Supplementary Information

Static friction scaling: the key is in the edge

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Model Parameters

The Kr-Pb interaction is modeled by the following Morse-modified potential:

$$V_{\mathrm{Kr-Pb}} = \alpha(x,y)\left(\mathrm{e}^{-2\beta(\mathrm{z}-\mathrm{z}_0)} - 2\mathrm{e}^{\beta(\mathrm{z}-\mathrm{z}_0)}\right). \quad (1)$$

The function $\alpha(x,y)$ in the Morse potential has the form

$$\alpha(x,y) = \alpha^{top} + M(x,y)(\alpha^{hollow} - \alpha^{top}), \quad (2)$$

with the on-top adhesion energy $\alpha^{top} = 150\,\mathrm{meV}$ and on-top equilibrium distance $z_0 = 3.75\,\mathrm{\AA}$ [1], while β is obtained by equating the second derivative of the potential to the experimental spring-constant,

$$V''(z_0) = 2\alpha^{top}\beta^2 = \omega^2 m_{Kr}\ , \quad (3)$$

where m_{Kr} is the atomic mass of Krypton. With a perpendicular vibration energy of $\hbar\omega \simeq 3\,\mathrm{meV}$ [1], we obtain $\beta = 0.775\,\mathrm{\AA}^{-1}$. The α^{hollow} parameter is varied accordingly to the desired corrugation, and takes the value of 142.5 meV and 147 meV for the simulated corrugations of 5% and 2% of the on-top adhesion energy, respectively.

[1] J. L. F. Da Silva, C. Stampfl, and M. Scheffler, Phys. Rev. B **72**, 075424 (2005); J. L. F. DaSilva, PhD thesis: `http://hdl.handle.net/11858/00-001M-0000-0011-1371-0`

Movie Captions

Movie 1: Depinning simulation of a Kr incommensurate hexagonal island ($N = 269101$) adsorbed on Pb(111), at the static friction threshold. The Moiré interference patterns of the soliton network (enhanced for visibility, see Methods), and their evolution, highlight the depinning mechanism characterized by the entry of a soliton at the island left edge. At later times, when the center-of-mass sliding is about 1.5 lattice spacings, a soliton exits the island on the right hand side, with a caterpillar-like dynamics.

Movie 2: Simulation of a commensurate island with ad-hoc modified Xe-Xe Lennard-Jones interaction in order to make it commensurate to $\sqrt{3}\times\sqrt{3}$ Cu(111) substrate at $T = 50\,\mathrm{K}$ (see Methods). Each atom is subject to a constant force of $1.7\,\mathrm{meV/\AA}$ pointing along positive X axis. The system slides upon thermal appearance of the lattice dislocation nucleus at the island edge, followed by a subsequent force-driven expansion. Green, blue, and red colors indicate Xe atoms located on hollow, interstitial, and top Cu(111) sites, respectively.

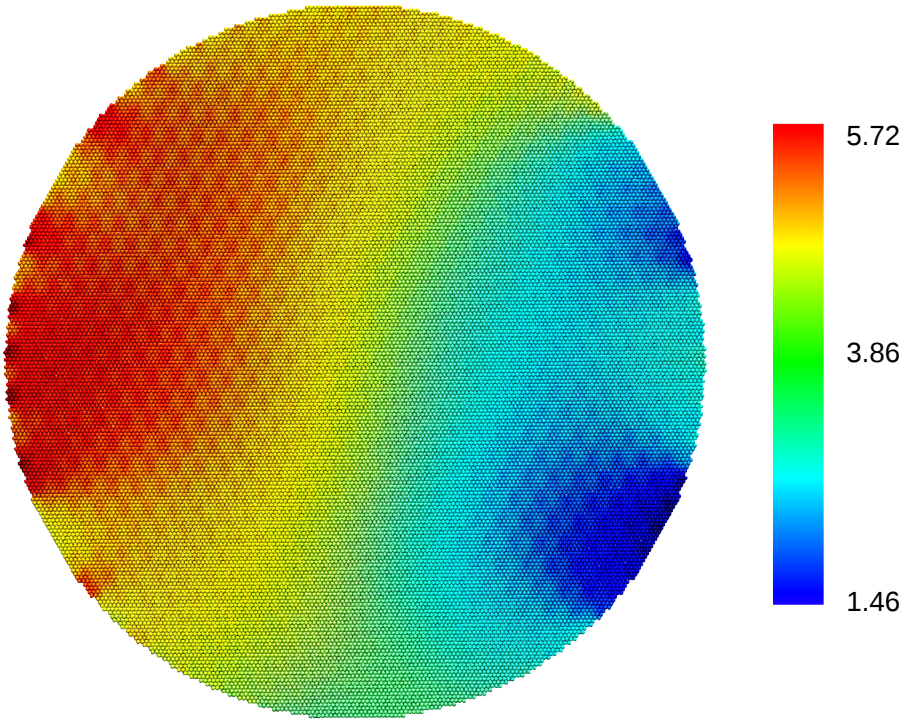

Figure 1: **Atomic displacement map before depinning.** The map shows the displacement of each atom of a circular island (diameter $\simeq$ 40 nm) under an applied force just below the static friction threshold with respect to the relaxed (zero applied force) state. The force is applied in the rightward direction. The color bar codes the displacement range in Angstrom.