UCLA Materials Science In situ Microscopy Studies of OD, 1D, and 2D Structures -Clusters, Nanowires, Graphene



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In situ Microscopy Labs

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3. Growth of Semiconducting Graphene on Pd(111)



Questions we'd like to address: 1.How does graphene form? 2.What is the role of substrate?

Potentially transformative

Can be tailor the electronic properties of epitaxial graphene & grow "device-ready" layers on Si wafers?

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I = 0.24 nA

 $V_{T} = +1.1 V$

Graphene/Pd(111):

tunneling bias-dependent image contrast



I = 0.24 nA $V_T = -1.1 \text{ V}$



STS of Graphene/Pd(111)



Substrate can greatly influence graphene properties



2. Nucleation and Growth Kinetics of Si and Ge nanowires

J. Tersoff, M.C. Reuter, and F.M. Ross IBM T. J. Watson Research Center, Yorktown Heights B.-J. Kim, C.-Y. Wen, and E.A. Stach Dept. Materials Science and Engineering, Purdue University

Questions we'd like to address: 1.How do nanowires grow? 2.What is the role of catalyst composition?

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Potentially transformative

Can be fabricate nanowire heterostructures with atomically abrupt interfaces, tunable shapes & structures?

Partially funded by

UC Discovery, UCEI, & Northrop Grumman Space Technology

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Si wire nucleation kinetics

$T = 525 \text{ °C}; Si_2H_6 = 8 10^{-7} Torr$

PIAY 15; 21; 29 09-25-06

t = 0, vacuum

Crystalline Au + Si₂H₆ \rightarrow liquid AuSi droplets \rightarrow Si nw/AuSi

Si wire nucleation kinetics

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t=390 s



Critical supersaturation of Si in AuSi droplets

B.J. Kim, J. Tersoff, S. Kodambaka, M.C. Reuter, E.A. Stach, & F.M. Ross, *Science* **322**, 1070 (2008).

Ge wire growth vs. Ge_2H_6 flux

$T = 410 \ ^{o}C$



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1. Thermal/Chemical Stability of Small Clusters



Questions we'd like to address:
1.How do hollow core structures form?
2.What is the role of surface/interface structure & orientation?
3.What controls their stability?

<u>Potentially transformative</u> Can be make better &

cheaper catalysts?

Funded by ACS-PRF 48108-G10 & Hitachi Labs

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Ostwald ripening of the titania cores

 $T = 850^{\circ}C$



Larger TiO_2 core grows at the expense of smaller one resulting in hollow graphitic shells



UCLA Materials Science Ultra-High Vacuum Variable-Pressure & Engineering Scanning Electron Microscope

- *In situ* SEM studies of:
- * Nanowire nucleation & growth kinetics
- * Liquid droplet/solid surface dynamics
- * Chemical & thermal stabilities of nanostructures

UHV-CVD in a **SEM**:

Operating pressure: $10^{-7} - 1 \text{ mTorr}$

Temperatures:**300 - 1250 K**Imaging modes:**SE, BSE, STEM**



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