Quantum materials: a new direction of surface science

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Recently, quantum materials are the hottest topic in condensed matter physics and also a new direction of surface science. However, *in situ* techniques are needed for this purpose, since the samples become smaller and thinner. By combining molecular beam epitaxy (MBE) with STM, ARPES and other techniques, *in situ* characterizations can be achieved. With atomic precision control of growth, MBE can provide clean and smooth surfaces for STM and ARPES. Meanwhile, STM, ARPES and other *in situ* techniques can also provide additional information for MBE to eliminate much of the trial and error during growth, so that one can fabricate the structures that do not exist in nature or cannot be grown by other techniques. Therefore, this kind of combined system can do some unique work which cannot be done by separate instruments.

In this talk, I will introduce several things done with the combined system. With help of STM, artificial cluster crystals, i.e. a periodical array of identical nanoclusters can be grown with precise control. Atomically flat Pb thin films, stanene etc. can be grown with MBE and studied with STM. In Pb films on Si(111), we found quantum well states (QWS) form due to the electronic confinement in the film normal direction and novel properties induced by QWS. We also found high quality topological insulator films can be grown with MBE. Standing waves and Landau levels were observed with low temperature STM and demonstrated the existing of the topological surface states and the prohibition of backward-scattering. Topological insulator/superconductor hetero structures are also fabricated for exploring Majorana fermions. Finally, in situ transport measurement was developed, and interface enhanced superconductivity in single layer FeSe on $SrTiO_3$ was studied. A superconductivity with a Tc>100K was also observed.

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