Public

Status update on outgassing of alternative resists

Gijsbert Rispens, Resist Outgassing Team

Resist TWG, February 21 2016

Outline

- October 2015 resist TWG recap
- Alternative resist approval procedure
- Alternative waiver status
- Summary

October 2015 resist TWG

Resist outgassing status and outlook

- **Traditional CAR**
  - The requirement for outgassing testing of ‘traditional’ CAR resists is removed permanently
  - ASML will continuously monitor EUV transmission of NXE tools

- **Alternative resists**
  - Procedure for resist approval is in place
  - Tool for experimental part of the procedure is available
    - Tuning of experimental conditions and interpretation of the results are the next steps towards finalizing the procedure
  - Multiple waivers have been granted and more are under consideration

Waiver procedure for alternative resists

1. Resist supplier requests waiver at ASML
   - Providing the chemical information needed to support approval flow
   - This chemical information also will be used to define the scope of the waiver
2. ASML reviews waiver request
   - Request will be reviewed based on available data.
   - If insufficient data is available additional data (from EIDEC) will be required
3. In case of a positive outcome of the risk assessment:
   1. ASML will grant a waiver to the resist supplier
   2. The resist supplier shares the waiver with the NXE owner planning to use a resist covered under the waiver
   3. The NXE owner is responsible for verifying that a waiver is in place before exposing a resist

Special considerations for ancillary materials

- Ancillary materials are defined as layers coated on the wafer that are not designed to undergo a chemical reaction under influence of EUV
  - Materials that are designed to undergo a chemical reaction are treated as a resist
- Ancillary materials can be either on top of the resist layer (e.g. a topcoat) or under the resist (e.g. an underlayer)

- A waiver is only required for a material if it:
  1. **Is on top of the resist layer**

     and
  2. **Contains elements other than (C, H, O, N, S, F, I)**

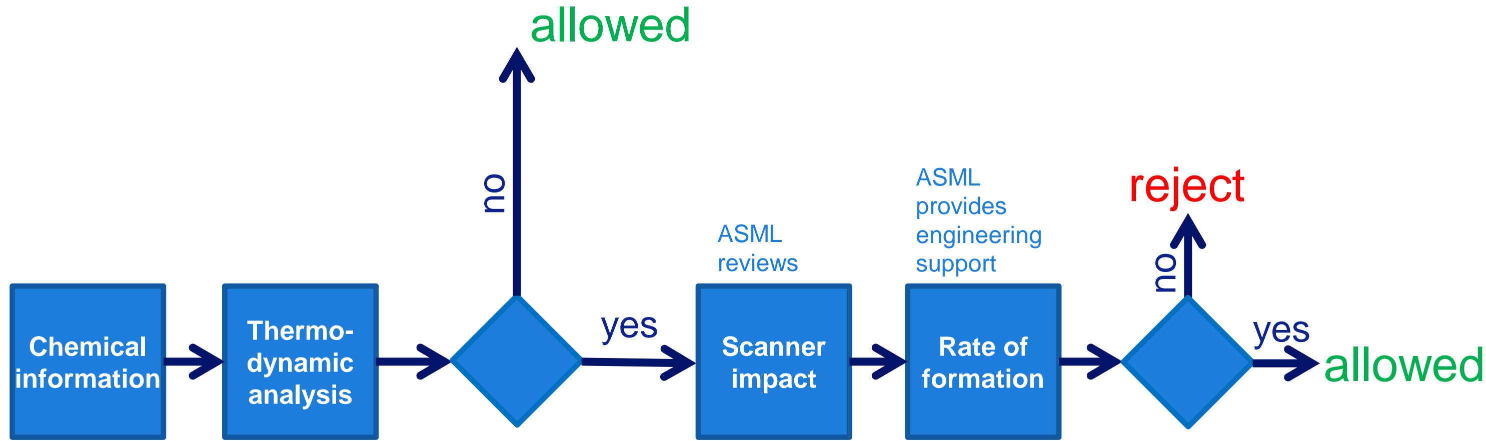
- **Other ancillary materials do not require a waiver for use in NXE scanners**

ASML way of working for alternative resist approval

ASML

Public

21-Feb-16



- What non-standard elements are present in the resist?
- What volatile species are expected?
  - Is formation of volatile (metal) hydrides possible?

Volatile elements expected other than *C, N, O, H, S, I, F?*

- What is the impact of the expected outgassing species on the scanner?
- What is the rate of formation of the expected outgassing species

Safe over scanner lifetime?

- Waivers are given to resist supplier
- Database of allowed materials maintained by ASML

Planning for finalizing approval procedure for alternative resists

Target to be final before April. Results indicate that HPEUV tool is representative

Today

	2015				2016		
	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1. Tool selection							
2. Experiments							
3. Interpretation							
4. Risk Assessment							

1. Selection of a tool that can support the requirements (H_2 + EUV)
2. Outgassing experiments under various conditions with known materials
3. **Interpretation** … **rimental conditions in order to be** … **scanner lifetime**
4. Risk assessment of novel materials (supporting resist approval procedure)

More details in the next talk by Eishi Shiobara, EIDEC

Alternative resist waiver status

- (Un)limited waivers have been granted to 4 different resist suppliers
- These waivers cover 8 different chemical elements

ASML

ASML Netherlands B.V.

raymond.maas@asml.com
phone

Company: XXXXX

Date: YYY

ASML has evaluated XXXX's resist platform ZZZZ and has deemed it acceptable for small wafer count exposures (max of 100) on NXE systems.

This letter can be shared under NDA with any NXE owner that wishes to use this resist platform for experimental exposures. It is the responsibility of the NXE owner to track the use of the material such that the small wafer account covered by this waiver is not exceeded.

ASML is of course interested in the results of such exposures and hopes that these can be shared with ASML.

Regards

Summary

Resist outgassing status and outlook

- ASML outgassing approach remains unchanged
    1. No outgassing spec for traditional CAR materials
    2. Waiver procedure for alternative materials
- ASML strategy is to give maximum freedom to resist suppliers to enable EUV in HVM
- Underlayers and organic topcoats do not require a waiver
- Waiver process is in place and working
- First HPEUV (EIDEC) results indicate that the tool is a representative tool

ASML

Traditional (Current) Chemically Amplified Resist Definition

- Traditional chemically amplified resist is defined as a resist that has a reaction mechanism based on the generation of photo-acids during exposure and a subsequent acid catalyzed reaction, that changes the resist solubility in a developer, during a post exposure bake.
- It consists of a photo-acid generator, polymer, quencher, possible additives and residual solvent and consists of (a subset) the following elements: **C, H, O, N, S, F, I**
  - If there are other elements that should be included, resist suppliers are asked to identify them to ASML
- For the purpose of resist outgas considerations, these resists are considered the currently available commercial platforms

Resist Family Explanation

- The scope of the resist family covered by a waiver will be decided based on the discussion between the material supplier and ASML.
- Any resist that falls out the resist family definition will require a new assessment.
- Elemental waivers will be made per supplier. Not applicable to all suppliers for an element.

Examples:

- If a metal A sensitizer used in a CAR resist gets a waiver, the waiver will apply for other formulations where same sensitizer is used up to the concentration which is waiverd, i.e. with different quencher, polymer, PAG etc.
- However the waiver will not automatically apply for a new resist platform (i.e. a non CAR resist with much higher Metal A content)
- If a nanoparticle of metal B + ligand C gets a waiver, nanoparticles of metal B + other ligand also gets a waiver, as long as the ligands do not contain elements outside of the CAR definition.

Limited Waiver procedure for alternative resists

Limited Waiver:

- is provided based on dialog between ASML-Material Supplier, ASML internal discussion and thermodynamic analysis provided by the material supplier
- is usually 100 full wafer equivalent* per resist per scanner
- may not be provided if there is thermodynamic concern, lack of data and/or other concerns
- 4-8 weeks of turnaround time is expected. There is no testing needed for a limited waiver, therefore testing time is not a limitation.

**see next slide for explanation*

Explanation of Full Wafer Equivalent

1 full wafer equivalent (fwe): is surface area of a 300 mm wafer ~ $70000 mm^2$

If one exposure field is $x*y$ mm^2, and there are z exposure fields on a wafer

The total number of wafers = fwe/(exposure field area in a single wafer)

= fwe/(x*y*z))

Example:

If there are 30 exposure fields on a wafer with 20mmx20mm dimensions each, this means → 70000/(20*20*30) ~ 6 such wafers counts as 1 fwe

1 fwe= 6 x