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Abstract:

The Si(111)5x2-Au surface has provided new understanding of the properties of one-dimensional electronic states.¹ The reconstruction includes an overlayer of Si adatoms which partly determine the surface electronic properties.² The chainlike surface structure naturally confines the adatoms to tracks, similar to bits in existing digital media, and previous workers have used the individual adatoms as bits in a model atom-scale memory.³ We have characterized the thermal 1-d diffusion of the adatoms by scanning tunneling microscopy. The statistics of motion are inconsistent with diffusion by a random walk. Instead, correlations between sequential adatom jumps in both direction and time imply that the diffusion is defect-mediated. We show that the unique character of the statistics of the diffusion is consistent with a model in which each adatom diffuses by hopping over a defect localized nearby. Specifically, the measured (nonbinomial) jump length distribution, the (nonexponential) wait-time distribution, and the observed correlations are all modeled accurately over a range of temperatures (145-215° C) using a Monte Carlo implementation of our model. The effective activation barrier for adatom diffusion is found to be 1.24 ± 0.08 eV. Intuitively, defect-mediated hopover diffusion is unexpected in a strictly 1-d system, because sequential diffusion events arising from adatom jumps back-and-forth over the defect are always in opposite directions leading to zero net displacement. Work supported by the U.S. DOE, Office of BES, DMSE. Sandia is operated by Sandia Corporation, a Lockheed Martin Company, for the U.S. DOE's NNSA under Contract No. DE-AC04-94AL85000.

¹ I. Barke, R. Bennewitz, J. N. Crain, S. C. Erwin, A. Kirakosian, J. L. McChesney, and F. J. Himpsel, Solid State Comm. 142, 617-626 (2007).

² H. S. Yoon, S. J. Park, J. E. Lee, C. N. Whang, and I.-W. Lyo, Phys. Rev. Lett. 92, 0986801 (2004).

³ R. Bennewitz, J. N. Crain, A. Kirakosian, J.-L. Lin, J. L. McChesney, D. Y. Petrovykh, and F. J. Himpsel, Nanotechnology 13, 499-502 (2002).

Note: Requested an Oral Session.