ND*nano* Undergraduate Research Fellowship (NURF)
2015 Project Summary

1. Student name: Daiki Kurihara

2. Faculty mentor name: Hirotaka Sakaue

3. Project title: Interdisciplinary research of chemical sensor development for fluid dynamic applications

4. Briefly describe any new skills you acquired during your summer research:

- Planning skill for proceeding the research smoothly
- Making the method to make two-color PSP uniformity
- Experiment techniques for measuring the spectrum of the two-color PSP
- Thinking methodically for the investigation

5. Briefly share a practical application/end use of your research:

The measurement method that I have been working with on my research can be used to measure pressure differences on objects that are rotating or flying such as helicopter rotor blades, bullets and other objects. To use this measurement method, the pressure of moving objects can be measured easier. Since PSP method provides more information the results are more accurate for the pressure measurement.

Begin two-paragraph project summary here (~ one type-written page) to describe problem and project goal and your activities / results:

On designing an airplane, surface pressure is very important. As a pressure measurement, researchers generally use the mechanical pressure sensors like Kulites. These mechanical pressure sensors need complex wirings. In addition, these sensors measure the air pressure at the point where they are placed. Another way to measure the air pressure is using Pressure-Sensitive Paint (PSP) measurement. PSP uses oxygen quenching to determine the air pressure. One of the benefits of using PSP measurement is that PSP measurement can measure the air pressure distribution on a surface without affecting the surface of the model. PSP measurement needs two kinds of images of the luminescent signal which are taken at different times to calculate the net intensity of the signal related only to the air pressure. One of the images is taken without the air flow, and the other is taken with the air flow. The air pressure information of two images is taken as a ratio, thus we can analyze the air pressure distribution through image processing. However the model which is used in an aerodynamics experiment is not allowed to move, because it would affect the image processing. PSP measurement can be used as long the model does not

move. There is Motion-Capture PSP measurement which was proposed by Dr. Sakaue to be able to measure air pressure if the model is moved during the experiment. Motion-Capture PSP uses two luminophores which have different emission wavelengths. In Motion-Capture PSP measurement, two images are taken at the same time by using high-speed color camera. Therefore we can get air pressure distribution if the model is moved. Motion-Capture PSP measurement is applied to the experiments that happen only once for example bullet and flutter wing experiments. The one of the issues of Motion-Capture PSP measurement is luminescent uniformity between emission intensity of the luminophores. If emission intensity of the luminophores is not uniform, PSP provides wrong surface pressure. Therefore PSP which has good uniformity is required.

In order to solve this issue, we investigate influence of the polymer and porous particle on luminescent uniformity. Motion-Capture PSP is composed of two luminophores, polymer, porous particle and solvent. From the components of the PSP, the polymer is used as a glue to hold two luminophores and porous particle on the surface of measured object. Also the porous particle is used to provide the high-speed pressure response, and the porous particle appears to hold two luminophores. It is assumed that the luminophores are hold in the both of polymer and porous particle. I examined the influence of the polymer and porous particle on luminescent uniformity to make the samples changed the amount of the polymer and porous particle. I obtained the following results. Gradually decreasing the percentage of polymer to the whole volume, the luminescent uniformity is improved. Also decreasing the percentage of porous particle to the whole volume, the luminescent uniformity is improved. These results show that the luminescent uniformity is improved, if the polymer and porous particle can move unlimitedly in the solvent. The luminescent uniformity was improved, but it is not enough to measure the pressure on the surface of the rotating body. The dynamic pressure at the leading edge of the rotating body we would like to measure is about 10 [kPa]. The luminescent uniformity makes an error which is about 25 [kPa]. As compared to the dynamic pressure, this error is too large to measure the pressure. The cause of luminescent uniformity which we can think is the thickness of the PSP. Continuously I would like to do research about this thickness.

Publications (papers/posters/presentations):