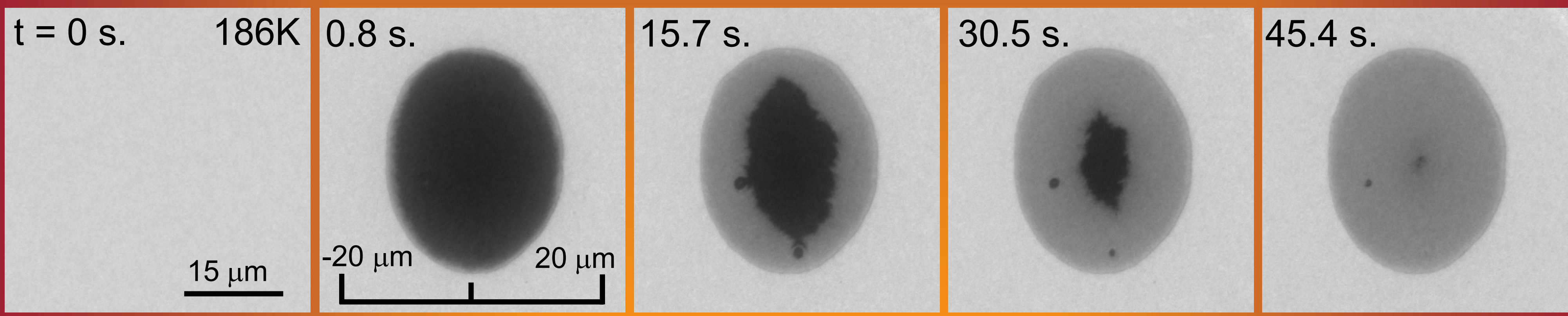
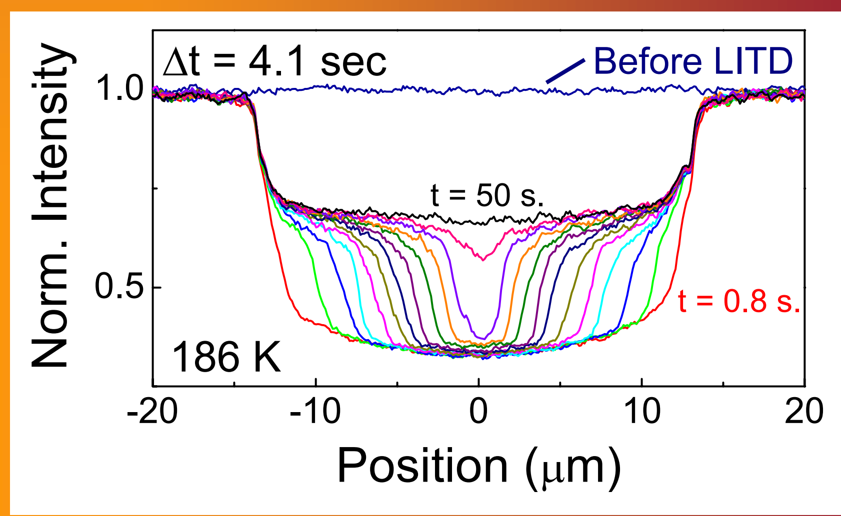
Anomalous Mass Transport in the Pb Wetting Layer on the Si(111) Surface

K.L. Man, M.C. Tringides, M.M.T. Loy and M.S. Altman, Phys. Rev. Lett. **101**, 226102 (2008).

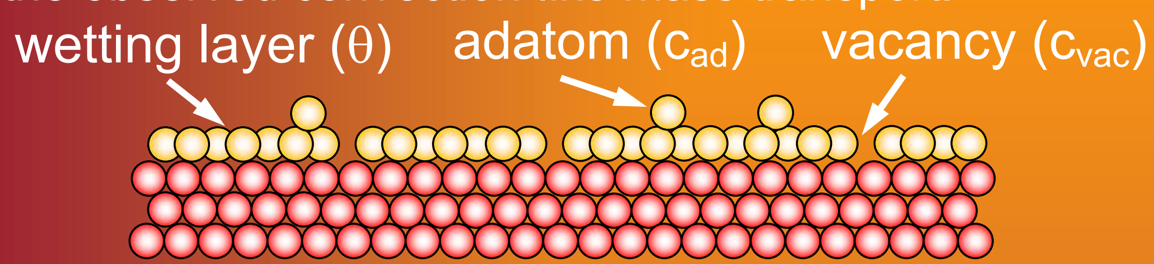
An exceptionally fast and unusual mass transport behavior has been discovered in the dense Pb wetting layer on the Si(111) surface. A convection-like mass transport has been observed, which is unprecendented at crystalline surfaces. Such anomalous mass transport is believed to facilitate the remarkably efficient self-organization of uniform height Pb quantum islands on Si(111) that was reported on widely in the past.



Mass transport is studied by observing non-equilibrium coverage profile evolution using low energy electron microscopy. The initial coverage step profile produced by laser induced thermal desorption (LITD) propagates rapidly at a constant velocity and with unperturbed shape. This differs significantly from the classical behavior which is characterized by profile broadening and gradual approach to equilibrium uniform distribution.

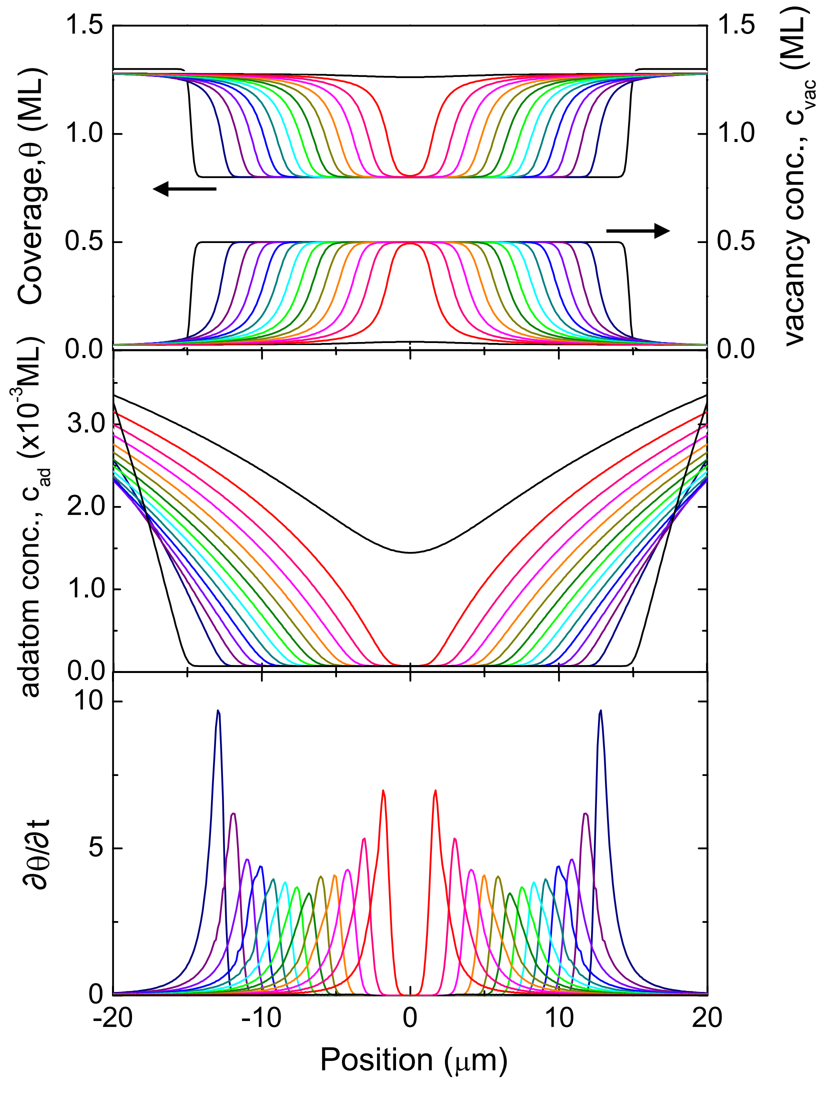


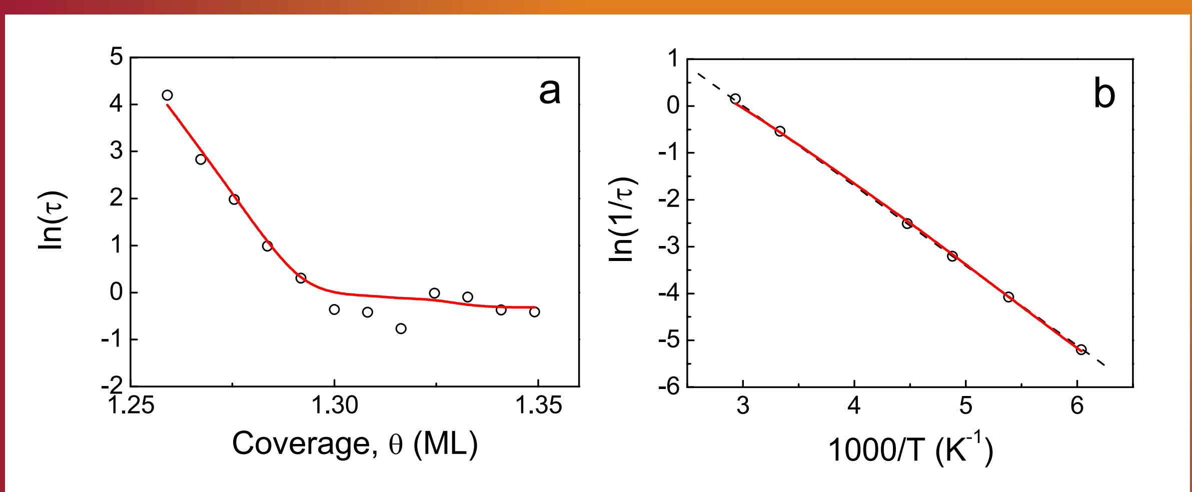
A model that attributes this nonclassical equilibration behavior to the diffusion of thermally generated adatoms on top of the wetting layer can account for the observed convection-like mass transport.



$$\frac{\partial c_{ad}}{\partial t} = D\overline{\nabla}^2 c_{ad} + [R_c\theta - R_a c_{ad} c_{vac}]$$

$$\frac{\partial c_{vac}}{\partial t} = -\frac{\partial \theta}{\partial t} = R_c\theta - R_a c_{ad} c_{vac}$$





The profile equilibration time, τ, exhibits (a) a dramatic coverage dependence, characterized by an exceptionally sharp divergence below a critical coverage and (b) a very weak temperature dependence corresponding to an activation energy of 0.15 eV. Model predictions are indicated by solid red lines.