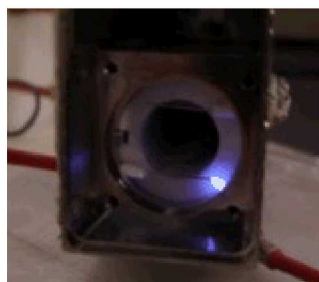
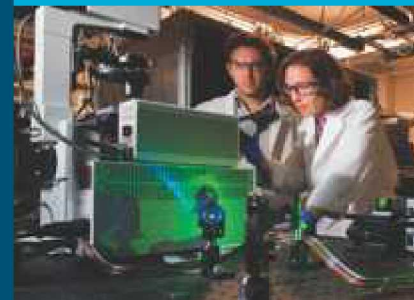




SAND2018-2854C

Work function of Pt thin films with disorder



PRESENTED BY

Ezra Bussmann (ebussma@sandia.gov)

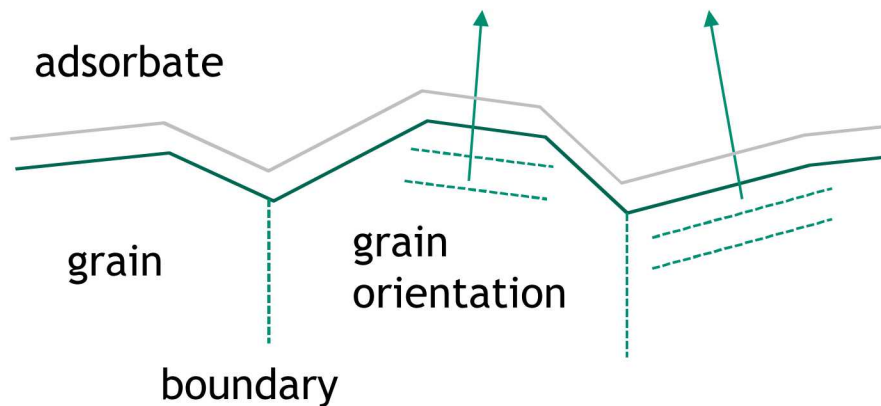
M. Berg, D. Scrymgeour, M. Brumbach, T. Ohta, S. Smith, H. Hjalmarson, P. Schultz, P. Clem, M. Hopkins, C. Moore



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Quantitative models of electron field emission from surface microstructure

- ❑ Arcs initiate via surface field emission
- ❑ General physics captured in Fowler-Nordheim equation
- ❑ Microscopic details are all captured in a empirical correction factors
- ❑ Microscale details key to arc initiation – e.g. emission hot spots at asperities



Empirical Fowler-Nordheim emission

$$J = \frac{A \beta^2 E^2}{\phi} \exp\left(-\frac{B \phi^{3/2}}{\beta E}\right)$$

- Current density $J(E, \phi, A, \beta)$
- E field
- ϕ work function
- Empirical fitting parameters: A, β
- β varies from 10-1000 *inside exponential*

- ❑ Motivation tune models to connect surface physical structure to local emission properties, e.g. compute real β for given surface topography, test vs experiment

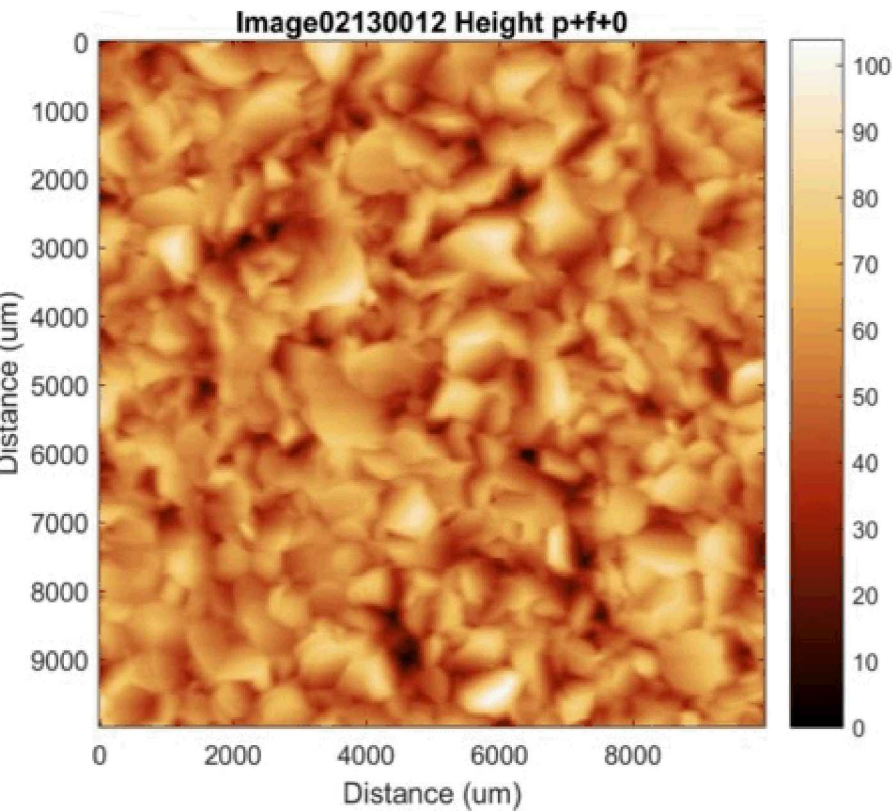
❑ This talk: In polycrystalline films with varying tilts local work function is varies with atomic step density at surface

Model thin films with topography & structural disorder

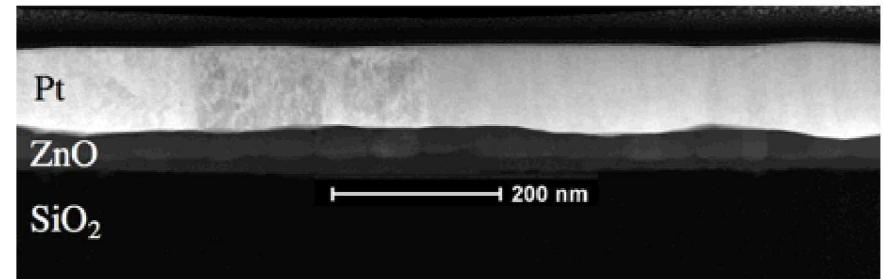
3

- Polycrystalline Pt thin film via sputter deposition
- Preferred 111 oriented grains ~few-hundred nm size

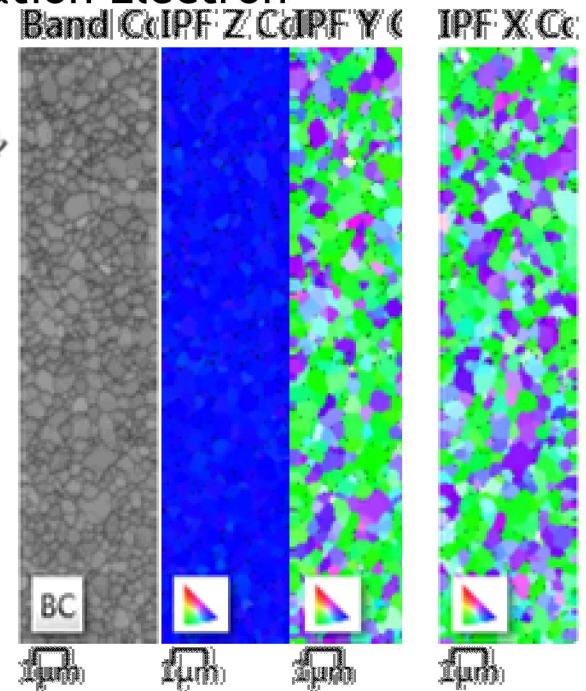
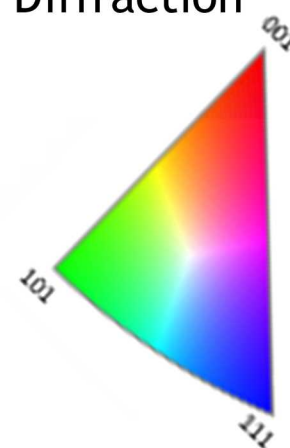
Film topography AFM



Bulk grain structure - cross-sectional TEM

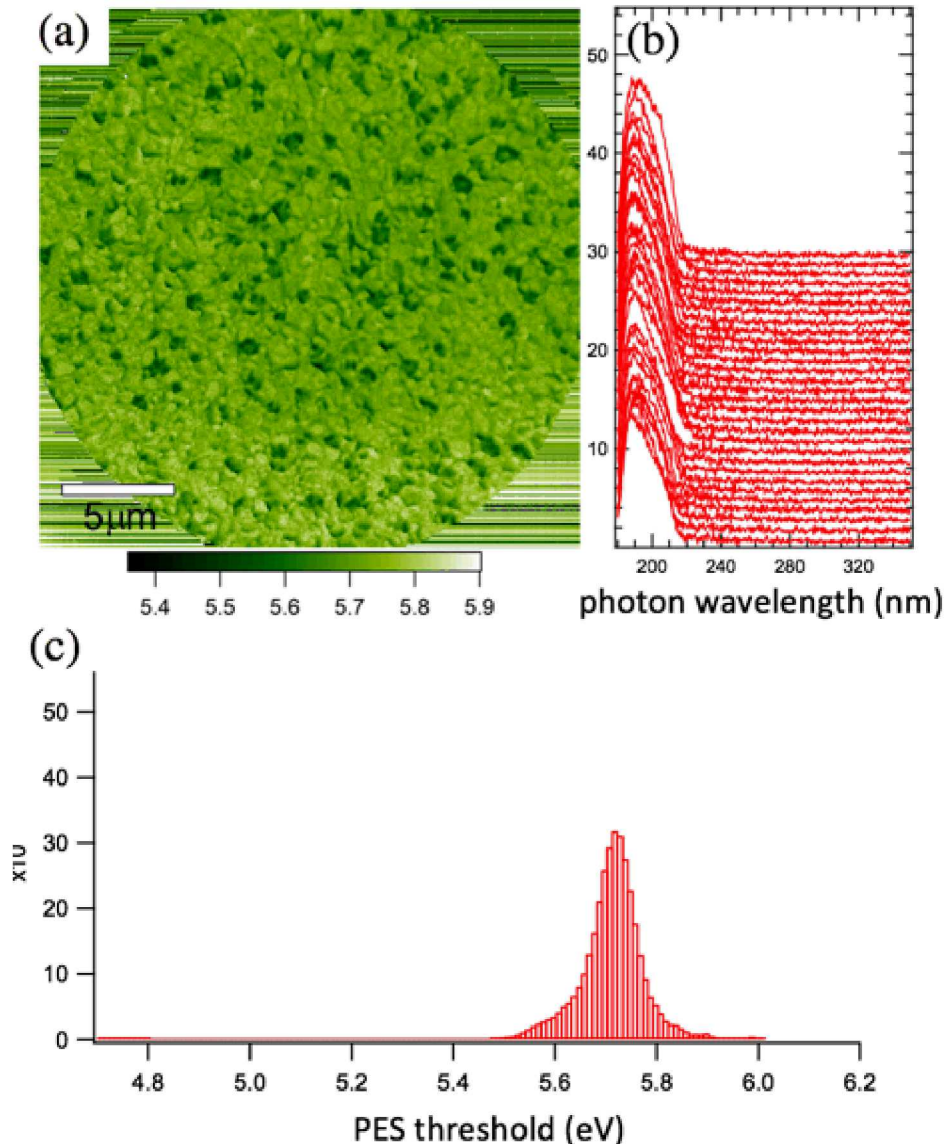


Grain orientation Electron Backscatter Diffraction



Work function spatial variation – Photo-emission electron microscopy

□ Photoemission threshold measures distribution of work functions 5.7 ± 0.1 eV



□ Whereas for flat Pt(111)

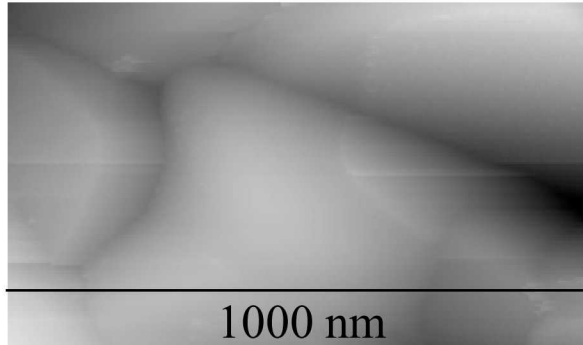
$$\Phi = 6.1 \text{ eV}$$

□ Lets try to explain how our 5.7 eV relates to this value

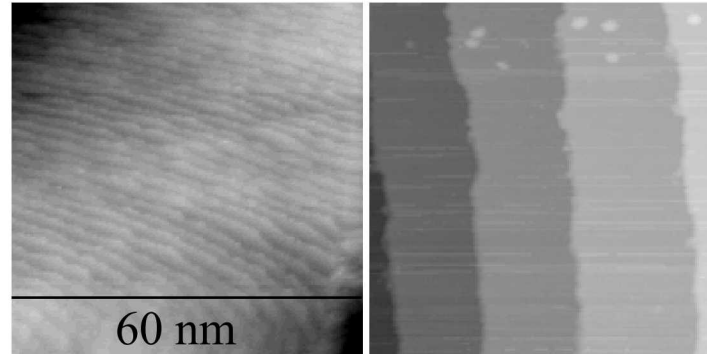
Plausible model for variations in work function via surface tilts

- Atomic step densities vary across surface owing to local grain tilt, surface slope
- Steps modify local work function owing to step-dipole (Besocke, Park ref)

Grain structure



Local step density variation



- Steps modify local work function owing to step-dipole (Besocke, Park)

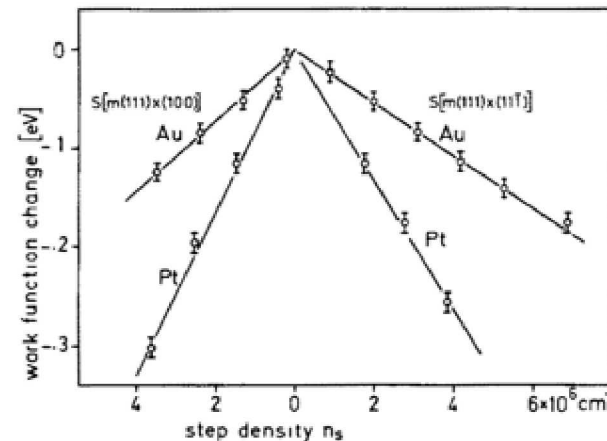
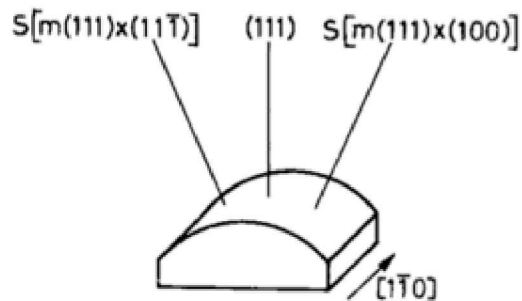
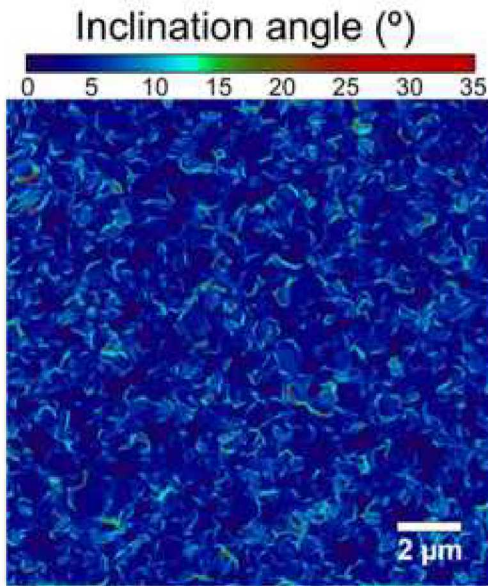


Fig. 5. Relative work function change versus step density for Pt and Au surfaces with (110) terraces and steps parallel to the $[1\bar{1}0]$ direction.

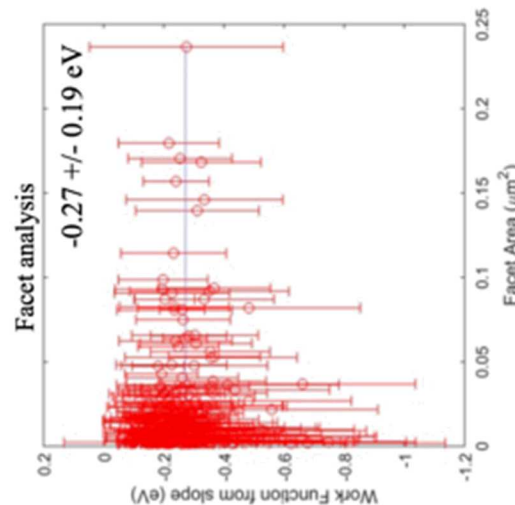
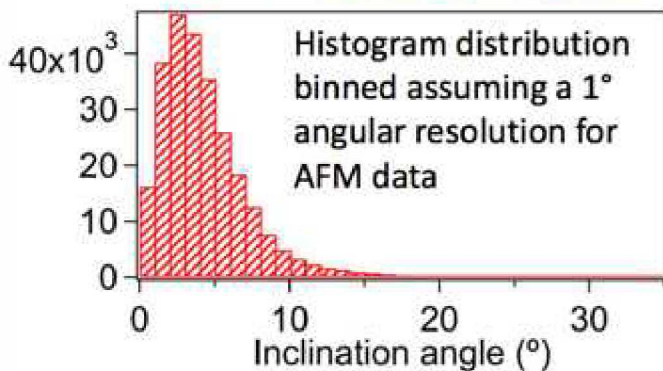
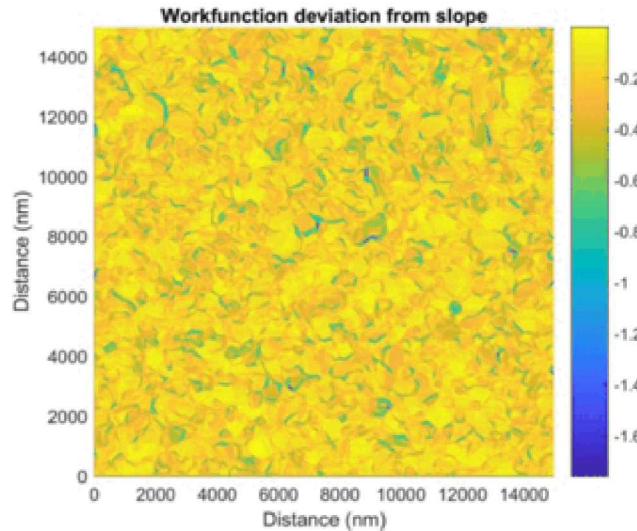
In-progress local work function versus surface structure

- 6 Using Besocke data, map local tilt & slope distributions to a work function

Slope map (AFM)



Step density \rightarrow work function
Using Besocke data



From entire image -0.27 \pm 0.21 eV

Expect Phi sags by ~ 0.3 eV

6.1eV \rightarrow 5.8eV

Similar to the 5.7eV
Via PEEM

Local nanoscale work function expectation value and variations on polycrystalline Pt estimated reasonably via model accounting for atomic tilts and related step dipoles



Acknowledgement This work is funded by Sandia Laboratory Directed R&D (LDRD) program and performed, in part, at the Center for Integrated Nanotechnologies, a U.S. Department of Energy (DOE) Office of Science User Facility. Sandia National Laboratories is managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a subsidiary of Honeywell International, Inc., for the DOE's National Nuclear Security Administration.