STM-PLD SYSTEM

The interplay between spin, charge, and orbital degrees of freedom in strongly correlated electrons would play a more crucial role in low-dimensional, nanoscale heterostructures than in bulk. We explore novel electronic properties in these unique structures using state-of-the-art ^{3}He-refrigerator-based low-temperature scanning tunneling microscopy (STM) combined with a pulsed-laser-deposition (PLD) system. We believe our research would present new insights for designing new oxide materials exhibiting unprecedented functionalities.

We have designed the PLD-STM system (Figure 1) that is installed in the Integration Laboratory (Katahira). This system allows us to perform STM measurements without exposing samples to air after **depositing oxide films using PLD**. Also, our STM can apply a **magnetic field of up to 7 T vertically and 1 T along any direction using a superconducting vector magnet at sample temperature of 400 mK**, which is ideal for controlling the spin direction and investigating the anisotropy of the spin interaction directly.

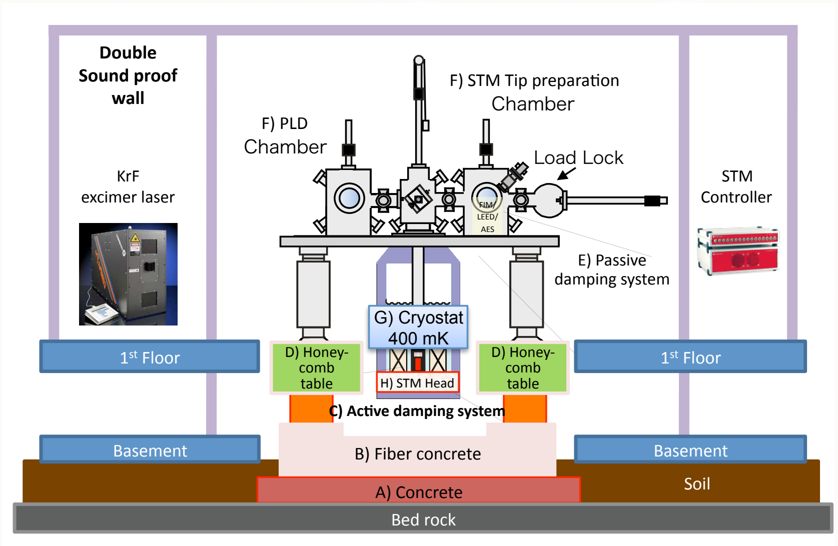
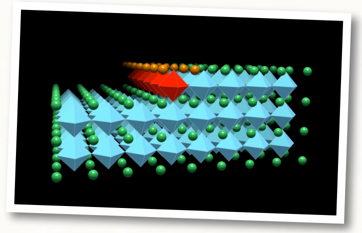


Figure 1. Overview of our STM set up

To achieve the best stability in the world in STM measurements, as much vibrational noise must be removed as possible. We have a massive base slab (A in Figure 1) on the bed rock, and placed a thick concrete block with a pit (B) on it. These concrete blocks weight about 80 Tons. Active vibration isolation dampers (C) are used to mount an honeycomb table (D) on the concrete block. A passive vibration isolation table (E) is installed on the honeycomb table and supports vacuum chambers (F), a cryostat (G), and an STM head (H). In addition, all of these components are located inside a soundproof room. Operators and all electronic components that may produce acoustic noise are located outside the room during measurement.

This unique system will be the only STM in the world with PLD, and will open the door to exploring science in nanoscale oxide materials.



Background&Objective

Transition-metal oxide systems provide us unique platforms where a variety of intriguing phenomena such as high-temperature superconductivity, ferroelectricity, and colossal magnetoresistance emerge due to the subtle interplay between spin, charge, and orbital degrees of freedom. Recently, the oxide thin film growth technique has made rapid progress using PLD and reflection high-energy electron diffraction (RHEED), which has enabled us to realize atomically controlled layer-by-layer growth of transition-metal oxide heterostructures.

So far, a variety of exotic properties peculiar to the interface have been reported. For example, the interface between band insulators $SrTiO_3$ and $LaAlO_3$ shows metallic behavior, and magnetic effects have also been found at the interface between these nonmagnetic oxides.

Due to further developments in thin film growth techniques, it is now possible to fabricate various low-dimensional nanostructures on the substrate, such as a one-dimensional perovskite chain or two-dimensional perovskite nano-island structure (nano-oxides, above figure), where we can expect unprecedented physical properties originating from low dimensionality, confinement, and various degrees of freedom of strongly correlated electrons.

We aim to investigate novel electronic properties emerging in these nanoscale structures at the interface of oxide thin films using a new low-temperature (400 mK) STM combined with a PLD system.