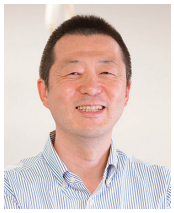
Clarification of Physical Properties and Reaction Mechanisms at Surfaces and Interfaces by Scanning Probe Microscopy

Instrument Center



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Surfaces and interfaces are fascinating fields for physical, chemical and biological phenomena. While these phenomena are well known, the mechanisms underlying them remain poorly understood in many cases. Scanning probe microscopy (SPM) is a superior method for analyzing the mechanism. We have established the advanced system to clarify these mechanisms at surface and interface in nano/atomic scales (Figure 1).

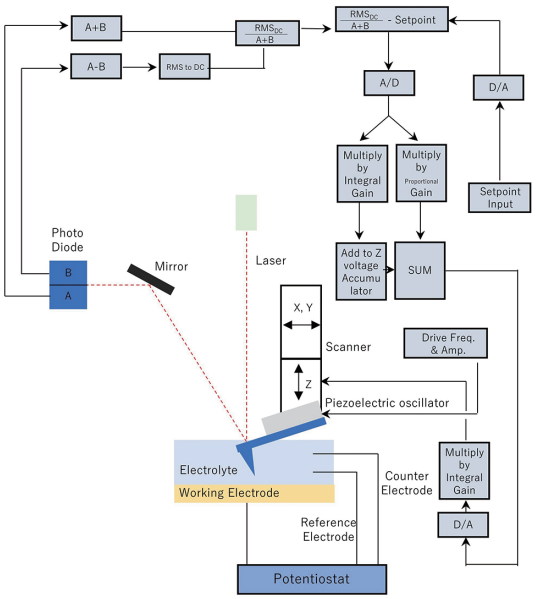

Figure 1. SPM system used in the analysis of physical properties and reaction mechanism at the surface and interface.

Recently, our focus has been on analyzing the electrode/electrolyte interface in electrochemical reactions.[1,2] Figure 2 shows the changes of the surface structure of gold electrode during the electrochemical dissolution in aqueous electrolyte. This dissolution reaction proceeds through the reactions of halogen ions with gold atoms. However, the elemental process driving this reaction remain unsolved. Through high resolved image and mechanical properties analysis of the surface by SPM, we have found the reactions are triggered by the distortion of the surface structure.

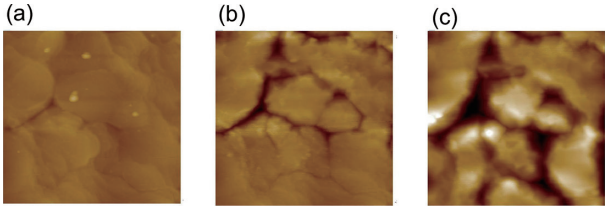

Figure 2. SPM images (1 μm × 1 μm) of the dissolution of gold surface obtained in aqueous electrolyte after (a) 0 min, (b) 5 min and (c) 9 min from starting dissolution.

In addition to above analysis, we reported several significant achievements in understanding the physical properties and reaction mechanisms by SPM. It is reported that when the electron transfers within chiral molecules, the conductivities exhibit spin-selectivity. By employing molecules capable of undergoing chiral transformations through photon and thermal excitation, stable switching of the spin selectivity within a molecule was demonstrated.[3] Also, it was reported that the spin-selectivity are not limited to only micro-scale chirality but can be applied to macro-scale chirality.[4] These reports are based on the collaborative works with the research group of Prof. Hiroshi Yamamoto at IMS. Further, we reported on investigations into the wettability and surface tension of ionic liquids with pentyl, ethoxyethyl, and ethylthioethyl groups.[5] This achievement is a collaborative work with the research group of Prof. Hideaki Shirota at Chiba University. These studies demonstrated that SPM can unravel the mechanism underlying surfaces and interfaces.

References

1) T. Minato and T. Abe, *Prog. Surf. Sci.* **92**, 240–280 (2017).
2) T. Minato, K.-i. Umeda, K. Kobayashi, Y. Araki, H. Konishi, Z. Ogumi, T. Abe, H. Onishi and H. Yamada, *Jpn. J. Appl. Phys.* (Review), **60**, SE0806 (2021).
3) R. Malatong, T. Sato, J. Kumsampao, T. Minato, M. Suda, V. Promarak and H. M. Yamamoto, *Small* **19**, 2302714 (2023).
4) H. Aizawa, T. Sato, S. Maki-Yonekura, K. Yonekura, K. Takaba, T. Hamaguchi, T. Minato and H. M. Yamamoto, *Nat. Commun.* **14**, 4530 (2023).
5) M. Ando, M. Ando, M. Koyakkat, T. Ueda, T. Minato and H. Shirota, *Langmuir* **39**, 12090–12098 (2023).