Synthesis and Processing of Carbon-based Nanostructured Materials

Plan of Initial Work: Action Items

I. Argonne National Laboratory:

A. ANL-LBNL collaborative work:

1. Grow UNCD films onto LBNL "wedge" samples for in-situ TEM nanoindentor measurements (Andy to specify thickness).

2. Grow UNCD films (~2 μm thick) onto 2" & 4" wafers coated with 100 nm SiO_2 layer, for fabrication of flexural strength test structures.

B. ANL-SNL collaborative work:

1. Grow UNCD on a-D provided by SNL

2. Grow UNCD on Si Cantilevers provided by SNL

3. Grow UNCD on conformality test structures provided by SNL

4. Grow two layers of UNCD onto SiN, SiO_2 layers, for SNL to conduct stiction tests using UNCD cantilever geometry.

5. Grow UNCD onto 2" wafers coated with sacrefical SiO_2 layer for fabrication of MEMS pull-tab structures (strength measurements).

C. ANL-NSCU collaborative work:

1. ANL to send NCSU series of UNCD films deposited onto silicon with different nitrogen doping levels (0%, 1%, 5%, 10%, 15%, 20% N_2 added to Ar/CH4 plasma).

a) NCSU will conduct FEEM/PEEM study to identify origin of electron field emission in these films (grain boundaries?), and also temperature dependence, stability, and areal density (uniformity) of emission.

2. NCSU will send ANL nanotubes samples

a) ANL will conduct study of macroscopic field emission properties (threshold voltage, stability, effect of ambient gases) of nanotube samples provided by NCSU.

D. ANL-ORNL collaborative work:

1. ANL to deposit UNCD onto ORNL VACNF samples (both high density & low density arrays)

a) ANL to examine effects of growth temperature, seeding process (nano-diamond powders or no seeding), and plasma chemistry on the morphology of the as-deposited UNCD onto the fibers (SEM, TEM, Raman, NEXAFS).

b) ANL to study macroscopic electron field emission properties of UNCD/VACNF nanocomposites (threshold voltage, stability, effect of ambient gases).

E. ANL-NW collaborative work:

1. V. Dravid: ANL to provide nitrogen doped UNCD samples for TEM holography measurements (examine E-field at nanometer resolution, to identify origin of field electron emission—does emission originate from UNCDgrain boundaries?).

F. Other ANL work:

1. Larry Curtiss: modeling (quantum chemical molecular dynamics) of the effects of CN on the growth of nitrogen-doped UNCD thin films. CESP funds being used to partially support Michael Sternberg (postdoc).

2. Simon Phillpot: Working on modeling thermal transport and phonon dynamics in nitrogen-doped UNCD films. CESP funds used to partially support Patrick Schelling (postdoc).

II. Sandia National Laboratory:

A. SNL-ANL collaborative work

1. Send ANL a-D samples annealed at different temperatures

a) ANL to grow UNCD on a-D

b) ANL to conduct NEXAFS study of a-D films as function of anneal temperature (sp^2/sp^3 ratio).

2. Assay as-deposited stress of UNCD-coated silicon cantilevers (will UNCD films bend cantilevers up or down? Can this be controlled via deposition temperature? Plasma chemistry?)

3. Test the conformality of UNCD coatings on conformality test structures (etch pits).

4. Stiction test structures:

a) Two-level with UNCD ground plane, SiN

b) Use to fabricate UNCD cantilevers

5. Contact angle measurements on UNCD films – measure hydrophobicity of UNCD films (doped and undoped).

6. Fabricate Pull-Tab structures to make UNCD strength measurements

B. SNL-LBNL collaborative work

1. SNL to coat "wedge" samples provided by Andy for in-situ TEM nanoidentation measurements.

III. Lawrence Berkeley National Laboratory:

A. Andy:

1. Develop new sharper "wedge" samples for in-situ TEM nanoindentation measurements.

2. Send both to ANL, SNL

3. Andy to specify thicknesses for ANL, SNL deposition of UNCD, a-D film.

B. Chris:

1. Design new mask for flexural strength measurements (single lever)

2. Develop mask for 2" & 4" wafers

3. 2 µm UNCD film on SiO_2

IV. Oak-Ridge National Laboratory:

A. ORNL-ANL collaborative work:

1. Send to ANL VACNF samples (dense forests, less-dense patterned arrays) for growth of UNCD/VACNF nanocomposites.

2. ORNL to conduct spacially-resolved electron field emission measurements of UNCD-coated VACNF arrays.

3. ORNL to grow VACNFs onto patterned UNCD surfaces

4. ORNL to conduct field emission studies of VACNFs grown onto UNCD surfaces.

B. ORNL-NCSU collaborative work:

1. ORNL to send NSCU VACNF samples for FEEM/PEEM characterization of electron emission properties.

V. North Carolina State University:

A. NCSU-ANL collaborative work:

1. NCSU will conduct FEEM/PEEM study to identify origin of electron field emission in these films (grain boundaries?), and also temperature dependence, stability, and areal density (uniformity) of emission.

2. NCSU will send nanotube samples to ANL—ANL will assay the macroscopic field emission properties of these samples (threshold voltage, stability, effect of ambient gases.

B. NCSU-ORNL collaborative work:

1. FEEM/PEEM studies of VACNF samples?

VI. Northwestern University:

A. NW-ANL collaborative work:

1. V. Dravid will do HRTEM measurements of the nanostructure of ANL UNCD films grown at different temperatures and substrate bias conditions.

2. V. Dravid: Will do TEM holography measurements on a series of nitrogen-doped UNCD samples, to examine E-field at nanometer resolution, to identify origin of field electron emission (does emission originate from UNCD grain boundaries?).