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Ultrafast mass transport during decay of gigantic Pb mesas on Ni(111)

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We have studied the initial growth of Pb films on Ni(111) at elevated temperatures of 424 K and 474 K. Quantum Well States (QWS's) have been found to be responsible for the morphology of these Pb films on Ni(111). The delicate balance between surface energies, elastic energies and QWS's is initially tilted towards QWS's, as discrete layer heights are observed. First, a strong preference for 5 and 7 layers high, flat topped Pb islands is observed, showing several striking similarities with Pb films on Si(111) and on Cu(111). Key examples of these will be discussed. When the character of the rough film gradually changes from 2D to 3D, the balance between these forces becomes more and more dominated by interfacial energies. A tipping point is reached by very slowly heating the surface to about 520 K. As the energetic balance is tipped for good in favor of the interface free energy, the electronically stabilized, extended, about 40 layers high mesas suddenly decay towards compact hemispheric structures. The spectacular speed at which the transition takes place (billions of atoms move over several microns during a few milliseconds!) is many orders of magnitude larger than what is expected, based on arguments involving thermally activated behavior on atomic scales. I will discuss peculiarities of the wetting layer and its changes, which appear to coincide with the ultrafast transition of the film morphology. With a widespread interest in nanostructures in general, our results illustrate the generic need to characterize all aspects of nanostructures, both structural and electronic, since small excursions away from equilibrium can have dramatic consequences. T.R.J. Bollmann, R. van Gastel, H.J.W. Zandvliet and B. Poelsema; Phys. Rev. Lett. 107, 116101 (2011); T.R.J. Bollmann, R. van Gastel, H.J.W. Zandvliet and B. Poelsema; New J. Phys. 13, 103025 (2011).