Morphologies and coarsening of quantum nanoislands on annealed metal surfaces

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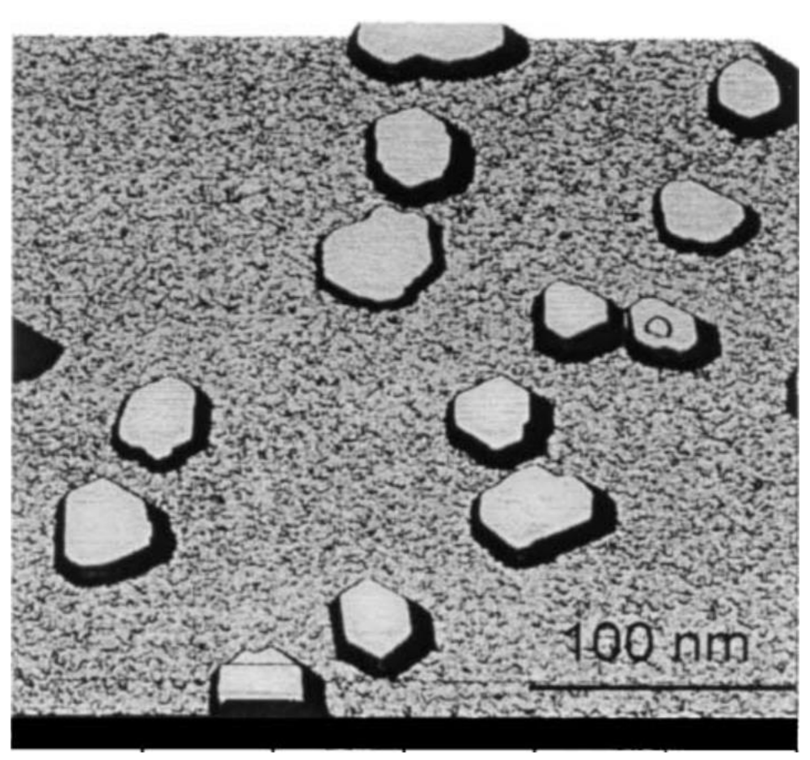
ABSTRACT

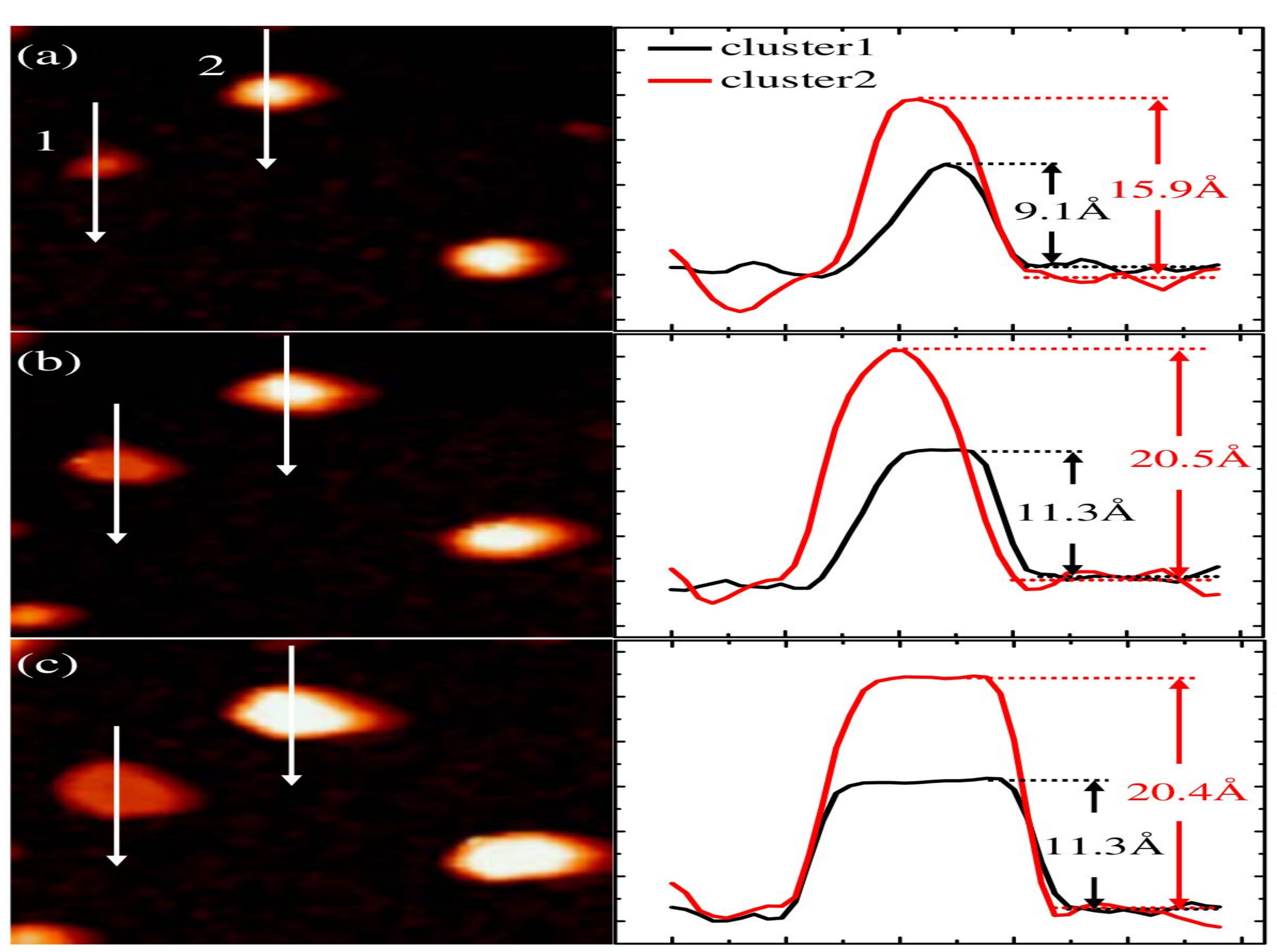
We present computed evolution (in the annealing stage) of the quantum Pb and Ag nanoislands that form on an ultrathin epitaxial film during non-traditional two-step growth (A.R. Smith et al., Science 273, 226 (1996)). We find the complicated spectra of a metastable and stable "magic" island heights, the surface diffusion pathways that lead to a flat-top 2D islands having these heights, and the coarsening rules that underlie the morphological evolution resulting in the "survival of the fittest" among nanoislands of different heights and sizes.

EXPERIMENT



W.B. Su et al., PRL 86, 5116 (2001)

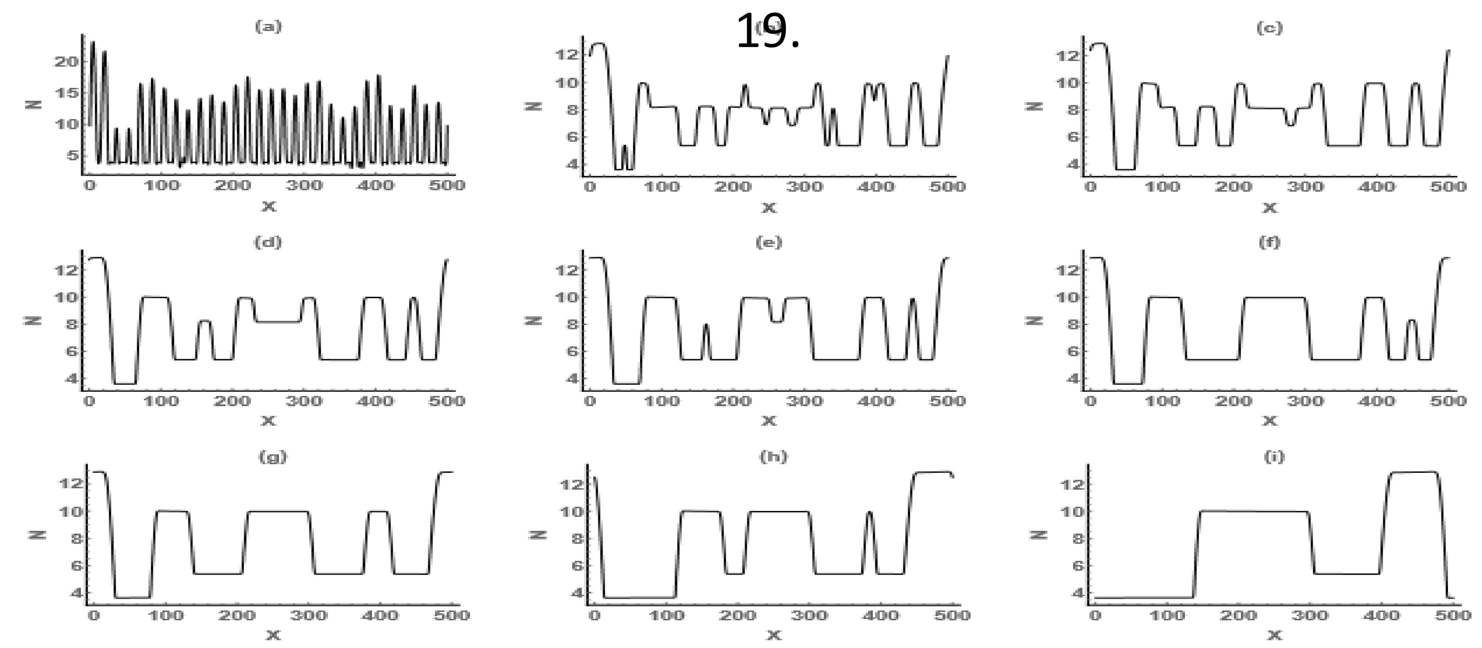
F. Calleja et al., Applied Surface Science 254, 12-15 (2007)

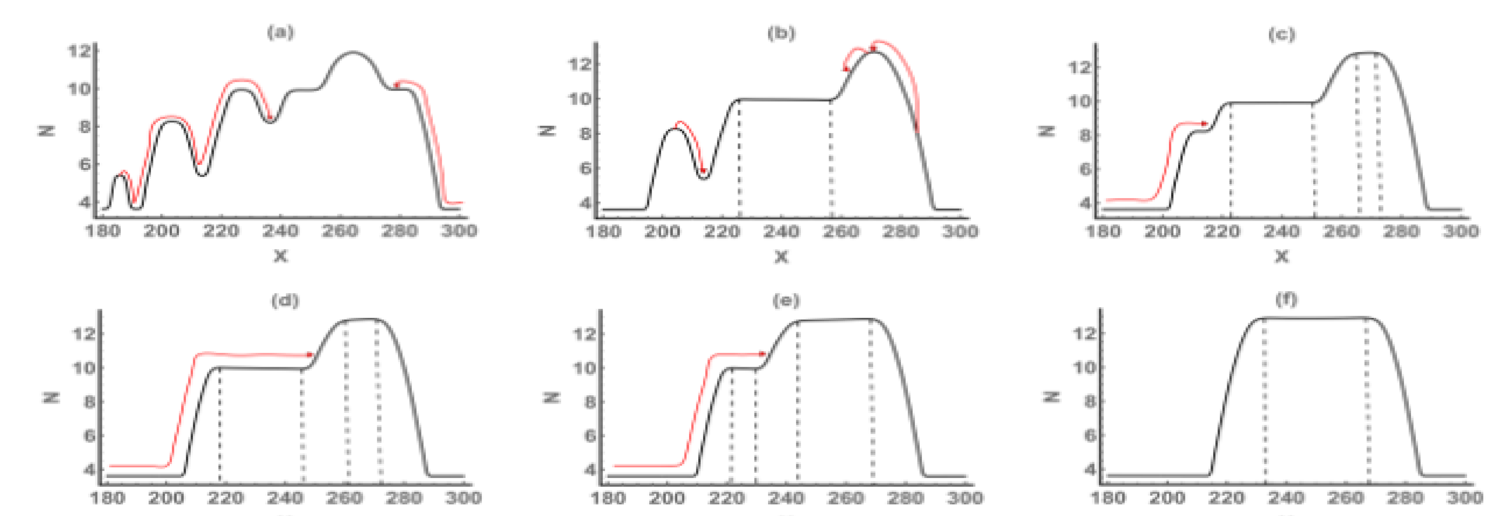


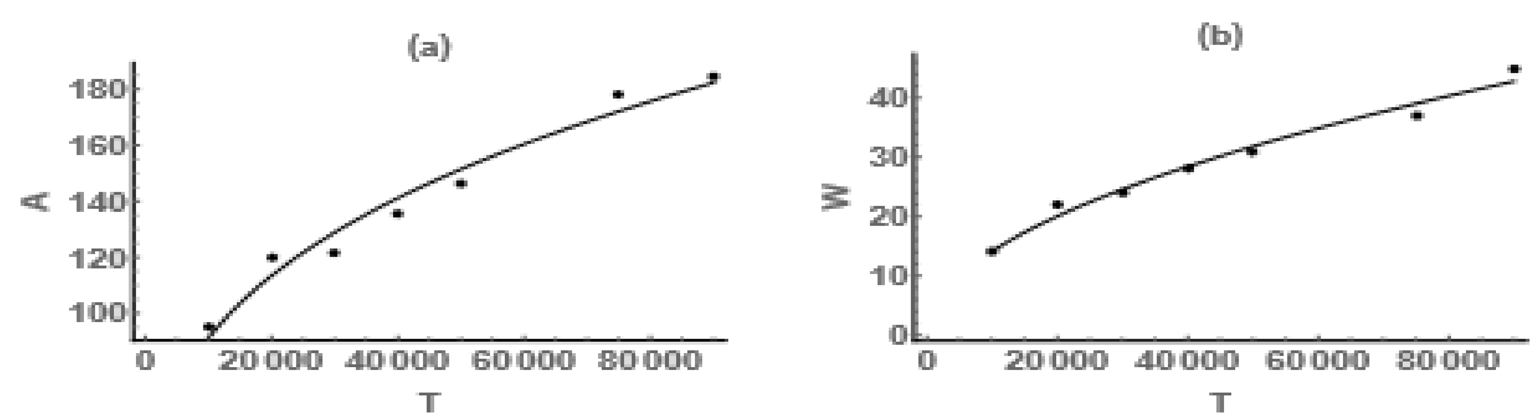
W.B. Su et al., J. Phys. D: Appl. Phys. 43, 013001 (2010)

Our model: Ag(110)

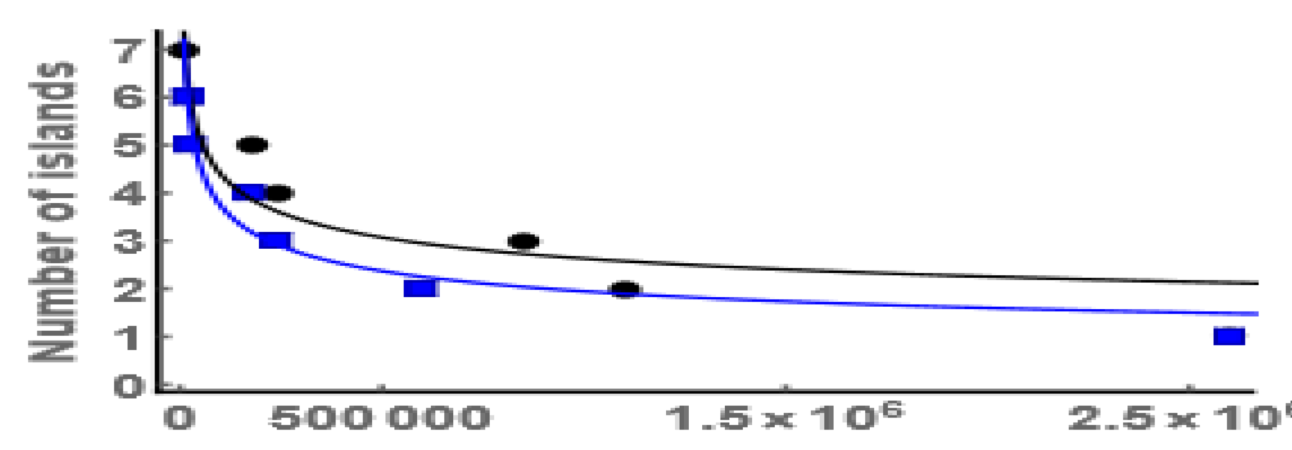
"Magic" nanoisland heights (N, in atom monolayers) from the experiment (Y. Han et al., Materials 3, 3965 (2010)): 2, 4, 6, 8?, 10?,...; from our theory: 2, 4, 5, 7, 8, 10, 13, 16, 19.







$A = 4.98\ T^{0.316}$ $W = 0.135\ T^{0.505}$



$NI = 98.16\ T^{-0.284}$ (sq., Trial 3) $NI = 57.4\ T^{-0.223}$ (cir., Trial 16)

KEY EQUATIONS OF THE MODEL

$$h_t = \sqrt{1+h_x^2+h_y^2}\ \mathcal{D}\nabla_s^2(\mu+\Sigma) \qquad (1)$$

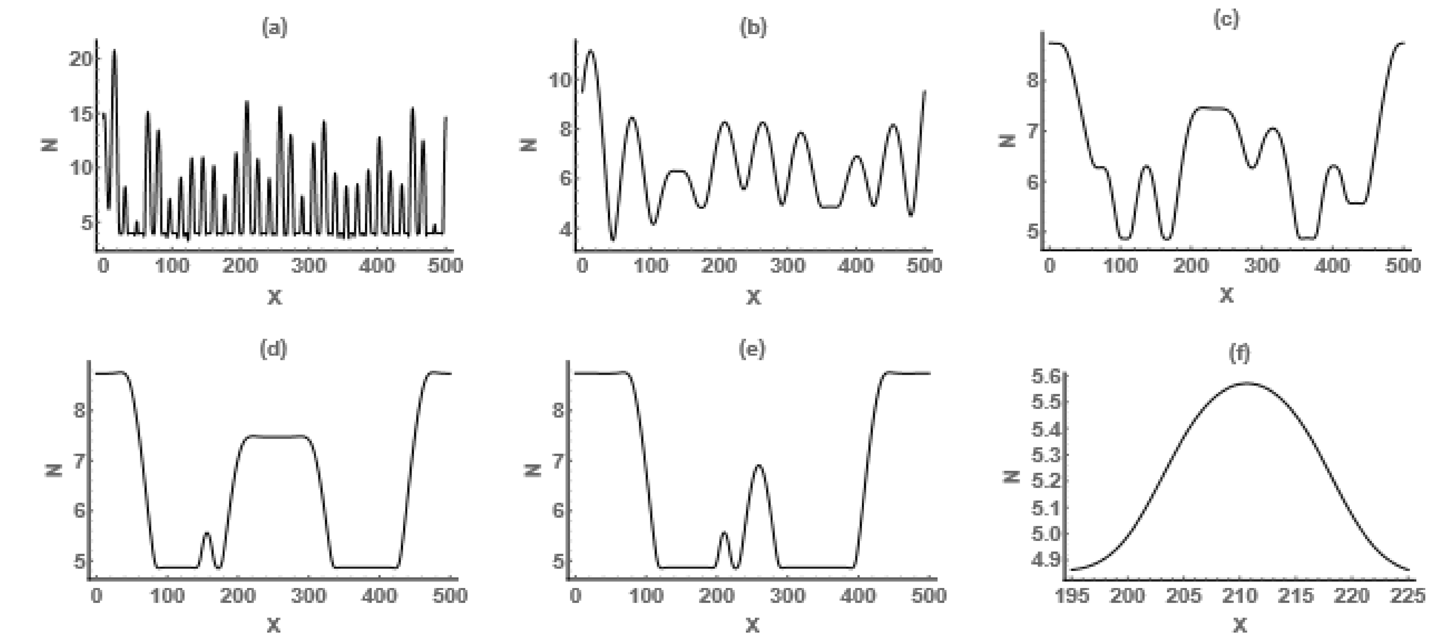
$$\mu = \gamma(h)\kappa + n_3\frac{d\gamma(h)}{dh} \qquad (2)$$

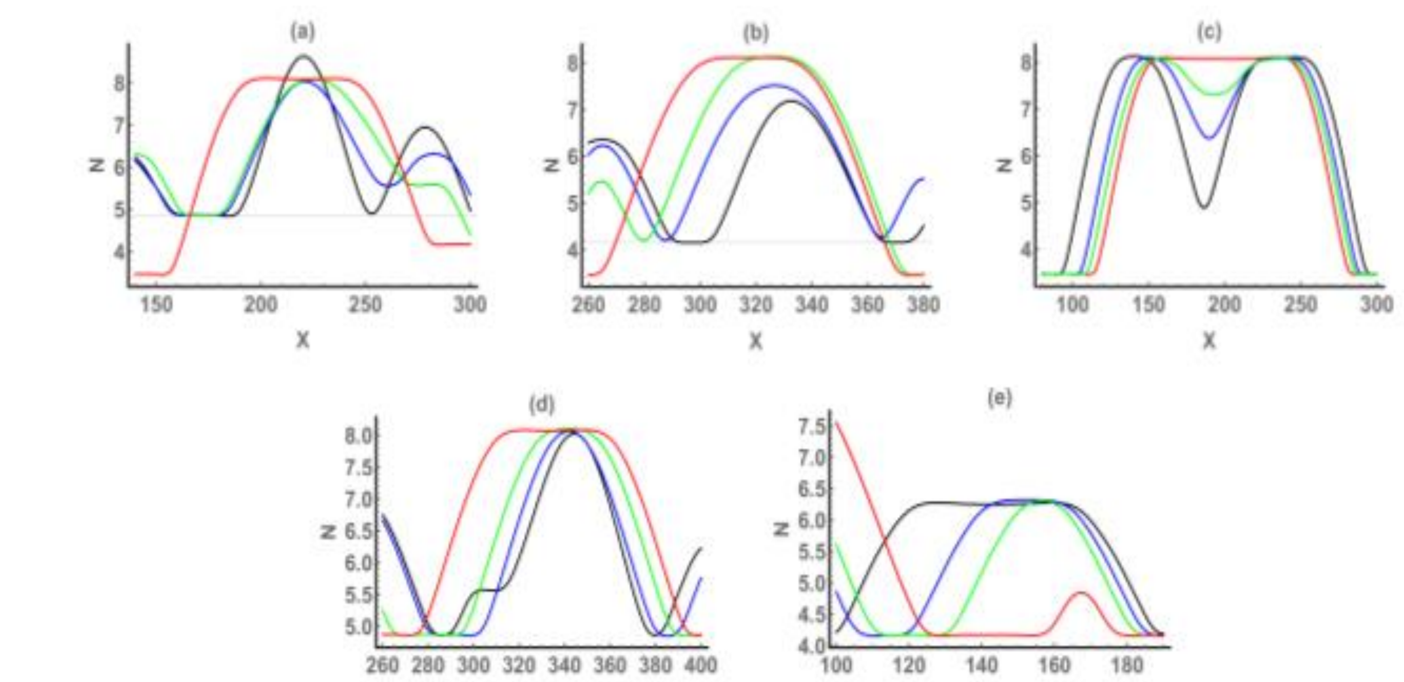
$$\gamma(h) = \gamma_{bf} + \frac{g_0 s^2}{(h+s)^2}\cos\omega_1 h\cos\omega_2 h - \frac{g_1 s}{h+s} \qquad (3)$$

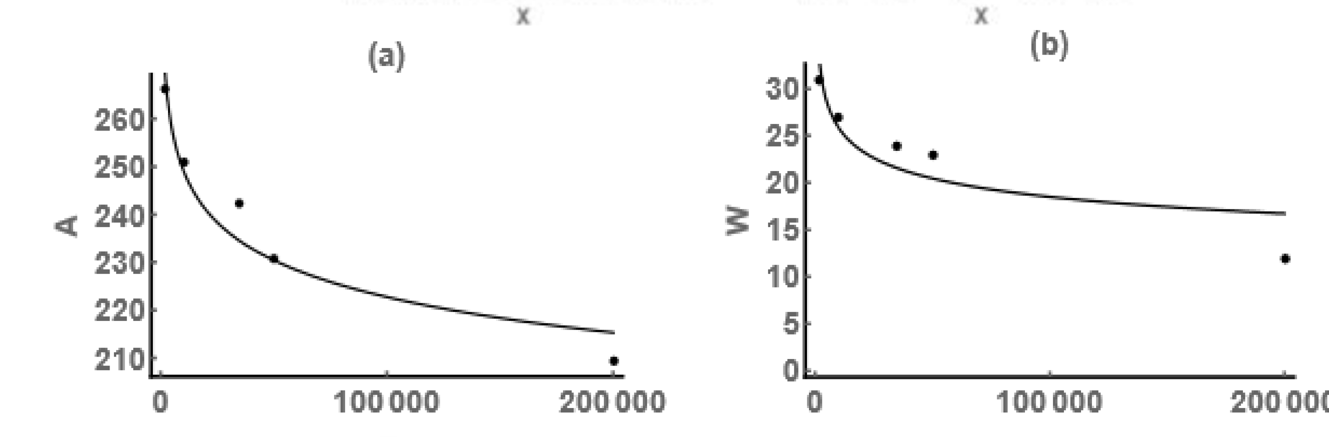
h is the film height, μ the chemical potential, γ the surface energy

Our model: Pb(111)

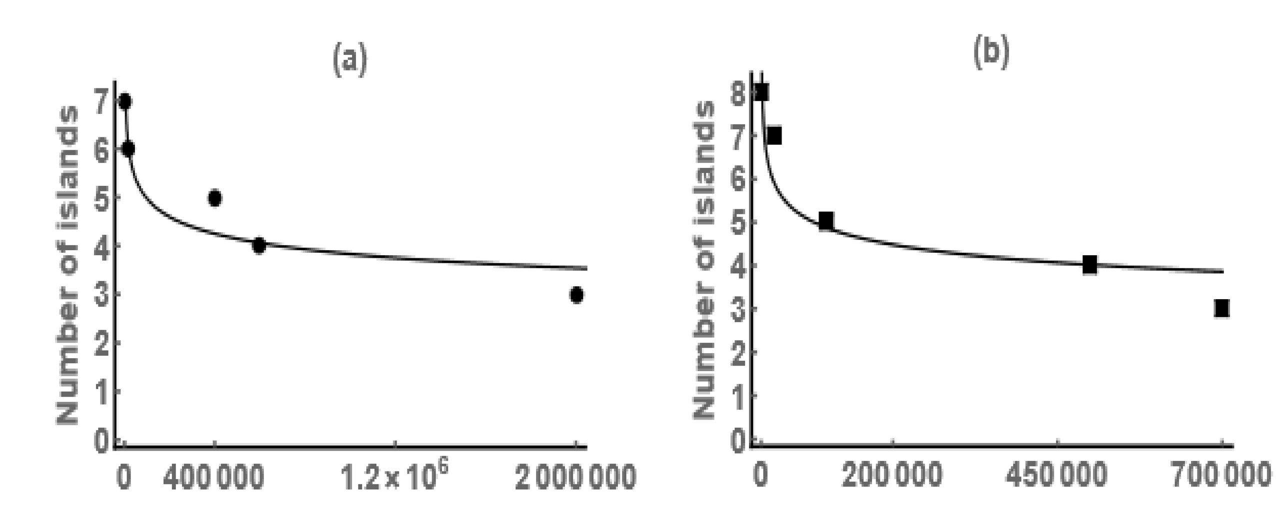
"Magic" nanoisland heights (N, in atom monolayers) from the experiment (M.M. Ozer et al., J. Low Temp. Phys. 157, 221 (2009)): 6, 8, 10, 12, 14(15), 17, 19, 21; from our theory: 2, 4, 6, 7, 9, 11, 12, 14, 16, 17, 19.







$A = 391.174\ T^{-0.05}$ $W = 98.584\ T^{-0.145}$



(a) $NI = 18.37\ T^{-0.113}$ (b) $NI = 19.24\ T^{-0.119}$

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