ADATOM-ADATOM INTERACTION MEDIATED BY AN UNDERLYING SURFACE PHASE TRANSITION

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Substrate-mediated interactions between adsorbed atoms play a key role in determining the static and dynamic properties of surfaces. Understanding these interactions is of high interest in a large variety of fundamental and technological problems ranging from epitaxial growth to heterogeneous catalysis. These interactions have been usually associated to the adatom coupling with the substrate elastic or electronic degrees of freedom. The coupling with the additional degrees of freedom behind a phase transition in the substrate could provide a new significant contribution to the adatom-adatom interaction. In this work [1] we present experimental and theoretical results showing the existence of such an interaction between adatoms mediated by an underlying surface phase transition. The interaction results from the system softening at wavevectors close to those associated with the corresponding order parameter of the transition, i.e., via the corresponding "soft-phonon".

By means of variable temperature scanning tunneling microscopy (VT-STM) we have analyzed the adsorption and diffusion of additional Pb adatoms on Si(111)-($\sqrt{3}$x$\sqrt{3}$)*R*30º-Pb surfaces at temperatures well below room temperature but above the critical temperature (T_c ~ 86 K) [2] of the ($\sqrt{3}$x$\sqrt{3}$)*R*30º-Pb $\leftrightarrow$ (3x3)-Pb phase transition. These VT-STM results have allowed to reveal the vertical displacement patterns induced on the substrate by the adsorption of single Pb adatoms (see Fig. 1). Our theoretical analysis of the displacement patterns on the Pb/Si(111) surface –based on a phenomenological Landau-type approach- shows that the main contribution comes from the "soft-phonon" [3,4] of the phase transition. Moreover, we show that, indeed, a novel non monotonic adatom-adatom interaction mediated by the underlying phase transition can be detected in the present case by comparing thorough quantitative STM measurements of the pair interactions between the additional Pb adatoms with theoretical interaction maps based on the "soft-phonon" contribution. This interaction differs from all other previously discussed in being a temperature dependent "tunable" interaction: the closer the transition is, the more important the interaction should become.

Our prediction that this new "soft-phonon" contribution to the adatom-adatom interaction should be the leading term, overwhelming any other, at temperatures very close to the transition represents an exciting challenge for further experimental research of adatom-adatom interactions on other surfaces undergoing structural phase transitions.

References:

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Figures:

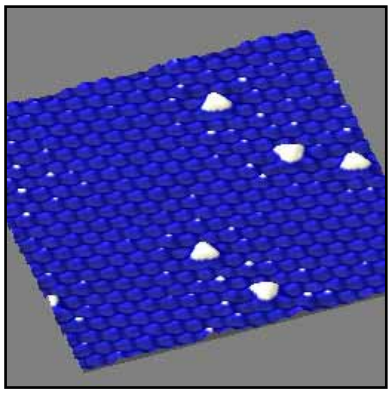

Figure 1: 12x12 nm^2 STM image measured at 140 K showing additional single Pb adatoms (triangular features) adsorbed on a Si(111)-(√3x√3)R30º-Pb surface. It can be observed the substrate perturbation induced on the substrate around each additional single adatom [1]. Tunnel parameters:-0.5 V, 0.1 nA.