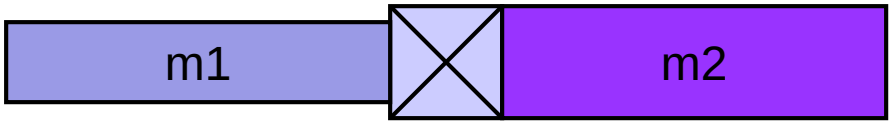
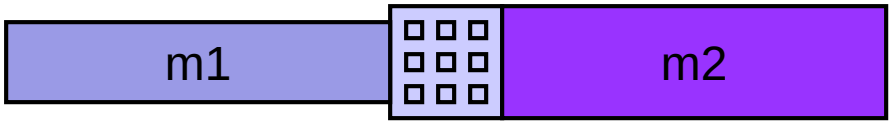
PHOTOMASKS

`magic` Layers vs. Mask Layers

- `magic` allows designers to work with logical layers
- Chip fabrication requires more detailed layers
- `magic` captures all necessary information and generates the rest
- Example magic layout with m1-m2 via



Example m1-m2 via pattern in actual mask

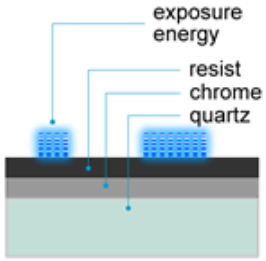


Mask Costs

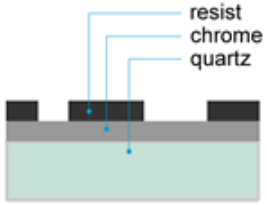
- Approximate cost for a set of masks for the indicated CMOS fabrication technology
  - 28 nm $2 million
  - 14/16 nm $4 million
  - 7 nm $8-10 million
    [Mark Papermaster, CTO AMD, CTO Forum, Nov 2016]
- Two of the reasons for the dramatic increases in cost are the finer features sizes, and the need for many more masks for multiple patterning lithography

How a Photomask is Made

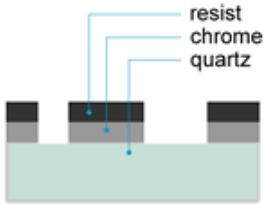
1. Generate Pattern
   - Convert circuit design data to image in resist through e-beam/laser exposure.



2. Develop Resist
   - Develop temporary pattern in resist to serve as a match for etching.



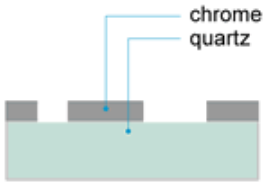
3. Etch Chrome
   - Define permanent pattern in chrome.



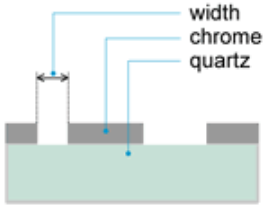
Source: www.photomask.com; Toppan Inc.

How a Photomask is Made

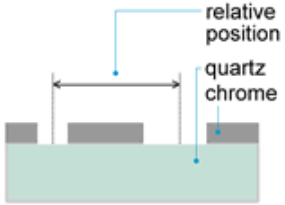
4. Remove Resist
   - Remove temporary masking layer.



5. Measure Critical Dimensions
   - Ensure features are the proper size.



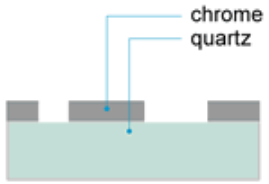
6. Measure Feature Placement
   - Ensure features are in the proper position.



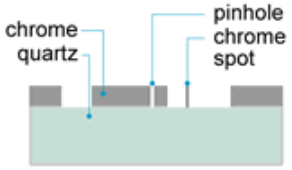
Source: www.photomask.com; Toppan Inc.

How a Photomask is Made

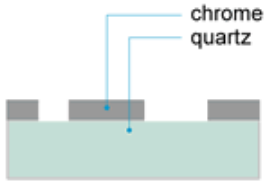
7. Initial Clean
   - Clean for defect inspection.



8. Inspect for Defects
   - Ensure no unetched chrome or pinholes are present.



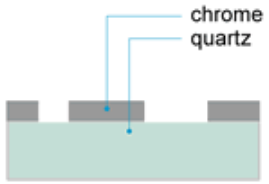
9. Repair
   - Repair any defects found.



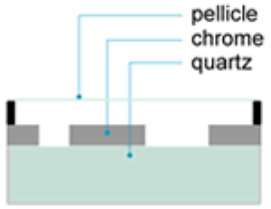
Source: www.photomask.com; Toppan Inc.

How a Photomask is Made

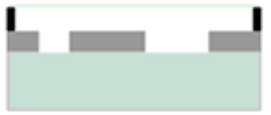
10. Pre-Pellicle Clean
    - Remove any particulates before pellicle application.
    - *Pellicle* is a protective cover that shields the photomask from damage and dirt.



11. Apply Pellicle
    - Provide a particle barrier to ensure the integrity of the pattern from particles.



12. Audit
    - Final check.



Source: www.photomask.com; Toppan Inc.