NOTES:

In situ metrology for curved optics

1) **what are we trying to measure? How fast does it happen?**
   a. Change in surface reflectivity
      i. Roughness
      ii. Build up of films (C, Si, …)
      iii. Reflectivity and wavefront uniformity
      (Different mirrors see different local environments)
   b. Film characterization
   c. Characterize vacuum conditions
      i. Partial pressure and total pressure
      (Airborne molecular contaminants)
      ii. Gradients of pressure and intensity

2) **How to ensure options of use to tool suppliers?**
   a. Damage prevention: detect before damage affects imaging
   b. Feedback
      i. dose control
      ii. determine schedule for cleaning cycles (online/offline?)
   c. Non destructive
   d. Non invasive (occupy little space in tool vacuum)
   e. May only need to monitor first and/or last mirror. Which mirror will decay fastest??
   f. Local metrology of single sites or full-mirror scanning??
   g. Metrology must match severity of degradation
      i. Periodic verses continuous monitoring
      ii. Emergency monitoring: only when something goes wrong
   h. Reliability and robustness
   i. Use beta/alpha-tool to develop instrumentation for protection against catastrophic failures

3) **Options? Type of information? How invasive would techniques be?**
   a. Optical techniques
      i. Spatially scanning of ellipsometry possible but requires design.
         1. Focused –vs- unfocused (?$$?)
         2. imaging at 2-4 microns possible, but implementation difficult in tool
      ii. Broadband reflectometry not sensitive enough to detect changes
      iii. IR spectroscopy not seen as viable due to low signal to noise.
      iv. IR ellipsometry possible – needs development. (?$$?)
   b. Optical fluorescence (Capping layer in EUV or X-rays) ??
   c. Monitor scattered EUV light??

   d. Mass spectrometry
      i. QMS
      ii. Chemical sensors
   e. How accessible would probe be to mirrors in tool??

4) Sources of cost
   a. Purchase price of off-shelf instruments
   b. Design cost of custom probes
   c. Cost of upkeep, maintenance, down-time

In Summary

Ellipsometry appears to be the least invasive, most sensitive technique for monitoring changes in all aspects of mirror degradation (build up of films, roughening, reflectivity, wavefront uniformity); it seems to be best for in situ monitoring. The implementation of this technology will depend on the following issues:

- Acceptable cost for development of ellipsometric imaging system?
- Acceptable downtime for cleaning cycles?
- How should the probes be distributed in the tool:
  - 1. Monitor only mirror with highest intensity, or other mirror(s)?
  - 2. Monitor only one location on a mirror or scan the probe?
  - 3. What are the available space and location limitations in tool for probes or ports for optical access?

Local vacuum environments throughout the exposure tool should be well characterized by some combination of

- residual gas analysis
- chemical sensors