東京大学
微細構造解析
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東京大学微細構造解析プラットフォーム
公開講演会

"Atomic Fabrication via Electron Beams: From Big Data to Atomic Robotics"

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Fabrication of atomic scale structures remains the ultimate, and yet not achieved, goal of nanotechnology. The reigning paradigms are scanning probe microscopy (SPM) and synthesis. SPM assembly dates back to seminal experiments by Don Eigler, who demonstrated single atom manipulation and writing. However, stability and throughput remain issues, and only in the last decade synergy of STM and surface chemistry was used to make several-qubit devices. The molecular machines approach harnesses the power of modeling and synthetic chemistry to build individual functional blocks, yet strategies for structural assembly remain uncertain.

In this presentation, I discuss the research activity coordinated by the Institute for Functional Imaging of Materials (IFIM) aimed at bridging imaging and theory via big data technologies to enable design of new materials with tailored functionalities. This goal is achieved first through a big data approach – i.e., developing pathways for full information retrieval and exploring correlations in structural and functional imaging. In electron microscopy, the big data approaches are illustrated by full data acquisition in ptychography and real-space crystallographic mapping. These techniques can be further extended to develop structure property relationships on atomic levels, allowing direct data mining of multimodal structural, chemical, and functional data and creating a library of atomic configurations and associated properties. A deep data approach will allow merging this knowledge with physical models, providing input into the Materials Genome program and enabling a new paradigm for materials research based on theory-experiment matching of microscopic degrees of freedom.

Finally, incorporation of the real time feedback in electron microscopy opens the pathway towards the third paradigm of nanotechnology —the use of atomically focussed beam of scanning transmission electron microscope to control and direct matter on atomic scales. Traditionally, STEMs are perceived only as imaging tools, and any beam induced modifications are undesirable beam damage. In the last five years, our team and several groups worldwide demonstrated that beam induced modifications can be more precise. We have demonstrated ordering of oxygen vacancies, single defect formation in 2D materials, and beam induced migration of single interstitials in diamond like lattices. These changes often involve one atom or small group of atoms and can be monitored real time with atomic resolution. This fulfills two out of three requirements for atomic fabrication. I will introduce several examples of beam-induced fabrication on atomic level, and demonstrate how beam control, rapid image analytics, and image- and ptychography based feedback allows for controlling matter on atomic level.

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Main meeting room at Institute of Engineering Innovation, UT

(工学部総合研究機構　9号館１階　大会議室)

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