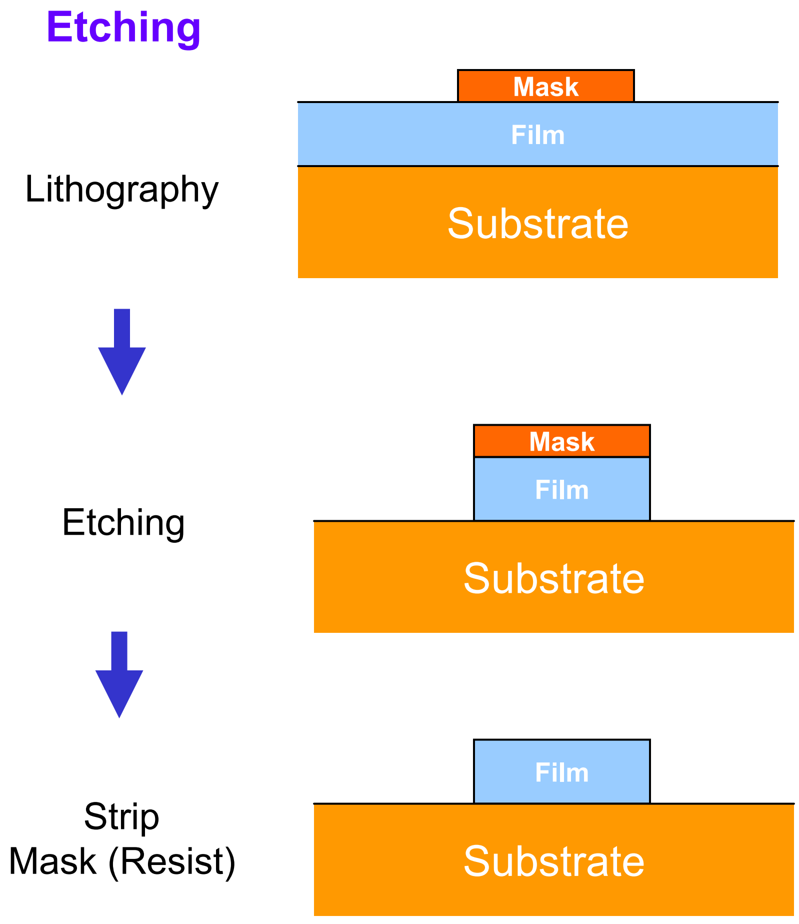
III. Wet and Dry Etching

	Wet	**Dry**
Method	Chemical Solutions	Ion Bombardment or Chemical Reactive
Environment and Equipment	Atmosphere, Bath	Vacuum Chamber
Advantage	1) Low cost, easy to implement 2) High etching rate 3) Good selectivity for most materials	1) Capable of defining small feature size (< 100 nm)
Disadvantage	1) Inadequate for defining feature size < 1um 2) Potential of chemical handling hazards 3) Wafer contamination issues	1) High cost, hard to implement 2) low throughput 3) Poor selectivity 4) Potential radiation damage
Directionality	Isotropic (Except for etching Crystalline Materials)	Anisotropic

NICHIA EXHIBIT 2014
Vizio, Inc. v. Nichia Corporation
Case IPR2018-00386

Pattern Generation (Transfer): Etch vs. Liftoff

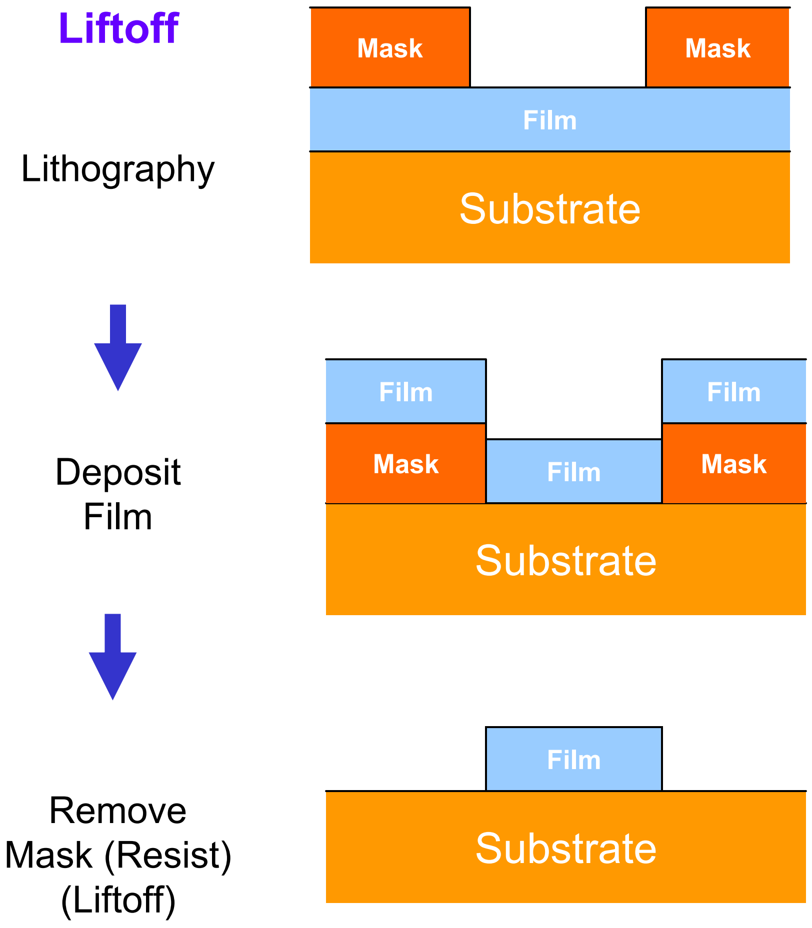


Etching

Lithography

Etching

Strip
Mask (Resist)



Liftoff

Lithography

Deposit
Film

Remove
Mask (Resist)
(Liftoff)

Isotropic vs. Anisotropic Etching

Isotropic Etching:	Etching rate is the same in both horizontal and vertical direction
Anisotropic Etching:	Etching rate is different in horizontal and vertical direction

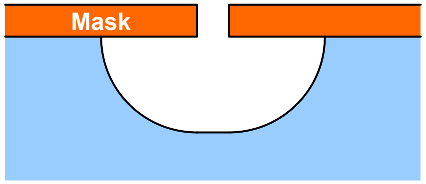
Lateral Etch Ratio:

$$R_L = \frac{Horizontal\ \ Etch\ Rate\ (r_H)}{Vertical\ \ Etch\ Rate\ (r_V)}$$

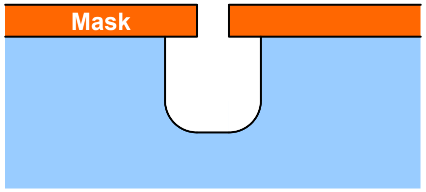
Isotropic Etching:	$R_L = 1$
Anisotropic Etching:	$0 < R_L < 1$
Directional Etching:	$R_L = 0$

Bias: the difference in lateral dimensions between the feature on mask and the actually etched pattern

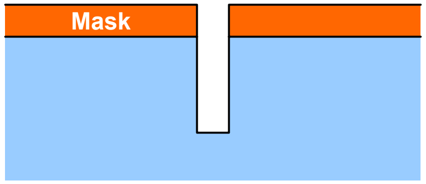
➡ smaller R_L results in smaller bias



$R_L = 1$

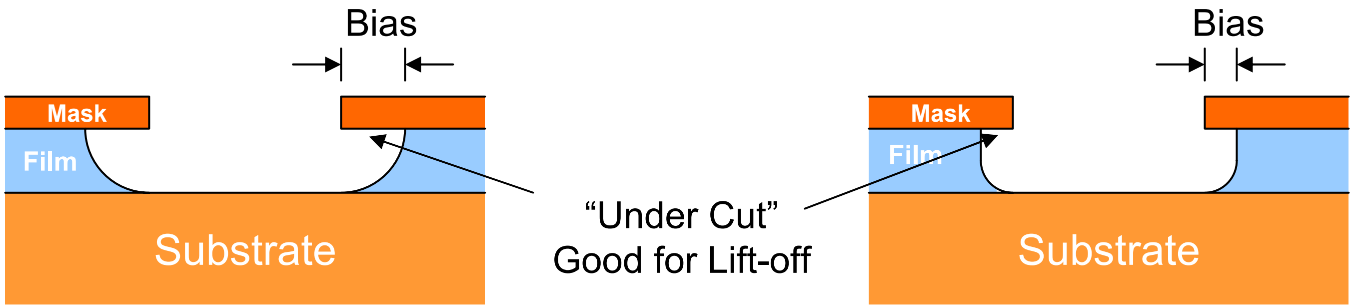


$0 < R_L < 1$



$R_L = 0$

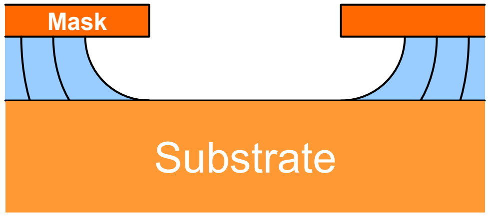
“Under Cut” and “Over Etch”



“Under Cut”
Good for Lift-off

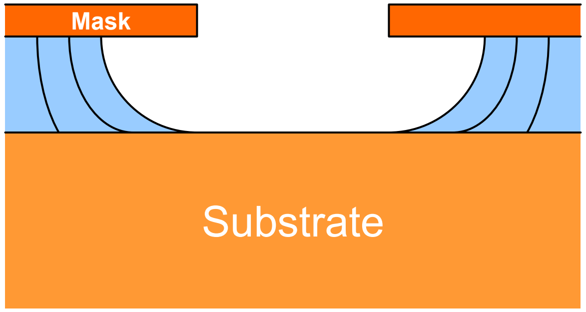
(R_l = 1, pattern dimension
is poorly defined)

(R_l = 0.5, pattern dimension
is better defined)



Over-Etch

➥ results in more vertical profile
but larger bias



Worse in thick film

➥ Poor CD control in
thick film using wet etch

Mask Erosion: Film-Mask Etching Selectivity

1) film horizontal etch rate (r_{fh}) < mask horizontal etch rate (r_{mh}):

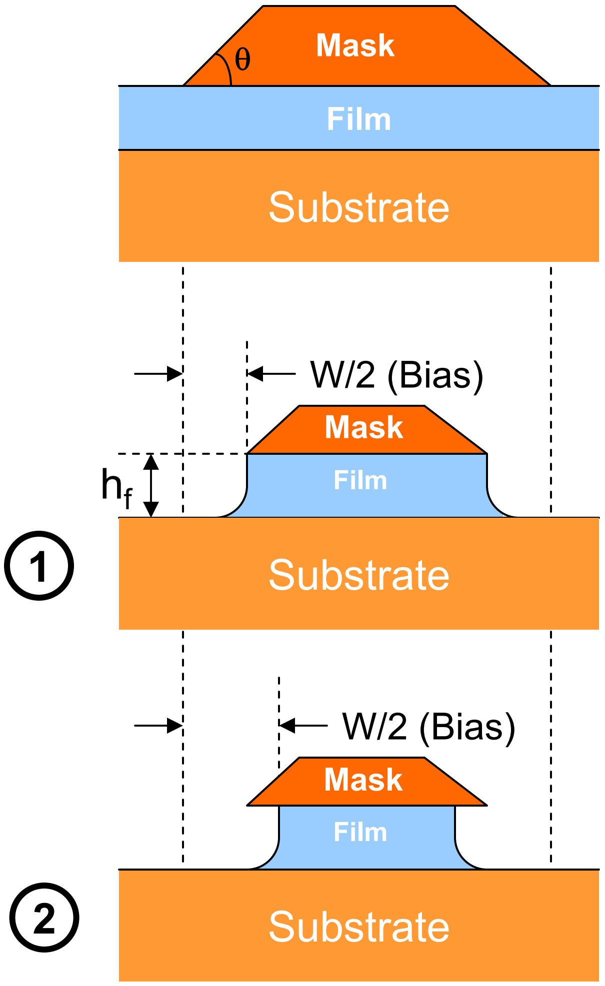
$$\frac{W}{h_f}(\%) = \frac{2}{S_{fm}}(\cot\theta + R_m)$$

$$R_{mL} = \frac{r_{mH}}{r_{mV}}$$ (mask lateral etch ratio)

$$S_{fm} = \frac{r_{fV}}{r_{mV}}$$ (ratio of film and mask vertical etching rate – **selectivity**)

2) If film horizontal etch rate (r_{fh}) > mask horizontal etch rate (r_{mh}):

$$\frac{W}{h_f}(\%) = 2R_m$$



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