EEE6009: Advanced Instrumentation Course (unit EM1-3) 3 March 2009

Title: Advanced Instrumentation – Electron Microscopy

Marking scheme:

There will be 100 points awarded in total.

1) 10 points are awarded for a logical layout of the essay explaining the need for removal of the silicon wafer substrate which will be too thick for any transmission electron microscopy.
2) 10 points will be awarded for using the right technical terms and proper language to provide a readable essay. This may be relevant as this year all MSc students seem to come from abroad.

The majority of points (80) will be given for proper discussion of the following points:

3) 2x10=20 points for 2 specimen preparation methods that will allow the user to transfer the particles from the wafer surface to the TEM or prepare an electron-transparent smaple, e.g.
   a) scratching / brushing them off mechanically onto a lacey carbon film on a metal grid
   b) washing off using clean liquid (ethanol etc.), collecting this in a glass, then drying off one drop of the suspension onto a continuous or holey carbon film supported by a metal grid
   c) mechanically depositing a thin layer of liquid epoxy glue (<1μm!) on top, curing this on a hot plate and then peel this off with the nano-particles embedded in it
   d) evaporating a thin amorphous carbon film on top of the silicon wafer, then peel off (hopefully with the nano-particles)
   e) fix the nano-particles by glue as above, then break the silicon wafer in square pieces, glue two pieces together and make a cross-sectional specimen which is thinned by mechanical grinding, polishing and argon ion milling until perforation
   f) back-thin the silicon wafer, cleave off small parts and mount these onto a metal support grid to look at the edges where some of the nano-particles might be visible (fast but statistically the most insecure method)
   g) focused ion beam thinning of a cross-section on the site of a particle, then lift out and transfer to specimen grid
4) 20 points for a good explanation of conventional bright/dark field imaging (CTEM), lattice fringe imaging (HREM) or annular dark-field scanning TEM (ADF-STEM), taking into account the problems of limited spatial resolution and thickness/bend contours in CTEM, the interpretation of phase contrast reversals with focus and thickness in HREM or signal/noise issues vs. inner detection angle in ADF-STEM, respectively.
5) 20 points for a proper explanation of SAED or CBED experiments to elucidate the structure by electron diffraction using either planar illumination (SAED) or convergent illumination (CBED), taking into account the problems of aperture size vs. particle size or multiple particles in SAED or of radiation damage when analysing small particles using a stationary focused electron probe in CBED.
6) 20 points for a good explanation of either EDXS or EELS, taking into account the problems of stray X-rays from the support material and the steel from both holder and vacuum chamber in EDXS or too thick embedding material and multiple scattering in EELS.

Lecturer responsible for problem layout and marking: Dr. Thomas Walther, Tel. 25891