

平成 30 年 3 月

国立研究開発法人理化学研究所  
理事 松本 洋一郎

## 平成 29 年度実施 主任研究員の研究業績レビュー（中間）の結果について

研究開発等評価実施規程（平成 15 年 10 月 1 日規程第 74 号）及び主任研究員及び上席研究員研究業績評価実施細則(平成 27 年 10 月 23 日細則第 84 号)を踏まえ、レビューアーから送られた評価結果は以下のとおりです。

### 1. 評価対象：石橋極微デバイス工学研究室 石橋 幸治主任研究員

#### 1) 評価体制

実施日：平成 29 年 12 月 15 日（金曜日）

4 名の所外有識者を評価委員とするヒアリングレビューを実施。

評価者：

Yasuhiko ARAKAWA, Professor  
The University of Tokyo, Japan

Per DELSING, Professor  
Chalmers University of Technology, Sweden

Kazuhiko MATSUMOTO, Professor  
Osaka University, Japan

Koichiro TANAKA, Professor  
Kyoto University, Japan

#### 2) 評価結果の概要等

*General comments:(arranged in random order)*

##### 【Reviewer 1】

The research objective of the ‘Advanced Device Laboratory’ lead by Dr. Koji Ishibashi is nanofabrication in molecular and atomic scales and coherent manipulation of quantum states in the devices. I was strongly impressed several results presented by Dr. Ishibashi. The most important point is that all subjects are quite challenging and including novel original ideas. The research has been executed in a quite high level and obtained results have high impact on the science in the research field.

One of the most impressive results is fabrication of the carbon nanotube based functional nanostructures. Isolated single-wall carbon nanotube ring is chemically synthesized and used as a quantum device. Beautiful Aharonov-Bohm type conductance oscillation was successfully demonstrated. This is a clear sign that quantum effect manifests the physical nature of the device. This will lead to a sensitive local magnetic sensor device in future. Another successful device is a quantum-dots-combined single-wall carbon nanotube. Light-controlled gate-like behavior was confirmed by fluorescence. In addition to carbon nanotube devices, Dr. Ishibashi also lead the group activity to the spin-related nano-devices. They fabricated several nano-devices in a resonator and topological Josephson junction and obtained initial results. These devices are all challenging and original ones.

As for the management of the Laboratory, I just say congratulations to Dr. Ishibashi and all members of the Laboratory. I interviewed several researchers in the Lab. All members are satisfied with Dr. Ishibashi’s direction and collaboration. Even a researcher joined

recently from the other group operated by a retired principal researcher said that he is happy in the group. Management was perfect.

For the future research plans, the research direction of Dr. Ishibashi is clear and has no problem for future. I recommend the continuous support for his research activity.

Overall, research activity of 'Advanced Device Laboratory' lead by Dr. Koji Ishibashi was excellent and has produced many fruitful results.

## **【Reviewer 2】**

### **Research objectives:**

Dr. Ishibashi and his group is pursuing research in a rather wide range of scientific topics, related to beyond CMOS devices, in most cases using the nanoscale devices. The activities include work on quantum dots, carbon nanotubes, nanowires, topological insulators, hybrid devices and more.

### **Research results:**

Dr. Ishibashi's Laboratory is doing high quality research, and the results are published in good journals. In particular the results on chemically induced quantum confinement and the work on topological insulators are impressive.

### **Management of the Laboratory:**

The management of the groups seems to work well. The senior scientists have a large freedom to run their projects, which cover a wide range of topics. In general, the members of the Laboratory seem to be very happy and content with the way that the Laboratory is managed. The Laboratory also has a number of good collaborations with other groups.

### **Future research plans: possibility of cooperation with related fields.**

During the review Dr. Ishibashi and his colleagues presented their future research plans. To a large extent this is a continuation of the ongoing successful research already performed in the Laboratory.

### **Overall assessment:**

In general, the group is doing very good research, reaching the forefront of research on several topics. The laboratory is well functioning and managed in a good way.

## **【Reviewer 3】**

### **Research objectives, Research results:**

- Combining the hetero knowledge of chemistry and electronics, he formed a CNT ring by combining CNT with molecules, and succeeded in measuring the standing wave of electrons in the ring. This result is extremely high original level. In addition to the observation of standing waves of electrons, he also succeeded in observing the very clear AB vibration using the same CNT ring. This can be evaluated as the world high level research.
- The method of creating CNOT using double quantum dots utilizing the localization of electrons in CNT is also quite unique. Although CNOT gates have already been proven by other methods, it is highly appreciated that demonstrating the CNOT gate in a completely unique way.
- It is the great and world high level result that he succeeded in getting the results of the possibility of Majorana particles for the first time in the world by observing the  $4\pi$  cycle

in the Shapiro step of the Josephson junction with the combination of the topological insulator and the superconductor system. This great result is attained by the international and internal collaboration with various research institutions in the world and in Japan. This worldwide collaboration is attributed to the ability of Ishibashi senior researcher's global friendship.

- He tried to increase the operation temperature of Q bit by using the Si MOSFET and Ion Implantation in collaboration with enterprises. This is the quite unique and important process to realize the Q bit as a practical application and future development. I hope the problem of yield and reproducibility should be improved in future.
- We wish a little more progress in the research of high temperature operation of the single electronic device using FIB to form the defects to the CNT.

#### **Management of the Laboratory:**

- From interview with young researchers, everyone gave great credibility to the management of the Ishibashi Chief Scientist, and received answers that they were quite satisfied with the research environment. This demonstrates the extremely well management is being carried out in the laboratory. It can be said that the trust that young people gave to Ishibashi chief scientist is sufficient.
- Research topics of Ishibashi' lab is quite wide and dispersed much such as CNT, Qbit, Majorana particles, oxide material, plasmonics, etc. However, this is not the responsibility of Chief Scientist Ishibashi, but the result of accepting the researchers at the end of other laboratories in the same field. Chief Scientist Ishibashi has been carefully protecting researchers in this field so that research can be carried out and it can be said he has extremely high morality.
- Because of the wide topics, discussion and collaboration are active within the theme of the original Ishibashi group, but collaboration with newly entering people is small. But, this is not his responsibility. This problem should be solved by RIKEN itself. There are many collaboration on the technology side and it is very healthy appearance.

#### **Future research plans: possibility of cooperation with related fields.**

- Chief Scientist Ishibashi has already carried out research by acquiring necessary special materials in collaboration with many organizations abroad and domestic, and has got fruit of cooperation sufficiently. Concerning the cooperation, it is not necessary to say opinions from the outside.

#### **Overall assessment:**

- In order to realize quantum computing, Chief Scientist Ishibashi have studied from various directions and steadily promoted research. Several topics are at a high level worldwide, and it can be said that development can be expected in the future.
- As already stated above, Chief Scientist Ishibashi is trying to improve the motivation of young researchers and their research environment, so we can say that his management is well arranged.
- Because of the large number of researchers he has taken in his laboratory, the Chief Scientist Ishibashi is overburdened with their supervision. However this is a systematic problem that needs to be solved by RIKEN

#### **Other opinions:**

- In order to maintain the continuity of the laboratory, I think that it is necessary to foster talent to succeed Ishibashi. If successors are trained, the motivation of young people increases, and the concern for the future decreases.

#### **【Reviewer 4】**

##### **Research objectives:**

Dr. Koji Ishibashi has been conducting fascinating research on the nanofabrication in molecular and atomic scale, the coherent manipulation of quantum states, the development of new materials and topological superconductors, and plasmonics aiming at creating new functions for new nanoelectronics. Since the objective of the group is set to be at the cutting-edge and challenging, we hope Dr. Ishibashi will continue to make more effort to overcome the world's competition and achieve further creative results.

##### **Research results:**

Dr. Ishibashi' group has made several excellent achievements in the field of nanophysics and nanoelectronics, including the development of single electronic devices, coherent manipulation of charge/spin, and the exciton qubit devices. In particular, investigation of physics of spin effects in a silicon MOS field-effect transistor is one of its important achievements.

##### **Management of the Laboratory:**

He is an excellent leader of the research group with a generous personality and strong leadership. He also actively carries out academic activities and acquired external funds of a certain level. It should be highly appreciated that he tolerantly accepted some senior researchers belonging to other laboratories which were closed. We are impressed to see that they are now satisfied with continuing to their research as members of Dr. Ishibashi's group.

##### **Future research plans: possibility of cooperation with related fields.**

Dr. Ishibashi emphasized significance of the research on "hybrid quantum systems, which is an important concept for the future of advanced interdisciplinary solid-state science and technology. The effort toward the establishment of this new fields should be further investigated by Dr. Ishibashi's group and its collaborators in the world.

##### **Overall assessment:**

Dr. Koji Ishibashi has been achieving a high-level research and demonstrating his superior management ability as a principal investigator (PI). As a result, he has been making a major contributor to RIKEN. Accordingly, it would be beneficial for both RIKEN and Dr. Ishibashi if he could receive an opportunity to continue to keep his research activities for a longer period.

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