

**Trip Report via 2010-2011 Faculty Grants for International Connections**  
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First of all, the author would like to thank the grant organizers and committee members for this grant for International Connections. The author traveled to Japan for two weeks between July/3 through 20th as proposed. During this travel, the author visited to two manufactures (JEOL and Toyota Central R&D Institute) and Kyushu University. The details of the individual visits are summarized following:

**JEOL, Tokyo (July/4-5)**

In the proposal, the author did not mention this visit. However, the author added to visit to JEOL in this trip for two purposes. The first purpose was to discuss configurations of our new state-of-the-art aberration-corrected analytical electron microscope, which has been funded by National Science Foundation (NSF) via the Major Research Instrument (MRI) program (award number: 1040229, Note: the author is the primary investigator of this grant). Although we got this big grant with Lehigh's cost share, it is a bit short to have all functionalities in this instrument. It was a very good opportunity for me to discuss the microscope configurations with them face-to-face. Finally, they agreed with our proposed configurations, which was very successful. In addition, we gather several data from a prototype instrument. Figure 1a shows the prototype instrument with Dr. Eiji Okunishi who demonstrated unique operations in this instrument. It should be noted that the new instrument will be installed at Lehigh in early 2012.

The second purpose to visit to JEOL was to develop auto-tuning software for aberration corrector in collaboration with Dr. Hidetaka Sawada. In an aberration-corrected analytical electron microscope, aberration tuning is one of the most important alignments. Some inexperienced users face to the difficulty to tune the corrector. Therefore, Dr. Sawada and the author have developed an aberration tuning procedure named a segmented image auto-correlation function matrix (SIAM) method. The software development was performed by using another test instrument at JEOL (Fig. 1b). Figure 2 compares high-resolution images of SrTiO<sub>3</sub> before (a) and after (b) applying the SIAM method, which were taken in the JEM-ARM200F prototype instrument. By applying the SIAM method, the atomic-resolution lattice fringes now appear clearly without any manual adjustment. This tool will be used for training new users on how to tune the corrector. This development was reported in the Microscopy & Microanalysis 2011 meeting, held at Nashville TN in August (the largest meeting for electron

microscopy in the world and the author was the program co-chair of this meeting this year).

#### **Toyota Central R&D Institute, Aichi (July/6-7)**

The second visit in this trip was Toyota Central R&D Institute (Fig. 3a). This institute belongs to the Toyota corporation group but is independent to the main corporation. Here they proceed R&D toward more basic science instead of applications. As described in the proposal, A new type of alloy called Gum Metal has been developed from a Titanium alloy by Drs. Kuramoto and Furuta in this institute. Unlike conventional alloys, the Gum Metal exhibits very unique properties such as super elasticity and super plasticity just like rubbers (this is why the name “Gum Metal“ comes from). They also discovered similar super elastic property in iron-base alloys. However, the reasons to exhibit such rubber-like super elasticity are still unknown. Therefore, they are interested in Lehigh’s materials characterization capabilities, especially aberration corrected instruments to investigate the unique mechanical properties in Gum Metals.

During this visit to this institute, the author gave one seminar talk entitled “Atomic-level Materials Characterization by Aberration-corrected Scanning Transmission Electron Microscopy” in Japanese (Fig. 3b). Then, the author had a tour in this institute and discussed about future collaboration. They would like to proceed this collaboration and promised me to provide small amount of research funding (~\$20k). Currently, we are processing some paperwork for this collaboration.

#### **Kyushu University, Fukuoka (July/8-20)**

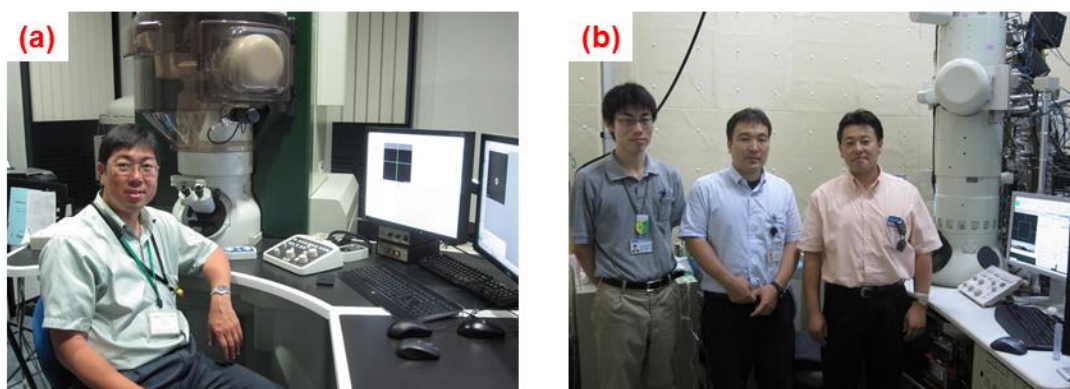
The last and longest visit in this trip was to Kyushu University (Fig. 4a). In this University, Professor Zenji Horita of Department of Materials Science and Engineering has developed a series of very unique materials processing called severe plastic deformation (SPD) to improve mechanical strength of metals and alloys while maintaining their ductilities. Now, his group applies this SPD process to various materials. However, they do not have sufficient capabilities to characterize these processed materials. The main purpose of my visit to Kyushu University was to establish collaboration between Prof. Horita’s group at Kyushu and the author’s group at Lehigh. The author gave a seminar talk entitled “Atomic-level Materials Characterization by Aberration-corrected Scanning Transmission Electron Microscopy and Multivariate Statistical Analysis” in Japanese (Fig. 4b). In addition to the official seminar, the author taught several microscopy techniques to graduate students using

their instruments (Fig. 4c).

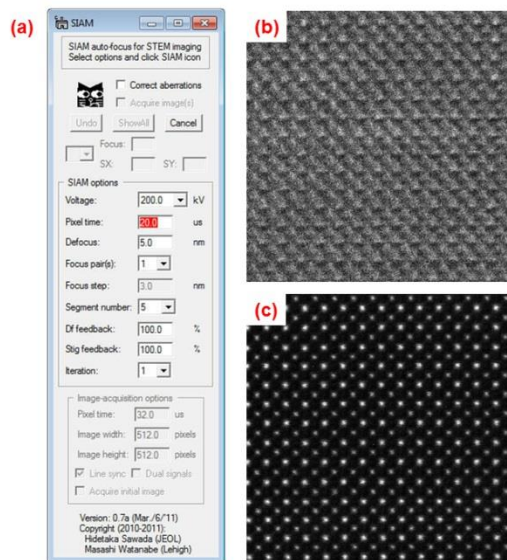
To start our collaboration officially, Professor Horita and the author decided to apply several research fundings together. When the author was in Kyushu University, two major research grants were announced from Japanese Science and Technology (JST) agency: one is named “Advanced Low Carbon Technology Research and Development Program (ALCA)” and other is the CREST program for creative research. It should be noted that these grants are for Japanese researchers who belong to Japanese Universities or Institutions. Therefore, the author cannot be the primary investigator (PI) for this grant proposal. On the other hand, the author can participate as a co-PI in the joint proposal. In these proposals, we ask two students (one is at Kyushu University and other is at Lehigh) and some instruments, which can be mounted on electron microscopes at Lehigh. Finally, they had a farewell party for me when I left (Fig. 4d).

In summary, this trip was very successful and very intense. But not finished at all. Professor Horita and this author are now planning to submit another joint proposal to JST and NSF together. The author is willing to expand the connections established within this trip for future research opportunities.

Finally, the author would like to thank the committee for me to have this opportunity to explore research connections.



**Fig. 1** (a) Dr. Eiji Okunishi with a prototype instrument of JEM ARM-200F at JEOL. (b) Drs. Takashi Hasegawa (left) and Hidetaka Sawada (center) with another prototype instrument, in which we developed a new auto-tuning procedure.



**Fig. 2** (a) A dialog for the SIAM method implemented in Gatan DigitalMicrograph and high resolution images of SrTiO<sub>3</sub> before (b) and after (c) three iterations of SIAM process.



**Fig. 3** (a) From left, Drs. Furuta, Kuramoto, the author and Senoo at Toyota Central R&D Institute. (b) The title slide of the author's seminar talk at Toyota Central R&D Institute.



Fig. 3 (a) The author at Kyushu University. (b) The title slide of the author's seminar talk at Kyushu University. (c) Graduate students, Mr. Lee and Mr. Iwaoka, in Professor Horita's group with their instrument. (d) One image from farewell party for the author with graduate students and Professor Horita (center).