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TAKE A LOOK INSIDE

Best Poster Presentations
—see page 11

Industry Briefs
—see page 12

KEY DATES

For a list of meetings
—see page 13

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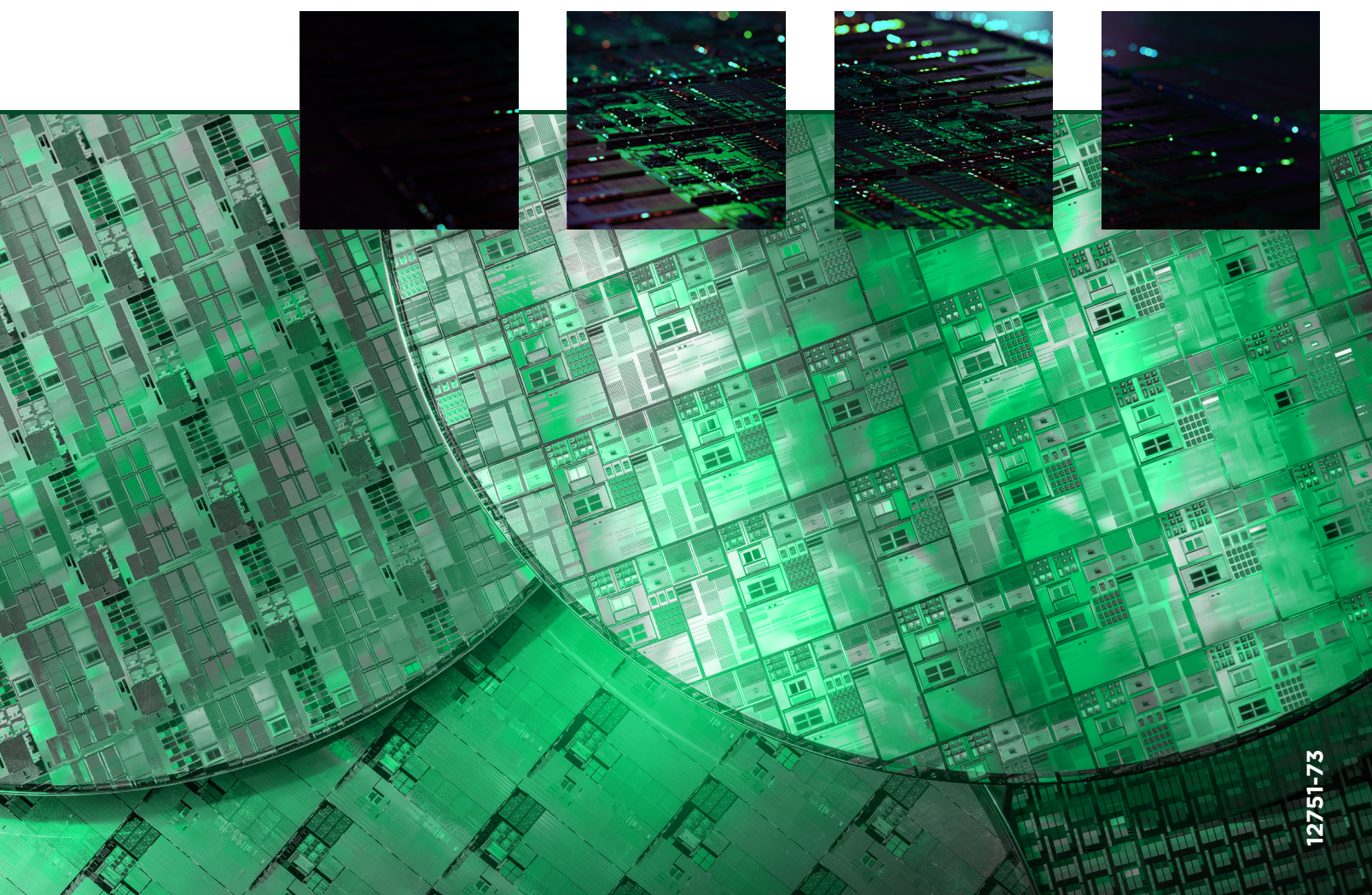
Highlights of the mask industry workshop on 6″x12″ mask format for EUVL



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EDITORIAL

Highlights of the mask industry workshop on 6"x12" mask format for EUVL

Frank E. Abboud, *Vice President Technology Development, Intel Corporation*

Our mask industry has been a driving force in enabling the extension of Moore's law and supporting the wafer fab communities in whatever it takes to keep advancing the semiconductor industry. Time and time again, the mask industry came through with innovations and solutions that provide the wafer fabs with better and cheaper ways to produce high-end devices. Mask evolved from the early days of 1X printing and then 4x projection steppers to the crazy times with reticle enhancement techniques, phase shift masks, and off-axis illumination that extended optical lithography beyond what anyone had ever imagined! Now we have the paradigm shift to EUV Lithography that was enabled by EUV masks. EUV mask making was no vacation for the mask makers. Everything had to change. Blanks, absorber material, writers, process equipment, and EUV wavelength inspection, and yes, a new pellicle that allows EUV to go through yet keep particles from falling onto the mask.

Recently, we started hearing about an even higher-NA (0.55) EUV scanner that provides higher resolution and capability over the current 0.33 NA scanner. Unfortunately, due to the optics design and the limitations on the landing angle, a design choice was made to cut the scanner field in half. This is done by making one axis at 4x magnification while the other axis on the mask at 8x magnification. In doing so, the scanner productivity is reduced due to the half field exposure.

Some suggested that one can use a larger mask to offset the negative productivity expectations of the high-NA scanner. On paper it looks very good and doable. If you have been in the industry as long as I have, you would know that there is nothing easier than PowerPoint engineering! However, making that a reality is a whole different ball game. This will require technical alignment among mask makers, mask-making equipment suppliers, blank equipment makers, and the scanner manufacturers. Also there has to be a commercial win for everyone. Inasmuch as we engineers rank that last on a list of benefits, money matters and without a commercial win, companies cannot justify the efforts to their shareholders.

Well, sitting on the sidelines and waiting for this to happen is not an option! We decided to organize an industrywide workshop on the topic of 6" x 12" large mask size and, thanks to the speakers and

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all the 60+ attendees, the event was successful. The workshop was attended by almost all mask industry suppliers of EDA, materials, and equipment. Also in attendance was EUV scanner maker ASML, and mask makers and users: IBM, Intel, Micron, Nvidia, Samsung, and TSMC.

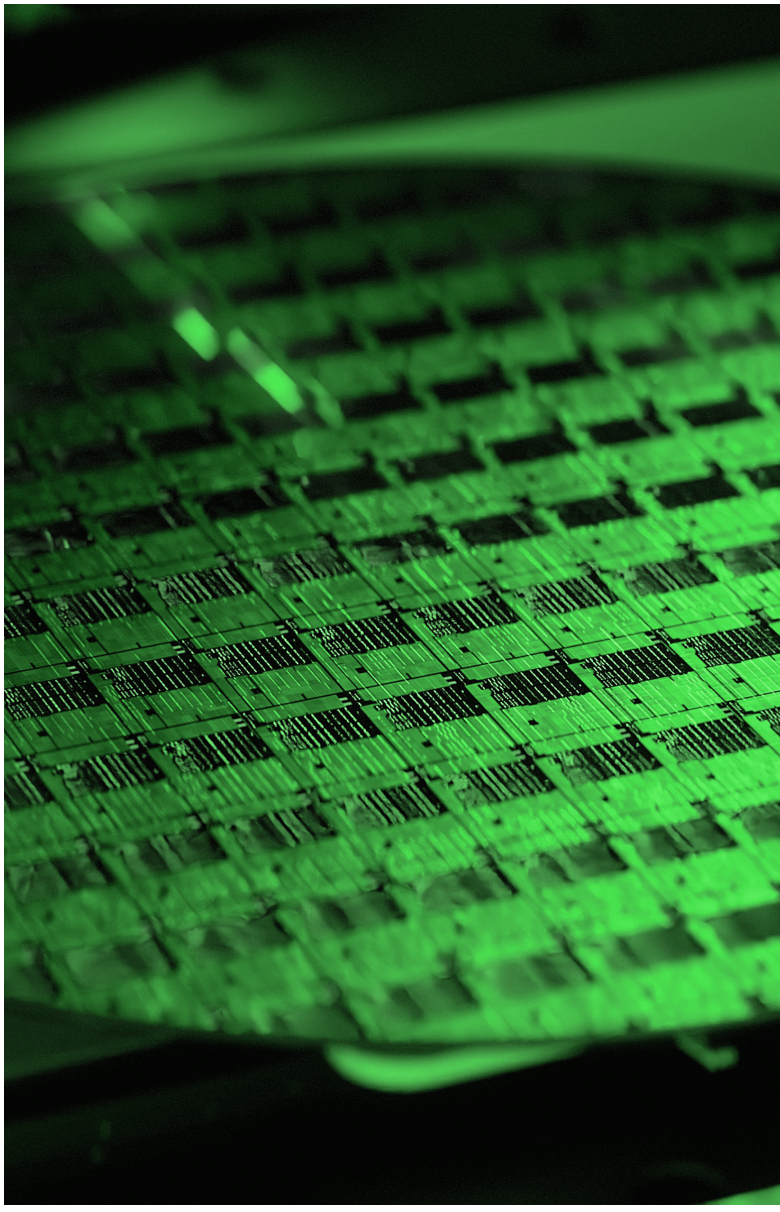
There was consensus by the chip makers that getting higher productivity from the expensive high-NA scanner is a good thing. The timing of a pilot-line insertion was close to 2028. ASML representatives confirmed that productivity increases by 15 percent (A-A reticle) to 40 percent (A-B reticle). The scanner modifications are primarily in the top module (mask chuck) and the design in the current system is compatible in terms of clearance. TSMC representatives who had a concern about mask handling in transition, proposed large mask for DUV too.

Summarized below are some of the highlights from the discussions as well as the presentations:

- Photomask users: Large mask format is favorable as it will avoid the need for stitching and hence increase scanner productivity.
- Mask materials: Blank suppliers are confident in their technical capability for manufacturing large mask blanks. Pellicle suppliers can already produce large membranes with carbon nanotubes (CNT). Both standard and requirement specification are needed.
- Process tools: Suppliers are confident (based on 300 mm wafer tools) in upgrading their current platforms to handle large masks for multilayer and absorber deposition, resist coat/bake and develop, etching, and cleaning. They expressed concerns about the effect of the larger non-symmetrical form factor on the processes and highlighted the challenges to maintain uniformity. It is important to have early access to metrology tools for process development.
- Writers, inspection, and metrology tools: These are all scanning tools where the area coverage is attained by mask travel. Therefore, relatively speaking, these tools require straightforward upgrade mainly on the stage and motion control modules.
- Handling and automation: EUV Pod and handling will require significant re-engineering, but FOUPs for 300 mm wafer can serve as a reference for consideration. Assessment is required to agree on the orientation in handling the large mask either from the short side or the long side.

My final impressions/take-aways: productivity advantage is real. Consensus is clear: there is a need to form a committee to define and publish spec/standard. Tool suppliers: no fundamental showstoppers, mainly engineering work that takes two to three years to develop. Process folks are concerned about non-symmetrical formfactor and impact on uniformity.

I am hopeful and confident that the mask industry will rise to the occasion and will enable the new mask size once the fabs establish the economical equation.



FEATURED ARTICLE **BEST POSTER PRESENTATION AWARD WINNER**

Identifying new absorber materials for EUV photomasks

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ABSTRACT

As semiconductor device fabrication moves towards 2 nm technology nodes with EUV lithography, new EUV absorber materials will be needed to replace the current Ta-based EUV photomasks. The industry is looking for new absorber materials with a low refractive index (n) and a high extinction coefficient (k), to produce an attenuated phase-shift EUV photomask capable of minimizing 3D effects. The challenge is that these new materials are often difficult to etch. To identify the etching pathway for new EUV material candidates, this paper proposes the approach of thermodynamic characterization for various chemistries as etching byproducts. The Gibbs free energy of formation for these compounds can be collected at standard state conditions, so the potential for such chemical reactions can be evaluated. Meanwhile, the volatility of these reaction products can be estimated by the respective boiling points, which can be calculated from respective heats of vaporization at reduced pressures typically found in a plasma etch chamber. Collectively, this information can help to screen for new low-n/high-k absorber materials, to focus the selection only to candidates with potential etching feasibilities.

INTRODUCTION

The industry's current standard extreme ultraviolet (EUV) photomasks contain a reflective multilayer component, made up of 40-50 alternating layers of molybdenum-silicon (~300 nm MoSi)[1]. A thin ruthenium (Ru) capping film separates the absorber and MoSi multilayer[1]. The absorber layer, typically made of tantalum-boron-nitride (TaBN) is etched to form the desired pattern[2]. During EUV lithography process, the exposed Ru/MoSi layer (from etching the absorber) reflects the incident EUV light, while the unetched absorber absorbs the EUV light. Therefore, the pattern generated on the EUV mask can be transferred to the photoresist film on a wafer.

Since the Ta-based absorber (~65 nm) is relatively thick in comparison to the wavelength of the EUV incident beam (13.5 nm), the thick absorber can induce phase deformations when the light interacts with both the MoSi layers and the absorber layer[3]. These phase deformations distort the aerial image which creates mask 3D effects that reduces image contrast on the photoresist[4-7].

Previous solutions to these mask 3D effects included updates to source illumination and changes in mask design[8]. However, with EUV lithography advancements towards 2 nm technology node, the actual material of the absorber needs to be changed to further reduce mask 3D effects[5-10]. A new absorber with a low refractive index (n) will allow for an attenuated phase shift mask (APSM) to be manufactured to improve image contrast[3,4,7,10-12]. Similarly, a new absorber material with a high extinction coefficient (k) can lead to the next generation of EUV binary mask, since such material would allow for a thinner film which would reduce mask 3D effects[3-5,7,10-12].

Although optimizing the n and k values of the absorber material is vital, the other aspects of the manufacturing process need to be taken into account in order to make a practical choice for an improved absorber material. First, the absorber material needs to be successfully made into a thin film that is amorphous, stable, uniform, of optimized thickness, and capable of adhering to the photoresist[11]. Second, the absorber material needs to exhibit excellent etching/repair capabilities[13]. From an etching perspective, the absorber needs to have a reasonable etch rate and high selectivity to the photoresist and surrounding layers, so the film can be patterned with optimal critical dimensions (CD) uniformity/fidelity[1,14,15]. The combined success of the absorber's optical properties, thin film properties, and EUV mask manufacturing capabilities is vital in choosing the next generation absorber photomask material.

Thermodynamic analysis serves as the fundamental basis for predicting if a reaction can potentially occur[16].

Under thermodynamic equilibrium, the Gibbs free energy can be calculated for a given surface reaction[16]. Furthermore, the reaction product's boiling point can also be calculated based on reaction conditions, such as pressure. The boiling point can serve as an indicator of a reaction product's volatility–Forming a volatile product is essential if a production worthy etching process can be developed. In this paper, the attempt is to apply thermodynamic analyses on potential low-n/high-k material candidates, by calculating the reaction Gibbs free energy and boiling point of respective plasma-solid surface reaction products under typical ICP plasma etching conditions[17-19]. It is important to note that the thermodynamic calculation is better suited for a closed system under thermodynamic equilibrium. In a typical plasma etching environment, plasma is considered at quasi-equilibrium, and reactants/products transportation is conducted under a very dynamic, high vacuum system. In addition, a viable etching solution strongly depends on surface reaction kinetics. This can become more critical for potential low-n/high-k material selection, where most of candidates are non-reactive metal elements. Nevertheless, reaction Gibbs free energy and boiling point calculations are a good starting point to identify the thermodynamic favorability of creating a compound that could be part of the etching reaction.

METHODOLOGY

The inductively coupled plasma (ICP) reactor such as Applied Materials' Centura® Tetra™ photomask etcher is most commonly used for photomask etching. These reactors operate typically at low temperatures (<100°C) and low pressures (<10 mT)[15,20]. A material's boiling point is often reported at standard pressure (760 Torr)[17-19]. However, a material's boiling point is a function of pressure, and therefore, within a plasma reactor's low operating pressure, the boiling point of a compound can be significantly reduced[20].

The Clapeyron equation expresses a dynamic equilibrium between the vapor phase and the condensed phase of a pure substance, where ΔV is the volume increment between the vapor phase and the condense phase, P is pressure, and T is temperature (Equation 1)[17]. If the condensed phase is a liquid (solid), the enthalpy increment is that of vaporization ΔH_v (sublimation ΔH_s) in kJ/mol.

$$\frac{dP}{dT} = \frac{\Delta H_v}{T\Delta V} \quad (1)$$

Substituting V=RT/P into Equation 1 gives the Clausius-Clapeyron equation as Equation 2. The ideal gas constant is 8.314 J/mol-K.

$$\frac{dP}{PdT} = \frac{\Delta H_v}{RT^2} \quad (2)$$

Rewriting this equation provides a means to evaluate the temperature of a substance at difference pressures, as shown in Equation 4.

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_v}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \quad (3)$$

$$T_2 = \left[\frac{1}{T_1} - \frac{R\ln(P_2/P_1)}{\Delta H_v}\right]^{-1} \quad (4)$$

Figure 1 plots the vapor pressure (Torr) vs. temperature (°C) for four compounds: MoF_6, CrO_2Cl_2, InCl, and $CdCl_2$[17-19,21,22]. The dots are the reported experimental values from the CRC Handbook[17]. The solid lines are estimates of the reduced pressure boiling points and

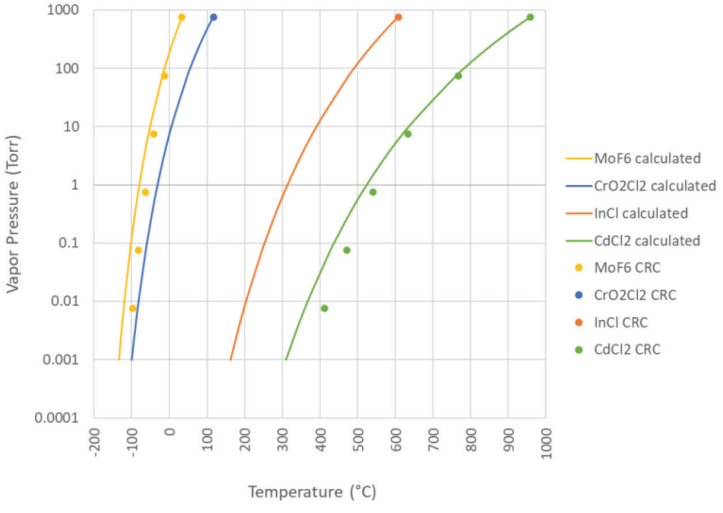

Figure 1. Vapor pressure (Torr) vs. temperature (°C) plot for four compounds. Dots are the reported experimental values from the CRC Handbook[17]. Solid lines are estimates of the reduced pressure boiling points and are calculated using the Clausius-Clapeyron equation and the compound's standard state boiling point and reported enthalpy of vaporization[17-19,21,22].

are calculated using the Clausius-Clapeyron equation (equation 4) and the compound's standard state boiling point and reported enthalpy of vaporization[17-19,22]. A typical ICP operating pressure is 1-10 mTorr, and the sample temperature is ~100°C, which can vary depending on the plasma parameters (ICP power, DC bias) and any thermal transfer between the sample and the electrode[20]. Therefore, all compounds in this report are passed through this filter: to be considered volatile, the compound's boiling point must be below 100°C at 1 mTorr. Figure 1 shows the calculated 1 mTorr reduced boiling points of MoF_6, CrO_2Cl_2, InCl, and $CdCl_2$ are -133.1°C, -99.9°C, 161.8°C, and 309.4°C, respectively. Therefore, MoF_6 and CrO_2Cl_2 pass through the filter, while InCl and $CdCl_2$ do not.

This paper has focused on calculating the boiling point at very low pressure (1 mTorr) and finding the standard molar Gibbs free energy of formation $\Delta_fG°$ and/or the Gibbs free energy of reaction ΔG_{rxn}, of the compounds that could be formed with various etching chemistries (F-, Cl-, H-, CH-, CO-, Br-, or O-based)[16,23-26].

The $\Delta_fG°$ is what is typically reported in chemistry handbooks and represents the formation of exactly one mole of product from reactants in their standard states (760 Torr and 298.15K)[17-19]. In a formation reaction (example reactions a, b, c in Table 1), the metal is in its atomic *solid* standard state (M), gases are in their *diatomic* standard states (F_2, Cl_2, H_2, O_2), bromine is in its diatomic *liquid* standard state (Br_2), and carbon is in its atomic *solid* standard state (C). From these formation reactions, $\Delta_fG°$ can be calculated using the standard molar enthalpies of formation $\Delta_fH°$ and the standard molar entropies S°.

Formation Reaction Examples	General Reaction Examples
a. M (s) + 5/2 Cl_2 (g) → MCl_5 (g)	**d.** M (s) + 5 Cl (g) → MCl_5 (g)
b. M (s) + 2 C (s) + 3 H_2 (g) → $M(CH_3)_2$ (g)	**e.** M (s) + 2 CH_3 (g) → $M(CH_3)_2$ (g)
c. M (s) + 6 C (s) + 3 O_2 (g) → $M(CO)_6$ (g)	**f.** M (s) + 6 C (g) + 6 O (g) → $M(CO)_6$ (g)

Table 1. Formation reaction examples with metal (M) and (a) Cl_2, (b) C and H_2, and (c) C and O_2. General reaction examples with metal (M) and (d) Cl, (e) CH_3, and (f) C and O[16,23-26].

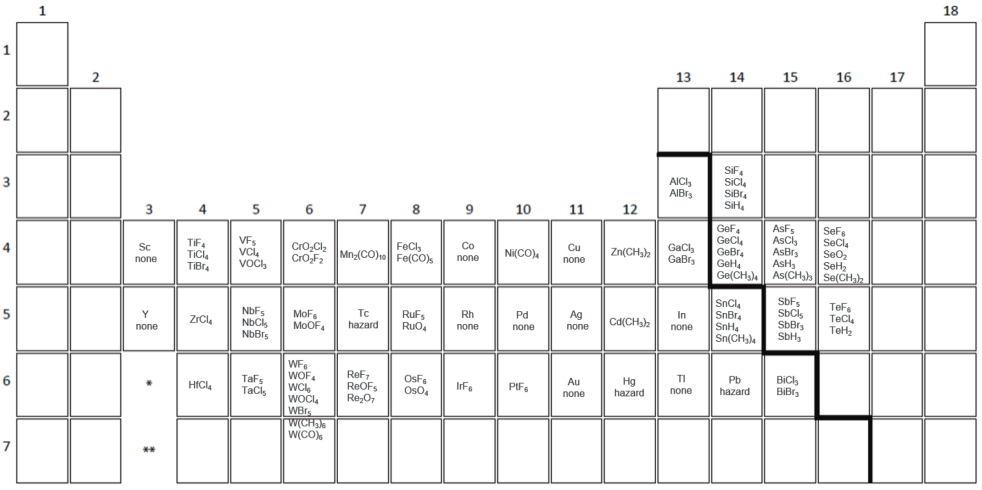

Figure 2. The selected elements form at least one compound with various etching chemistries (F-, Cl-, H-, CH-, CO-, Br-, or O-based). Only the compounds that have their boiling point below 100°C at a reduced pressure of 1 mTorr, and have a negative Gibbs free energy of reaction, are shown in this periodic table. Data is collected in Table A3 in the Appendix of a previous publication[28].

Alternatively, one can write a reaction that is more representative of the plasma constituents that would be the reactants. Notably, the reactions happening in a plasma environment are complex and often involve multistep intermediate reactions with transient species. Instead, this paper explores very simple reactions (example reactions d, e, f in Table 1), where the metal is in its atomic *solid* standard state (M), gases are in their *atomic* states (F, Cl, H, O, C), bromine is in its *atomic* liquid state (Br), and methyl is in its molecular *gas* state (CH_3)[16,24-27]. From these general reactions, ΔG_{rxn} can be calculated using the standard molar enthalpies of formation $\Delta_fH°$ and the standard molar entropies S°. Note that all these Gibbs free energies are being calculated at standard temperature and pressure, and not at plasma chamber operating conditions.

RESULTS AND DISCUSSION

The boiling point at reduced pressure and the Gibbs free energy of formation/reaction has

been reported in Table A3 in the Appendix for various elements on the periodic table in a previous publication[28]. Compounds are deemed potentially volatile if their boiling point at a reduced pressure of 1 mTorr is below 100°C, and their Gibbs free energy of formation or reaction is negative. This information has been distilled into the periodic table in Figure 2, which provides a visual representation of only the potentially volatile compounds of the elements investigated.

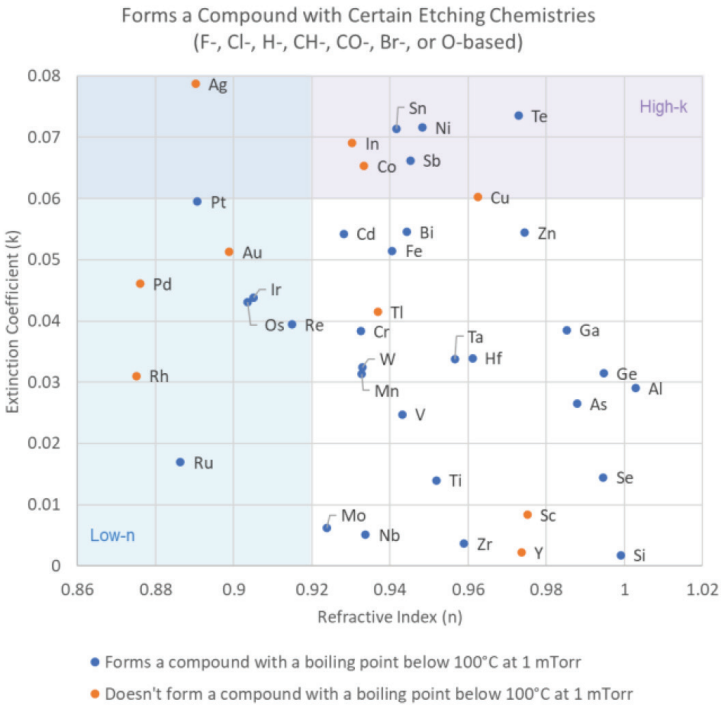

Figure 3. Refractive index (n) vs. extinction coefficient (k) of elements at λ=13.5nm[29]. The elements shown, form at least one compound with various etching chemistries (F-, Cl-, H-, CH-, CO-, Br-, or O-based). Preferred low-n (n<0.92) and high-k (k>0.06) regions are indicated by a blue and purple region, respectively.

The elements that form the potentially volatile compounds in Figure 2, have also been reported in Figure 3, plotted by their refractive indices (n) and extinction coefficients (k) (determined from the CXRO database at the EUV wavelength of 13.5 nm)[29]. The POR Ta-based absorber material used in high-volume manufacturing follows the proposed thermodynamic model, since it has compounds (TaF_5 and $TaCl_5$, see Figure 2) that have negative Gibbs free energies of formation/reaction and their boiling point is at or below 100°C at a reduced pressure of 1mTorr. Figure 3 can provide a starting point for identifying potential new photomask absorber elements that have low-n or high-k values, while also tending to form reaction products with relatively low boiling points. Alloys have been attracting great interest as candidates for a new absorber as well[3,8-10,13,30,31]. Etching an alloy is often more achievable when all elements in the alloy can react with the same etching chemistry to form products with low boiling points[32,33].

Actually, the absorber etching capabilities of two alloy film materials (AB and AC) was recently analyzed by Applied Materials. As can be seen in Table 2, three materials (A, B, C) with different gas combinations (X, Y, Z), show that certain compounds are potentially volatile (blue) if their boiling point at a reduced pressure of 1 mTorr is below 100°C, and their Gibbs free energy of

Material	Gas	Compound	Reduced pressure (1mT) B.P. (°C)	Gibbs free energy of formation $\Delta_f G°$ (kJ/mol)	Potentially Volatile Compound below 100C and 1mT
A	X	AX5	<100	<0	Yes
	Y	AY3	>100		No
	Z	AZ4	<100	<0	Yes
B	X	BX5	<100	<0	Yes
	Y	BY5	<100	<0	Yes
	Z	B2Z5	>100		No
C	X	CX5	<100	<0	Yes
	Y	CY5	<100	<0	Yes
	Z	CZ5	>100		No

Table 2. Three materials (A, B, C) with different gas combinations (X, Y, Z), showing that certain compounds are potentially volatile (blue) if their boiling point at a reduced pressure of 1 mTorr is below 100°C, and their Gibbs free energy of formation is negative, otherwise they are potentially non-volatile (orange).

Gas	Material		
	A	B	C
X	AX5	BX5	CX5
Y	AY3	BY5	CY5
Z	AZ4	B2Z5	CZ5
*potentially volatile (blue), potentially non-volatile (orange)			

Table 3: Summary of Table 2, three materials (A, B, C) with different gas combinations (X, Y, Z), showing that certain compounds are potentially volatile (blue) if their boiling point at a reduced pressure of 1 mTorr is below 100°C, and their Gibbs free energy of formation is negative, otherwise they are potentially non-volatile (orange).

Alloy Film	Gas	Normalized Etch Rate (Å/s)	Potentially Volatile Compounds	Conclusion
AB	X+Z	1	AX5, BX5	Non-zero etch rate since A and B form potentially volatile compounds with same X gas, see Table 3.
	Y+Z	0	BY5, AZ4	Zero etch rate since A and B do not form potentially volatile compounds with same gas, see Table 3.
AC	X+Z	0.6	AX5, CX5	Non-zero etch rate since A and C form potentially volatile compounds with same X gas, see Table 3.
	Y+Z	0	CY5, AZ4	Zero etch rate since A and C do not form potentially volatile compounds with same gas, see Table 3.

Table 4: Two alloy film materials investigated by Applied Materials, gas chemistry used for plasma etching, reported etch rate (Å/s), and conclusion referenced to Table 3.

formation is negative, otherwise they are potentially non-volatile (orange). A summary of the compounds from Table 2, are reported in Table 3. Then the etch results of the two alloy film materials investigated by Applied Materials are reported in Table 4. Recall, etching an alloy is often more achievable when all elements in the alloy can react with the same etching chemistry to form products with low boiling points[32,33].

For film AB, a plasma gas chemistry of X+Z produced a non-zero etch rate since A and B form potentially volatile compounds with the same X gas to produce AX5 and BX5, see Tables 3 and 4. On the other hand, a plasma gas chemistry of Y+Z did not etch material AB since the potentially volatile compounds that formed are of two different gas chemistries (BY5 and AZ4). Film AC follows the same trend, in which the etch rate is non-zero when the two elements in the alloy form potentially volatile products with the same etching gas (AX5 and CX5).

The above examples illustrate how using thermodynamic analyses guides the search for low-n/high-k material candidates with potential plasma chemistry, to enable a material's etching capability. Although finding the appropriate gas chemistry to product volatile compounds is an important first step, it is only the tip of the iceberg in terms of optimizing the process and hardware conditions to produce a successful outcome of reasonable etch rate, high uniformity and selectivity, and desired CD. To reiterate, all information is based on thermodynamic feasibility. Actual etching results is a complicated problem that requires ideal kinetics and process condition optimization. This is especially true in the case of alloy etching when more than one etching chemistry is involved – It is very possible that under various combinations, non-volatile product(s) can be formed under the plasma environment to stop the etching process.

The etch rate of the AB alloy film was further investigated with different bias RF, source RF, and pressure setpoints. As can be seen from Figure 4, the pressure does not impact the normalized etch rate, indicating that this process is not chemically enhanced. Similarly, the AB film's etch rate stayed low and showed minimum change when the source RF is doubled. Such an etch rate response indicates that the gas chemistry being tested lacks a chemical etching character for the AB alloy film. On the other hand, a higher bias RF setpoint increases the etch rate proportionally, indicating that the etching process is mainly driven by ion energy, and therefore carries a strong physical etching character. Results from Figure 4 clearly suggest that to develop an etch solution for such low-n/high-k films, both physical etching and chemical etching challenges need to be addressed with innovative hardware features, as well as gas chemistry selection with enhanced surface reactions.

CONCLUSION

The challenge is significant for the industry to search for the next generation of EUV photomask

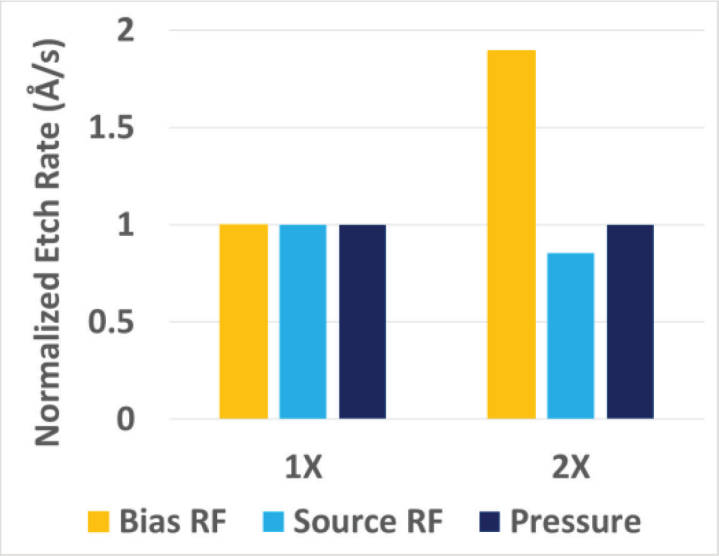

Figure 4. Normalized etch rate of alloy film AB with respect to bias RF, source RF, and pressure.

material to enable advancement of EUV lithography to 2 nm technology node and beyond. It is essential that a viable material candidate for the next generation EUV photomask demonstrate the desired optical property requirements (low-n and high-k), as well as meet the fabrication requirements for volume production. Among the EUV photomask manufacturing steps, the etching capability of the new EUV material is one of the key challenges that needs to be addressed.

This paper applies thermodynamic analysis as one guide for the selection of next generation EUV film material with low-n/high-k properties. For a given surface reaction between a solid material and etching chemistry, the Gibbs free energy to form the reaction product needs to be negative to ensure the reaction is thermodynamically favorable. Furthermore, the reaction product needs to have a low boiling point so it can potentially be removed from the material surface, such that the etching process can continue to complete. Those are the important considerations when identifying a material's etching capability, so that the etching process can be optimized for etch rate, selectivity, uniformity, and ultimately CD performance[14,15].

The results from the thermodynamic analysis presented in this paper focus on screening efforts among new material candidates with low-n/high-k optical properties. The boiling point calculation is conducted under typical EUV mask plasma etching conditions (temperature and pressure). If an etching product exhibits negative Gibbs free energy of reaction and low boiling point, the composition of such compound can provide general guidance on etching chemistry selection. Specifically, for low-n/high-k alloys as potential new EUV absorber film material candidates, it's important to select both metallic elements to be chemically reactive to a same etching chemistry. This could enhance the chance of developing a viable etching solution successfully.

Although thermodynamic calculations of Gibbs free energies of reaction and boiling points is a reasonable starting point for identifying material candidates for a potential etching solution, a thermodynamically favorable reaction does not speak to reaction speed, which is dictated by kinetics. A successful chemical reaction is much more complicated in an actual plasma etching environment, due to multistep intermediate reactions with transient species, that can be extremely difficult to model. Consequently, we do expect gaps to exist between the thermodynamic predictions vs. the material's actual etching feasibility.

Even if a surface reaction is thermodynamically and kinetically favorable using the combination of etching gases and absorber material, finding the optimal etching process parameters (temperature, pressure, gas flow, RF power, time), as well as the best specific hardware for the etching chamber, all dictates the practical success of etching. This was shown by the two alloy films investigated by Applied Materials. Due to the complexity of the etching process, both chemical and physical etching needs to be addressed when developing etching solutions. And experimental results are always needed to confirm if a material is etchable, and if the desired critical dimension (CD), selectivity, and uniformity can be achieved.

As the photomask community strives for the next generation EUV absorber film with the desired optical properties, examining a material candidate's etching capability through thermodynamic feasibility in parallel, can be very beneficial in accelerating the development cycle time. To that end, industrial collaboration is critical in delivering the next generation EUV lithography technology.

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AWARDS FROM SPIE PHOTOMASK TECHNOLOGY + EXTREME ULTRAVIOLET LITHOGRAPHY 2023

Best Presentation Award 1st Place:

Paper 12751-1: Actinic pattern mask inspection for high-NA EUV lithography (Invited Paper)

Author(s): Toshiyuki Todoroki, Kou Gondaira, Lasertec Corp. (Japan); Arosha Goonesekera, Lasertec USA Inc. (United States); Hiroki Miyai, Lasertec Corp. (Japan)

Best Presentation Award 2nd Place:

Paper 12751-38: EUV APSM mask prospects and challenges (Invited Paper)

Author(s): Shy-Jay Lin, Chien-Min Lee, Yen-Liang Chen, Lee-Feng Chen, Kuo-Lun Tai, Chien-Chao Huang, Frankie F. G. Tsai, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan)

Best Presentation Award 3rd Place:

Paper 12751-49: Improvements on pattern fidelity at high curvature region of curvilinear mask with a novel method of MPC (Invited Paper)

Author(s): Ai Kaneko, Taigo Fujii, Itaru Ono, Ahmad Syukri Bin Abdollah, Yohei Torigoe, Nippon Control System Corp. (Japan); Mincheol Kim, Sukho Lee, SAMSUNG Electronics Co., Ltd. (Korea, Republic of); Eok Bong Kim, SAMSUNG Electronics Co. (Korea, Republic of); Sanghee Lee, SAMSUNG Electronics Co., Ltd. (Korea, Republic of)

Best Poster Presentation Award:

Poster 12751-73: Identifying new absorber materials for EUV photomasks

Author(s): Rebecca D. Stern, Applied Materials, Inc. (United States); Michael Grimbergen, Applied Materials (United States); Jeff Chen, Rao Yalamanchili, Applied Materials, Inc. (United States)

INDUSTRY BRIEFS

imec, ASML team for pilot line for sub-1nm development

Nick Flaherty – June 28, 2023

A Memorandum of Understanding signed today covers the installation and servicing of ASML's full suite of advanced lithography and metrology equipment in the imec pilot line in Leuven, Belgium.

This includes tens of millions of euros of equipment with the latest model 0.55 NA EUV, the TWINSCAN EXE:5200 the key for 2nm and 1nm process development, as well as the latest models 0.33 NA EUV TWINSCAN NXE:3800. The deal also includes DUV immersion with the TWINSCAN NXT:2100i, Yieldstar optical metrology and HMI multi-beam.

eenewseurope.com/en/imec-asml-team-for-pilot-line-for-sub-1nm-development/

Why curvy design now? Manufacturing is possible and scaling needs it

Jan Willis – September 21, 2023

Have you ever seen roots or tree branches take a 90-degree turn? Nature doesn't do 90-degree turns, yet the entire chip-design infrastructure is based on the Manhattan assumption of 90-degree turns. While it would take time to change, is there any doubt that a curvilinear chip, if made possible, would be smaller, faster, and use less power?

semiengineering.com/why-curvy-design-now-manufacturing-is-possible-and-scaling-needs-it

Biden-Harris Administration announces final national security guardrails for CHIPS for America incentive program

September 22, 2023

The U.S. Department of Commerce released the final rule implementing the national security guardrails of the CHIPS and Science Act, to help ensure the investments enhance global supply chain resilience.

nist.gov/news-events/news/2023/09/biden-harris-administration-announces-final-national-security-guardrails

Exclusive: China to launch $40 billion state fund to boost chip industry

Julie Zhu, Kevin Huang, Yelin Mo and Roxanne Liu – September 5, 2023

China is set to launch a new state-backed investment fund that aims to raise about $40 billion for its semiconductor sector, two people familiar with the matter said, as the country ramps up efforts to catch up with the U.S. and other rivals. It is likely to be the biggest of three funds launched by the China Integrated Circuit Industry Investment Fund, also known as the Big Fund. Its target of 300 billion yuan ($41 billion) outdoes similar funds in 2014 and 2019, which according to government reports, raised 138.7 billion yuan and 200 billion yuan respectively.

reuters.com/technology/china-launch-new-40-bln-state-fund-boost-chip-industry-sources-say-2023-09-05/

Trends in imaging design: Why do we need optical design kits for flat optics?

Jun 30, 2023

The semiconductor industry has long handled mass production with over a trillion units shipped worldwide each year. With pervasiveness, miniaturization, and integration becoming strong drivers for optical components, efforts have been put into leveraging existing semiconductor processes for their production. Emerging optical components are often referred to as flat optics, since they are manufactured on flat silicon or glass substrates. One advantage is that they can be manufactured using semiconductor processes instead of traditional injection molding or glass polishing techniques.

blogs.synopsys.com/optical-solutions/2023/06/30/trends-in-imaging-design-why-do-we-need-optical-design-kits-for-flat-optics/

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Founded in 1980 by a group of chrome blank users wanting a single voice to interact with suppliers, BACUS has grown to become the largest and most widely known forum for the exchange of technical information of interest to photomask and reticle makers. BACUS joined SPIE in January of 1991 to expand the exchange of information with mask makers around the world.

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Key Dates

2024

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25–29 February 2024
San Jose, California, USA
spie.org/al

Photomask Japan
16–18 April 2024
Yokohama, Japan
smartconf.jp

SPIE Photomask Technology + EUV Lithography
29 September–3 October 2024
Monterey, California, USA
spie.org/puv

You are invited to submit events of interest for this calendar. Please send to tyb@spie.org.

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