostructure, but it doesn't have any structures. Probably, I mistook focusing on appropriate sample. Figure14&15 are suspension images. It shows a lot of nanostructure. If we choose this method to make electrode materials, it is possible.

We can't use XRD method in this situation because XRD can be used just solid sample cases. In this case, we appropriated to measure "zeta potential". Zeta potential is potential difference between interface of charged particle and sufficiently distant point.

Sample Name	Zeta Potential [mV]
③	-50
④	-32.4

Table1: Zeta potential result of ③&④

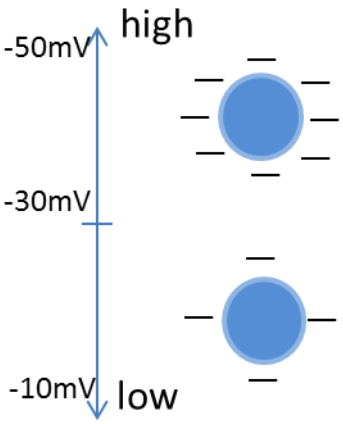


Figure16: Zeta potential when particle has negative charge

High zeta potential has high density of negative charge. Figure16 shows results of our samples. It can be said ③ sample is high zeta potential. High zeta potential is better to make the good Super-capacitor.

After we conducted experiment to synthesize *GO/MnO2*, we tried to do coating method. It is called electrophoretic deposition. This method means phenomenon that charged particles move in the electric field in order to Al with GO.

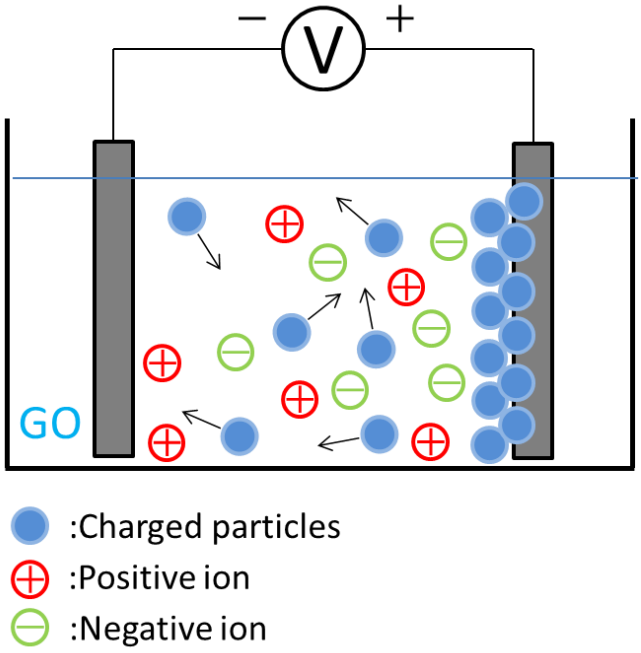


Figure17: Image of electrophoretic deposition

Using this method, we could make the Al sheet coating with GO.

Figure18: Al sheet coating with GO

We checked surface of Al sheet we made by SEM, we could get Figure20.

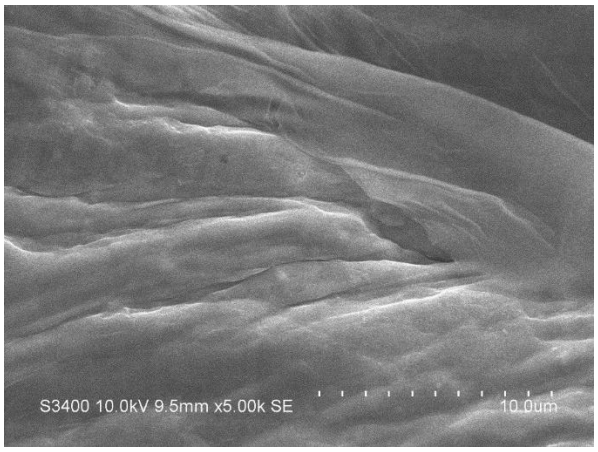


Figure19: SEM image of *GO/Al*

This figure shows flat surface. Flat surface is better for good Super-capacitor too. Because electrolyte can go through inside of electrode materials. We guessed this coating method is possible for making electrode materials.

We decide samples to make electrode materials. That is *GO(2mg/mL) + KMnO4(20mM)*. We conducted same way with ③ experiment. We made a suspension of *GO + KMnO4* and warmed up this suspension in hydrothermal on 140℃ during 12hours. After that, we used electrophoretic deposition again to coat Al with *GO/MnO2*. In this way, we made the capacitor electrode. In order to analyze, we used SEM, XRD and measuring zeta potential.

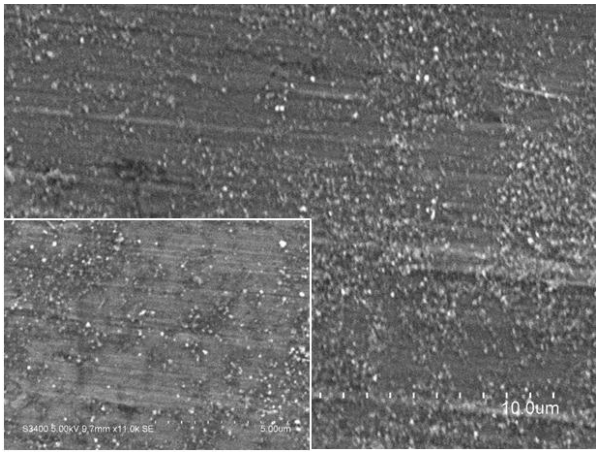


Figure20: SEM image of GO/MnO2 on Al

This picture shows some particles on the surface. Also, it has flat surface. Based on this sample surface, we made an electrode materials for Super-capacitor.

Sample Name	Zeta Potential [mV]
GO/MnO2 on Al	-48.8

Table2: Zeta potential results of GO/MnO2 on Al

This zeta potential is high as well as ③. Because this value is similar to ③ data.

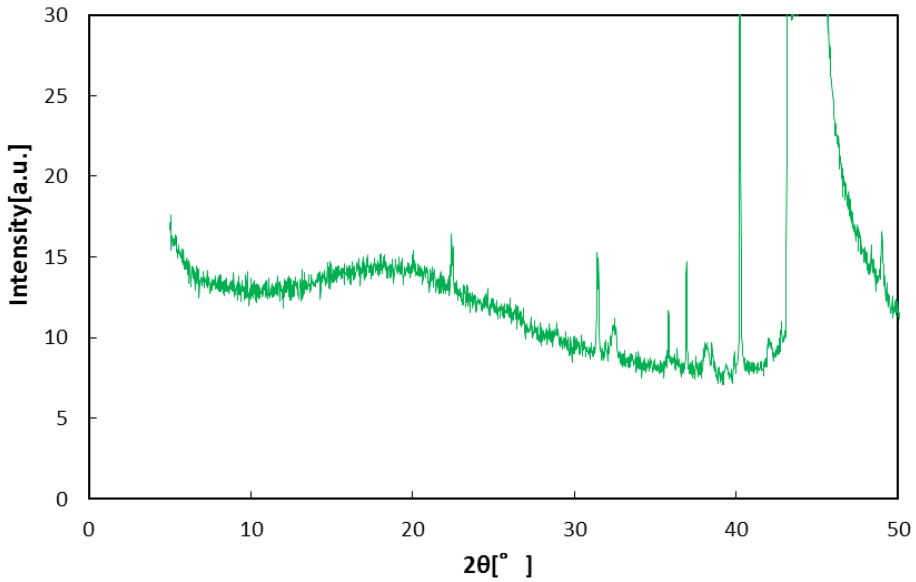


Figure21: XRD result of GO/MnO2 on Al

In our previous prediction, this picture will show the β face. However, this XRD pattern doesn't fit with any MnO2 literature(Figure11). I can't explain enough detail.

As another analysis method, we conducted Cyclic Voltammetry method. From this method, we could get cyclic voltammogram.

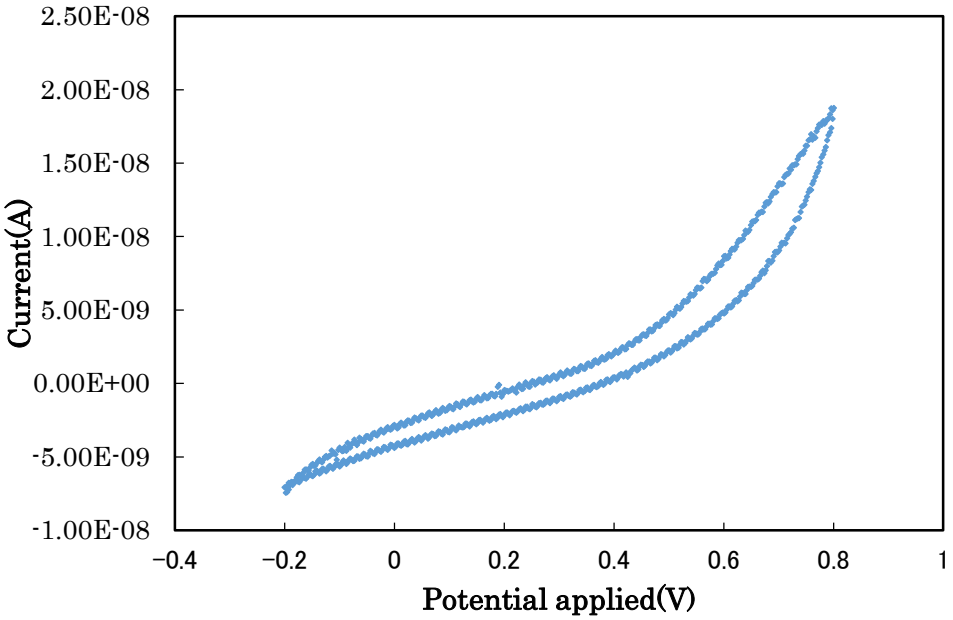


Figure22: Cyclic voltammogram of our sample

Figure22 shows hysteresis curve. In calculating area of hysteresis curve, we can calculate area capacitance of our sample. The formula of capacitance is following;

$$C_{area} = \frac{\oint I(V)dV}{mr \times 2(V_f - V_i)}$$

m: area *r*: the potential scan rate
Vf: final voltage *Vi*: initial Voltage

From these way, our capacitance has,

$$C_{area} = 50nF / cm^2$$

Actually, this is quite small capacitance. I guessed there are some problems.
Probably, the coating layer is too thin. And, accessibility of electrolyte is not good.
As the summary of experiment, I could make electrode materials through the synthesis *GO* and *MnO2* and electrophoretic deposition method. I wanted more time in order to conduct an experiment.

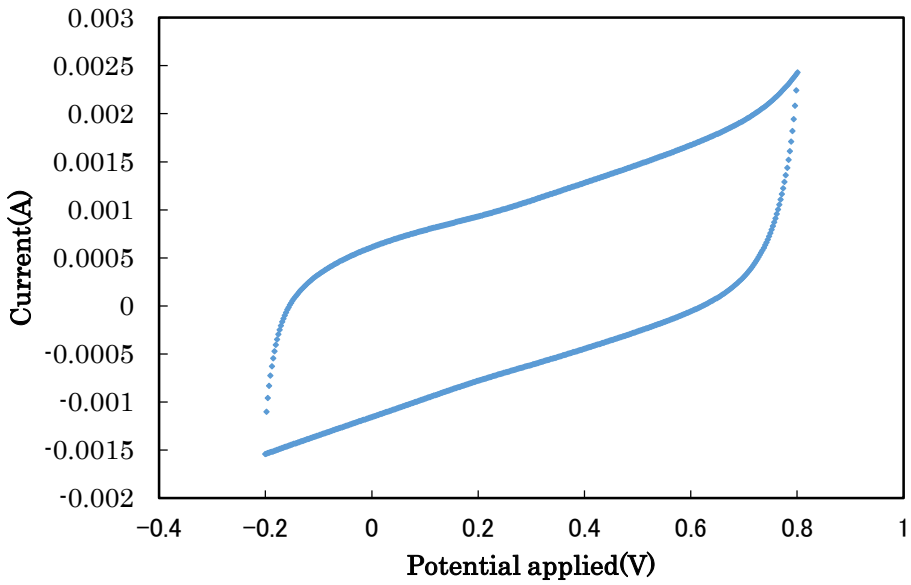


Figure23: Cyclic Voltammogram of General Super-capacitor(5F)

Figure23 shows the example of cyclic voltammogram of general Super-capacitor. It's a commercial one. It has 0.4*F/cm2* capacitance. This figure has a more symmetric area than our sample. Generally speaking, the larger the integral area, the higher capacitance.

-Others-

During internship in Thailand, I could feel Thai culture from many things. From here, I'd like to explain about my days in Thailand.

Figure24: My parent come Bangkok

Figure25:TAIST student

In August 19-20, My parent came Bangkok to meet with me. They said “We come to check whether you didn’t do bad things”. They are just parents even if time passed.
I took part in TAIST classes partially as exchange student. Then, I met some Thai students. Figure25 shows my best Thai friend! He taught me Thai language. The paper I have, but it is hard to see, shows my mane in Thai. Also, some TAIST students planned short trip to Ayutthaya for me.

Figere26: Ayutthaya

Ayutthaya is historical place in Thailand. Ayutthaya is close to Bangkok. If you go to Ayutthaya from Bangkok by bus, you take 2hours. Easy to access, most of traveler visit here.

-Conclusion-

From this exchange program, I learned the advanced scientific knowledge. And I had courage to speak English than previous me. I felt that Thai culture and kindness of the people. I want to challenge more international program or project. This internship has physics and chemistry field. It’s not directly related to my master research. However, I believe this experience will be useful in my future.