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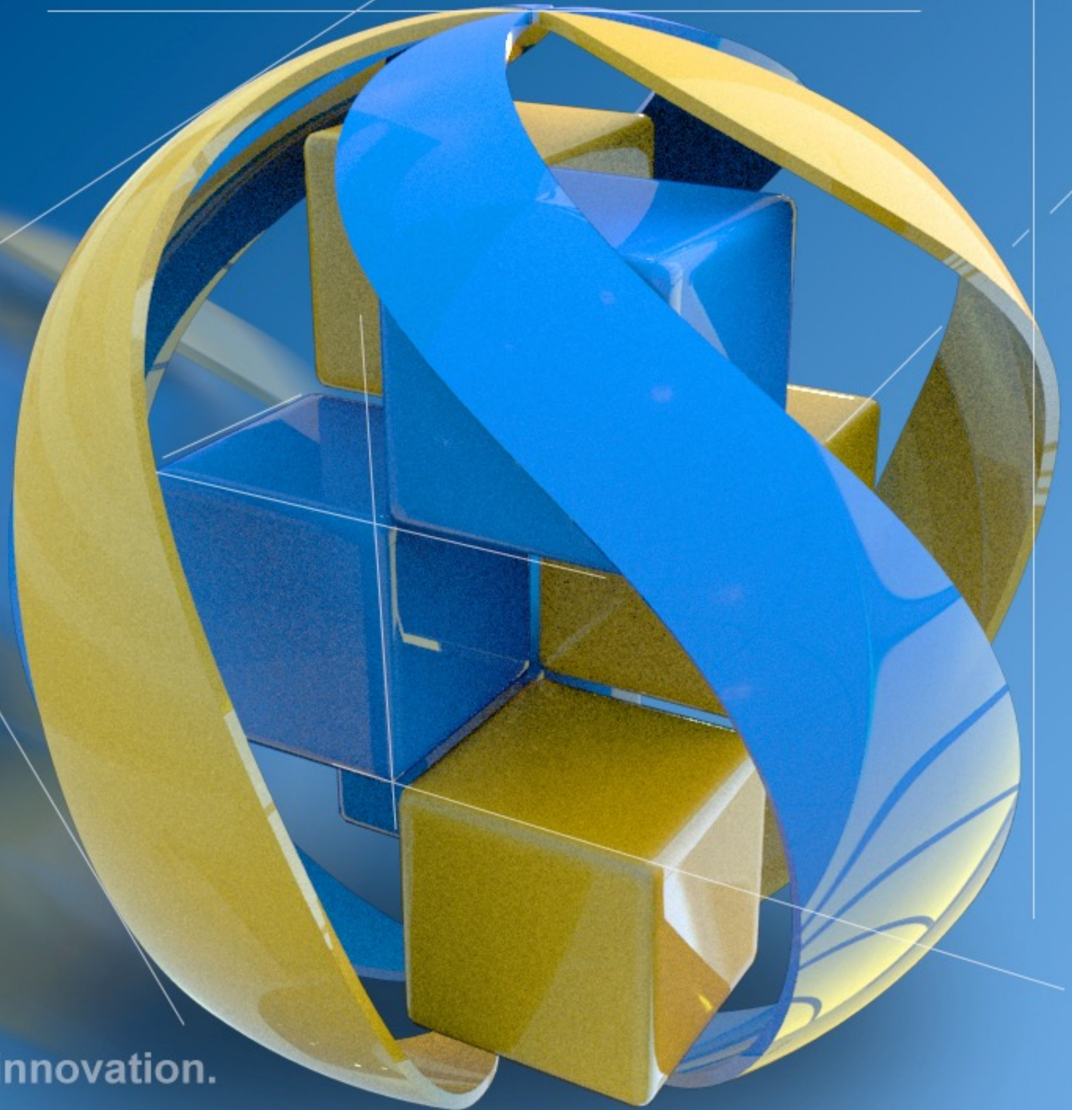
engineering



The convergence of research and innovation.

Reticle (Photomask) Layout vs. Wafer Layout

Stepper vs. Contact Photolithography

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Stepper vs. Contact Litho.

Contact Alignment

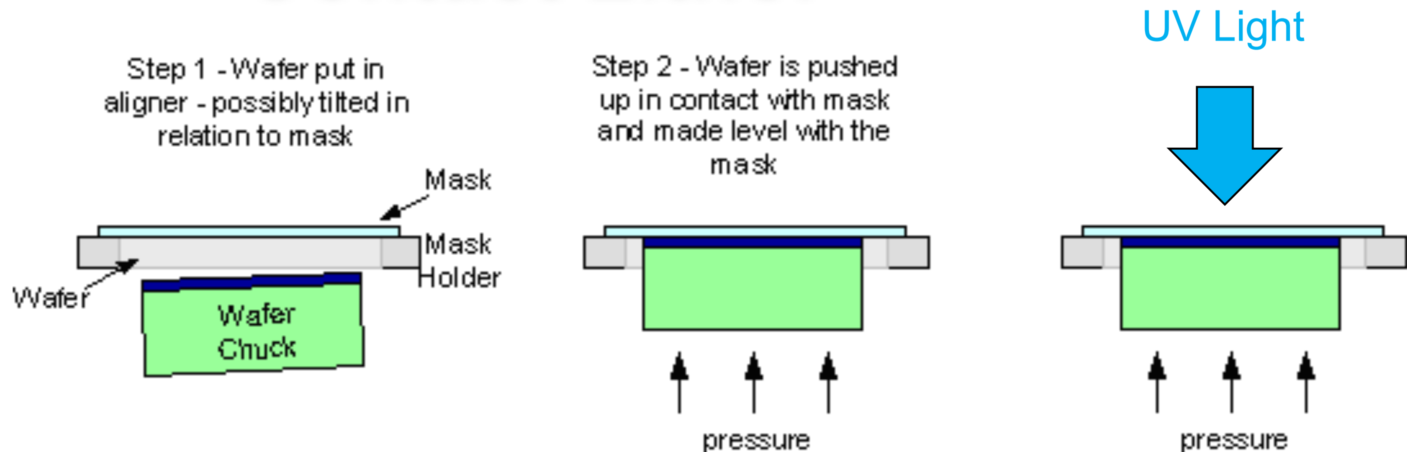
- Places a reticle/mask in direct contact with a wafer.
- Benefit – can fill a single reticle with lots of varying designs, patterns entire wafer in one sinlge exposure.
- Drawback – 1-2μm size variations across wafer, ~1-2μm minimum feature size.

Stepper Lithography

- Gives <1μm resolution and accuracy. Our DUV Stepper gives ~200nm resolution relatively easily, I-Line steppers ~500nm.
  - Wafer-Placement & Stitching accuracy is **≤ 20nm**
- Drawback is the smaller exposure field size – you can't expose a whole wafer in one shot, so filling a full-wafer with many different designs could require **many (expensive) reticles**.
  - Except: For repetitive pattern (eg. optical gratings), the Stitching capability allows for ***more*** variations to be included on a single reticle.

Contact Litho.

Contact Litho.:



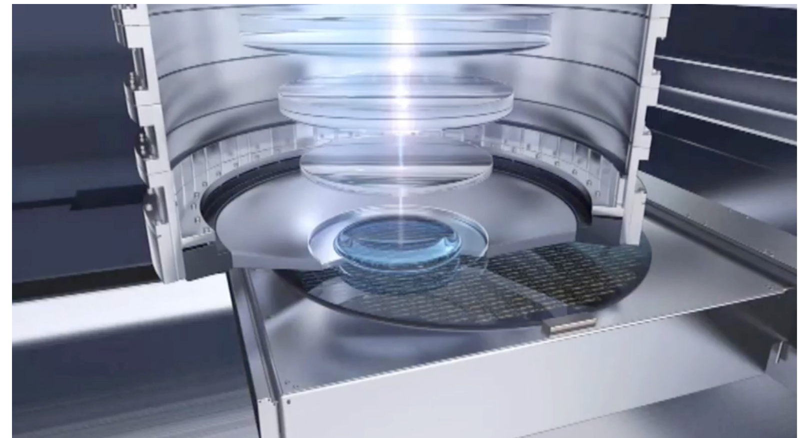
- **Contact Alignment** places a reticle/mask in direct contact with a wafer.
- Benefit – can fill a single reticle with lots of varying designs, patterns entire wafer in one exposure.
- Limits:– 1-2µm size variations across wafer, ~1-2µm minimum feature size, ~1µm alignment tolerance.
- Patterns are limited to the current mask plate – can not mix/match different mask plates easily.

* Image from Aaron R. Hawkins, Brigham Young University, "*Contact Photolithography Alignment Tutorial*" (online)

Stepper Litho.

- Fully motorized and computer programmed.
- Rely on highly accurate motorized wafer-placement and reticle placement
- Laser-Interferometric wafer-stages allow for
  - ≤ 20nm placement in a single exposure session
  - ≤ 50nm layer-to-layer alignment accuracy
- Automatic Focus/Tilt measurement on each die before exposure
  - I-Line steppers: ~300-500nm minimum feature size
  - DUV stepper: ~200nm minimum features size
- The steppers can be programmed for flexible exposure maps
  - Can expose multiple patterns on multiple reticles.
  - More complex programming, but highly flexible layouts. Wafer layout is different from reticle/photomask layout.

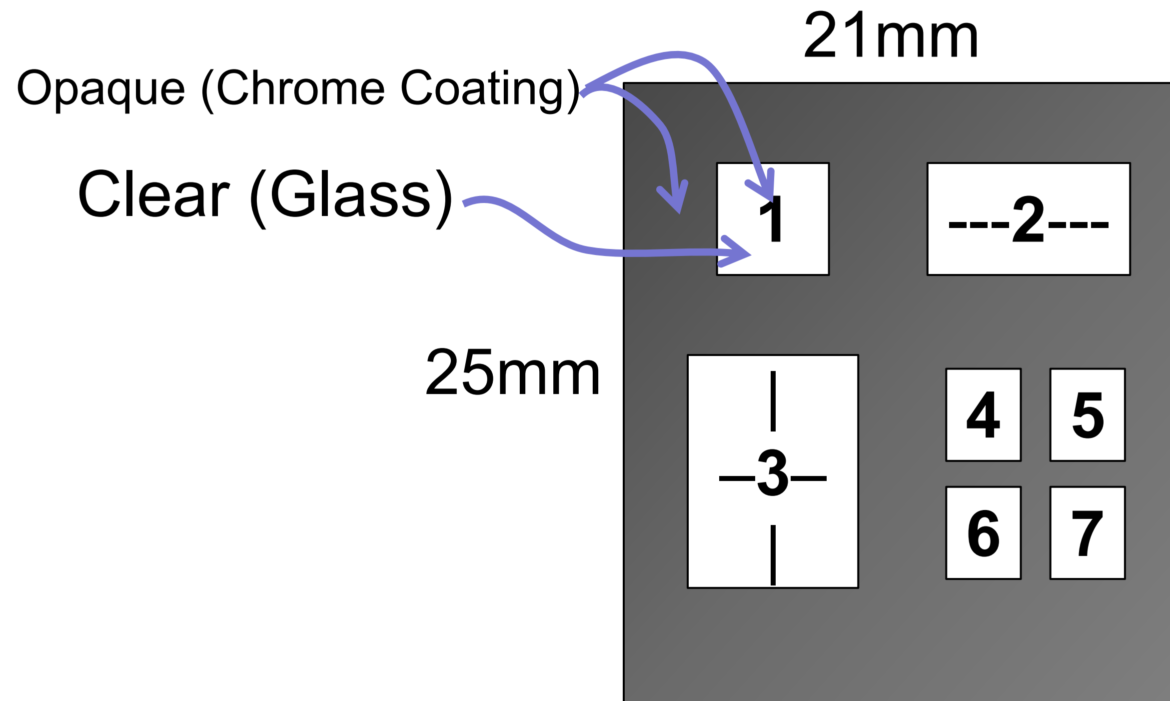
"Stepping" a single photomask pattern across a wafer. The same pattern is repeated, and/or different photomask regions can be stepped in sequence.



* Video from ASML, "*Powering the next phase of semiconductor manufacturing*" (online)

Stepper Litho: Reticle / Mask Layout

- Can place a number of different patterns onto the reticle, and then programmatically choose which ones will be shot onto the wafer, and where on the wafer they will be exposed.
- Example Reticle – a Glass (clear) plate with Chrome Patterns, defined by the CAD drawing you/we submit.

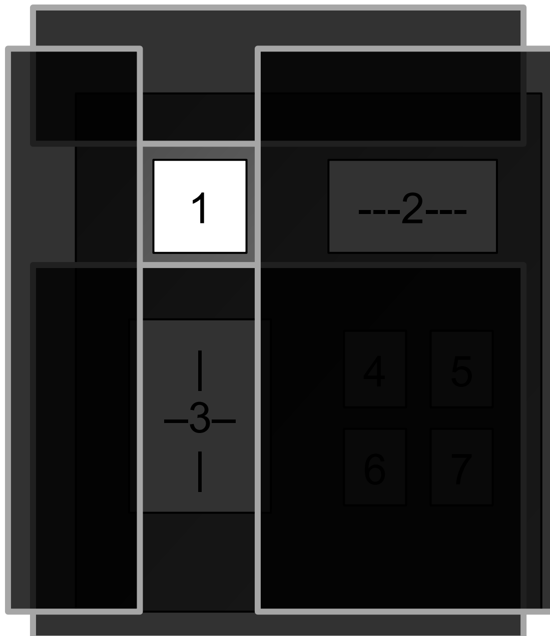


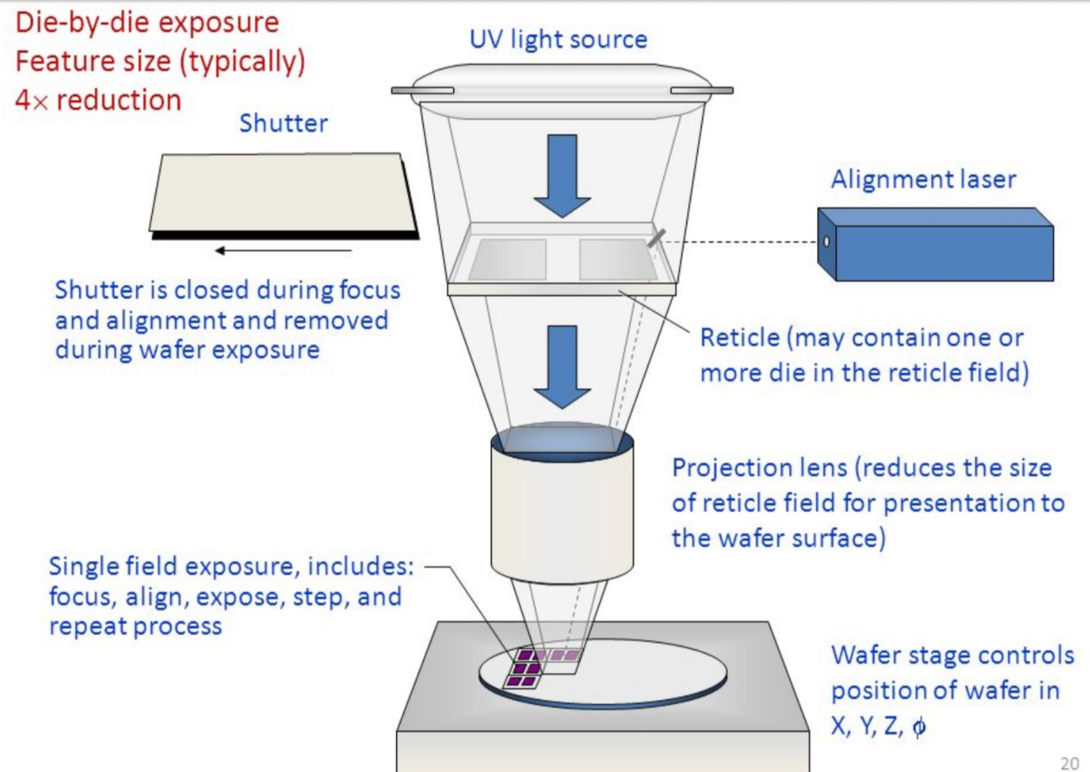
Multiple patterns (7), Size arbitrary
(within reticle size limit and coordinates/sizes should be well-defined)

Stepper Blade-Off

- Projection steppers can blade-off unwanted regions of the reticle, to select only a single pattern at a time for exposure.

Exposing only the "1" Image with motorized shutter blades



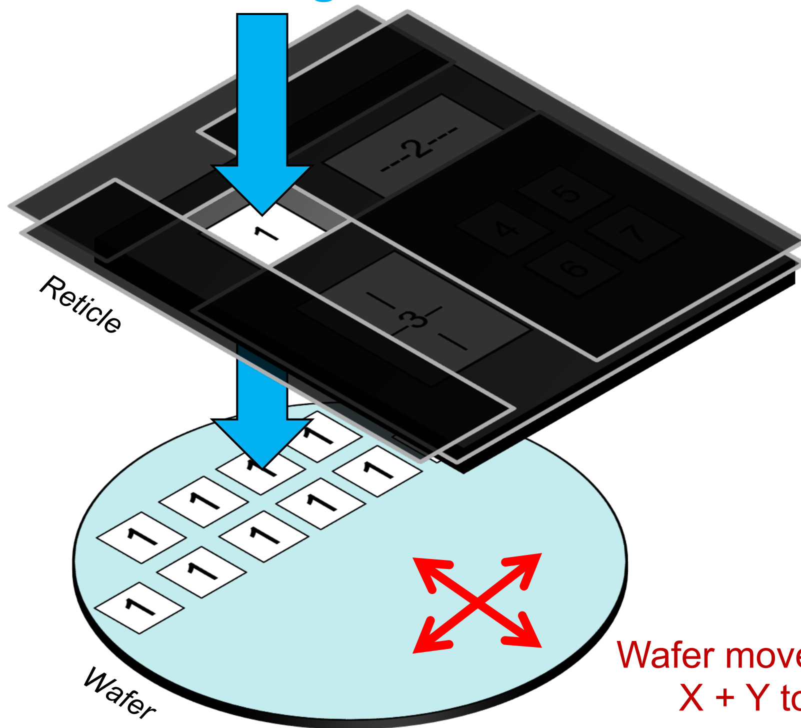


* Stepper schematic from: Prof. Bo Cui, U. Waterloo, Class NE 343 Microfabrication and thin film technology, "*Chapter 5 Lithography*" (online)

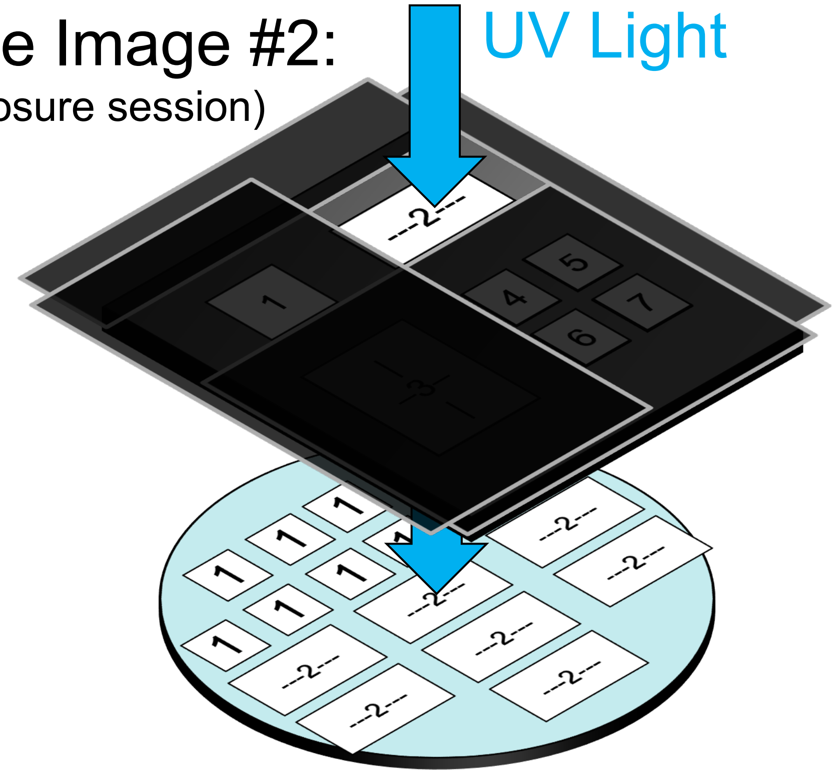
Stepper Blade-Off

- Projection steppers can fill the wafer with different Patterns at different locations (on a fixed pitch though)

Expose Image #1:



Then Expose Image #2:
(during same exposure session)



Wafer moves in X + Y to step/repeat the exposure

These could be done in a single exposure “job” (”Layer”) – after all exposures are complete, you perform a single Develop step and proceed with your process.

Stepper Blade-Off

- You could also choose to shoot the entire reticle at one time and repeat that across the wafer.