附件四、技術説明表

具平坦結構之嵌入式極紫外光微影用衰減式相位移光罩及其製造方法

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市場及需求:

半導體晶片製造產業及相關領域

技術摘要(含成果):

本發明揭示一種具平坦結構之嵌入式衰減式相位移光罩及其製造方法，應用於極紫外光(EUV)微影製程。傳統衰減式相位移光罩因衰減層與相位移層堆疊於多層反射鏡上而形成「凸字型」結構，易在高數值孔徑(high-NA)條件下產生三維效應(3D effect)，主因為遮蔽所造成之強度與相位誤差，因而造成臨界尺寸偏差與成像對比度下降。本發明採用嵌入式設計，使相位移層與衰減層部分或全部埋入布拉格反射鏡內，達成光罩表面平坦化，並透過精準調控多層膜厚與等效折射率，使反射相位差維持 180°±3°、反射率維持於 5-10%。此外，相對多層反射鏡之光學平坦度控制於入射波長 1/5 以下(<λ/5)，可避免局部相位扭曲並有效抑制高 NA 系統中的 3D effect。此結構可提升成像解析度與製程穩定性，適用於下一世代高數值孔徑(high-NA)微影曝光機及相關技術，具高度產業應用潛力。

優勢:

本發明採用嵌入式平坦結構設計，使相位移層與衰減層相對多層反射鏡之光學平坦度維持在入射光波長 1/5 以下(<λ/5)，有效消除傳統「凸字型」光罩的高度差，使表面高度起伏對反射相位與繞射行為之影響可忽略，顯著抑制 3D effect，並提升臨界尺寸控制精度與成像對比度。透過精準控制相位移層與衰減層之厚度與光學常數，可達成 180°±3°的反射相位差與 5-10%的反射率，兼具相位差精準度與準確反射率。本技術同時具備高數值孔徑(high-NA)系統相容性，並提供優異的製程穩定性與產業應用潛力。

競爭產品:

尚無

專利現況:

專利申請準備中

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Embedded Attenuated Phase-Shift Mask (APSM) with Planar Structure for Extreme Ultraviolet Lithography and Method for Manufacturing the Same

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Experience:

https://sites.google.com/view/ntumse-noel

Market Needs:

Semiconductor Industry

Our Technology:

This invention discloses a planar embedded attenuated phase-shift mask (att-PSM) and its fabrication method for extreme ultraviolet (EUV) lithography. Conventional Att-PSMs for EUV lithography place the absorber and phase-shift layers on the top of the multilayer reflector, creating a "raised" structure that induces severe three-dimensional (3D) effects under high numerical aperture (high NA) illumination, leading to critical-dimension errors and reduced imaging contrast.

The proposed design embeds the absorber and phase-shift layers entirely inside the reflector to achieve a planar mask surface. By precisely controlling the layer thicknesses and optical constants, the reflective type att-PSM mask provides a phase shift of $180°\pm3°$ with a reflectance of 5-10%. In addition, the optical flatness between the embedded layers and the multilayer mirror is maintained below one-fifth of the wavelength ($<\lambda/5$), suppressing local phase distortion and effectively reducing 3D effects, especially in high-NA exposure systems. This structure improves imaging resolution, offering substantial potential for next-generation high-NA EUV lithography.

Strength:

The embedded planar architecture maintains optical flatness between the absorber/phase-shift layers and the reflector to less than $\lambda/5$, eliminating surface-height variation typically found in conventional raised-structure masks. The minimized phase and diffraction disturbances significantly suppress mask 3D effects, improving critical-dimension control and image contrast. Precise thickness and optical constant tuning enable a well-controlled $180°\pm3°$phase shift with 5-10% reflectance, achieving both high phase accuracy and reflectance.

The technology is compatible with high-NA EUV exposure systems, providing excellent process reliability and industrial scalability.

Competing Products:

None

Intellectual Properties:

Patent pending

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