

# Discussion - Resist Outgassing

## General optics contamination

- Why have the results from different labs been inconsistent?
  - Can we understand the vacuum differences that may have led to the variations?
  - Can we move to more consistent results between labs with some standardization of procedures or calibrations?

# Discussion - Resist Outgassing

## General optics contamination

- First step should be standardization of calibration and RGA procedures, witness plate testing.
- Setup of small independent expert team to look at issues (contamination, vacuum science, etc.) at different sites desirable.
- Small differences (pumping speed, etc.) among vacuum systems have large effect on outgassing results.
- Different mirrors suffer different contamination mechanisms (due to location, radiation flux, etc.)
- What about radical (not neutral) fragments ejected from resists? Secondary electrons cause fragmentation of hydrocarbons.
- Use deuterated hydrocarbons or carbon isotopes to track contaminants.
- MET results have Si signature, which does not point to resist as source of contaminant.



# Discussion - Resist Outgassing

## Resist outgassing physics/chemistry

- How does outgassing change for different pulse structures, and pulsed vs. continuous wave (synchrotron) sources?
- How does outgassing vary with
  - total dose?
  - dose rate?
  - bandwidth of illumination?
  - exposed area of resist?
  - thickness of resist?
- Are there any clear observations about different formulations and their effect on outgassing?
- Are there molecules that are more likely to contaminate (that can be focused on)?

# Discussion - Resist Outgassing

## Resist outgassing physics/chemistry

- Is there data that suggests a difference between pulsed and cw sources? SEMATECH round robin, which included different sources, does not seem to show significant difference. However, large parameter space does not fully allow conclusion.
- Carbon growth with pulsed vs. cw source could be different.
- Could there be a benchmark test that allows comparison between different chambers?
- Check contamination with and without wafer?



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## Resist outgassing physics/chemistry

- Could one coat resist twice as thick and reduce time by 50 %?
- Check contamination build-up without exposure to see effect of solvent.
- Do experiment on heated chuck? Measure amount of outgassed solvent?
- Can the solvent content in resist be measured independently, i.e. after coating, baking, etc.? Infrared spectroscopy (right solvent, etc.) or deuteration might work (difficult) → There are estimates for a typical film.
- What are the solvents? They are not proprietary. List is small.
- Determine porosity of film by x-ray (grazing incidence)?

# Discussion - Resist Outgassing

## Resist outgassing physics/chemistry

- PMMA contaminates strongly.
- What about e.g. benzene vs. isobutylene? – Molecules with higher molecular weight have longer lifetimes on surface. That probably increases contamination. CO, OH groups are more “sticky” than saturated hydrocarbons. In general, polar molecules have longer lifetimes.
- Rate of carbon build-up is only substrate-specific (capping layer, Si, etc.) for first few monolayers of contamination. (*Initial* growth rate is substrate-specific.)
- Determination where molecules that cause carbon build-up come from?

# Discussion - Resist Outgassing

## Witness plate testing – based on ASML proposed test

- How does the capping layer choice effect the results?
  - Should the community settle on a standard choice, like Ru, TiO<sub>2</sub> or Si capped?
- Does the angle of illumination of the mirror matter?
- Does the distance from mirror to resist matter?
- Does the illumination bandwidth affect the results due to reflectivity changes?
  - If there is a change, is it well understood and can it be accounted for in the results?
- How do the results scale with the total dose on the mirror – which will be different if the illumination area changes?
- Does the pulse structure of the illumination affect the results?
- How does the background pressure affect the results?
  - Can this be accounted for by a control test without resist?
- Are reflectivity measurements capable of accurately detecting changes of a few % ?





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## Witness plate testing – based on ASML proposed test

- NIST suggested to use reference mirrors for witness plate testing. General agreement that reference mirrors are useful. Specific surface and other involved parameters still have to be agreed on.
- Comments on NIST proposal:
  - What is angle of incidence? 45 or 6 degrees?
  - What about other end/capping layers (Ru, Si)?
  - Check with exposure tool manufacturers whether they accept the choice of end/capping layer.
- Participants to provide feedback to A.Wüest, SEMATECH, with suggestions and comments on witness plate testing standardization.

