

## 【Grant-in-Aid for Scientific Research (S)】

### Science and Engineering (Interdisciplinary Science and Engineering)



**Title of Project : Assembly of nanostructure on insulating surfaces and investigation of gas reaction mechanism using atomic force microscopy**

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Research Area : Scanning probe microscopy

Keyword : Atomic force microscopy, Nano-structure, Charge transfer, Gas reaction mechanism

#### 【Purpose and Background of the Research】

The investigation of the physical and chemical properties of nanostructures on insulator surfaces is very important for those application to sensors, catalysis, and electronic devices. Nanostructures, composed of a few to several tens of atoms, exhibit strong quantum size effect. The electronic structure of the corresponding confined electrons differs completely from that of bulk materials. The presence of defects on insulator surfaces introduces unsaturated binding sites, which serve either as charge donors or acceptors. The electronic structure of nanostructures grown on insulator surfaces would be strongly influenced by charge transfers to or from the surface defects, dramatically changing the physical and chemical properties of the nanostructures. Therefore, in order to design and realize nanostructures with the desired novel functionality, e.g., a certain catalytic property, it is critical that we have a detailed understanding of the interaction between nanostructures and surface defects.

The objectives of this research are to clarify the charge transfer phenomena between defects and nanostructures on insulator surfaces and to clarify the relationship between the structure and the charge state of the nanostructures to the catalytic reaction mechanism on the atomic scale in reactive ambient environment.

#### 【Research Methods】

- (1) Elucidation of the defect structure and the charge state on insulator surface using atomic force microscopy and electrostatic force spectroscopy.

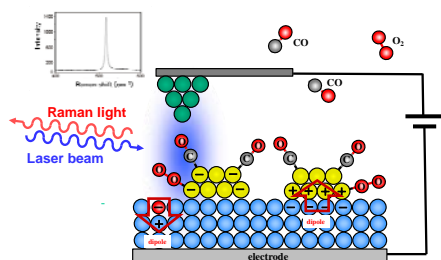


Figure 1 Experimental method

- (2) Elucidation of the structure change in nanostructures and the charge state changes due to the reactive gas adsorption.
- (3) Elucidation of the adsorption state of the adsorbed gas on the nanostructures using tip-enhanced Raman spectroscopy.
- (4) Elucidation of the mechanism behind the catalytic reaction on nanostructures under reactive ambient environment conditions.

#### 【Expected Research Achievements and Scientific Significance】

By investigating the physical and chemical properties of nanostructures on insulator surfaces, we can acquire knowledge on the electronic state and novel function in nanostructures. Such knowledge will provide a huge contribution to progress in “physics and chemistry of nanostructure on insulator surface in reactive ambient environment”. Furthermore, such knowledge will provide a huge contribution towards the realization of next-generation catalytic nanomaterials, fuel cells, and high sensitive gas sensors.

#### 【Publications Relevant to the Project】

J. Bamidele, S. H. Lee, Y. Kinoshita, R. Turanský, Y. Naitoh, Y. J. Li, Y. Sugawara, I. Štich, and L. Kantorovich, “Vertical atomic manipulation with dynamic atomic-force microscopy without tip change via a multi-step mechanism”, *Nature Communications*, 5, 4476, 2014.  
Y. J. Li, J. Brndiar, Y. Naitoh, Y. Sugawara, and Ivan Štich, “Atomic force microscopy identification of Al-sites on ultrathin aluminum oxide film on NiAl(110)”, *Nanotechnology*, 26, 505705, 2015.

**【Term of Project】** FY2016-2020

**【Budget Allocation】** 139,100 Thousand Yen

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