

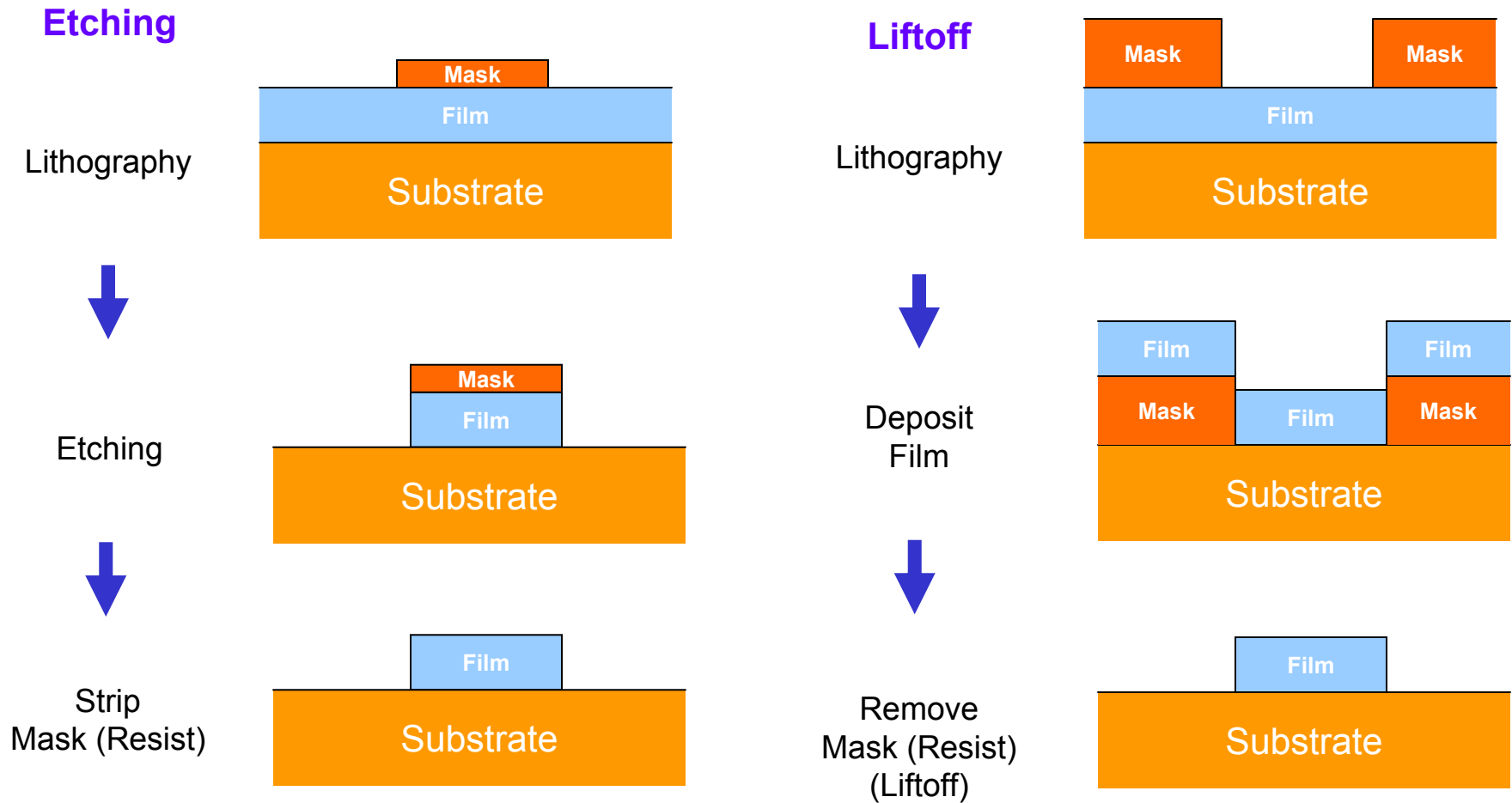
III. Wet and Dry Etching

	Wet	Dry
Method	Chemical Solutions	Ion Bombardment or Chemical Reactive
Environment and Equipment	Atmosphere, Bath	Vacuum Chamber
Advantage	<ol style="list-style-type: none">1) Low cost, easy to implement2) High etching rate3) Good selectivity for most materials	<ol style="list-style-type: none">1) Capable of defining small feature size (< 100 nm)
Disadvantage	<ol style="list-style-type: none">1) Inadequate for defining feature size < 1μm2) Potential of chemical handling hazards3) Wafer contamination issues	<ol style="list-style-type: none">1) High cost, hard to implement2) low throughput3) Poor selectivity4) 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



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:

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

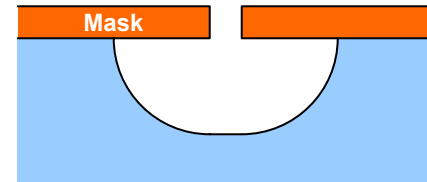
Isotropic Etching: $R_L = 1$

Anisotropic Etching: $0 < R_L < 1$

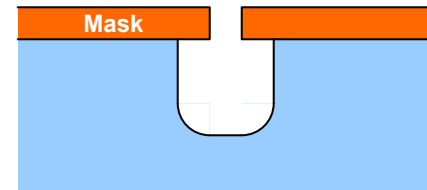
Directional Etching: $R_L = 0$

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

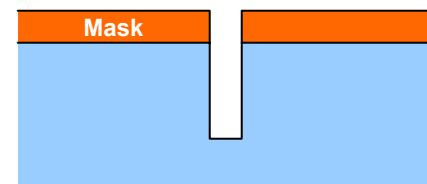
➔ smaller R_L results in smaller bias



$$R_L = 1$$



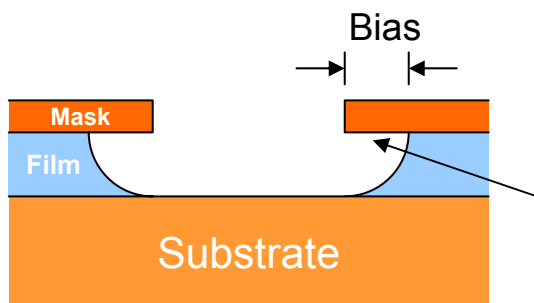
$$0 < R_L < 1$$



$$R_L = 0$$

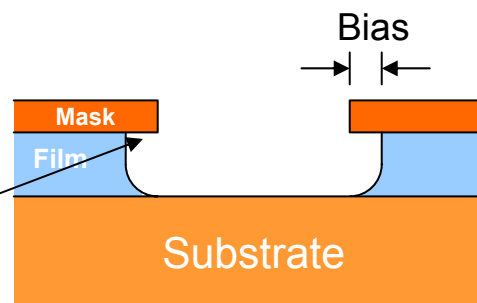


“Under Cut” and “Over Etch”

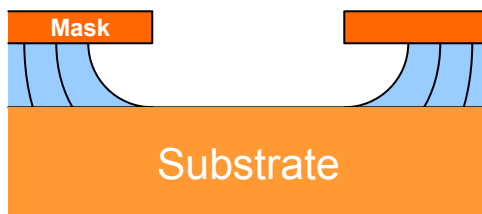


($R_f = 1$, pattern dimension is poorly defined)

“Under Cut”
Good for Lift-off

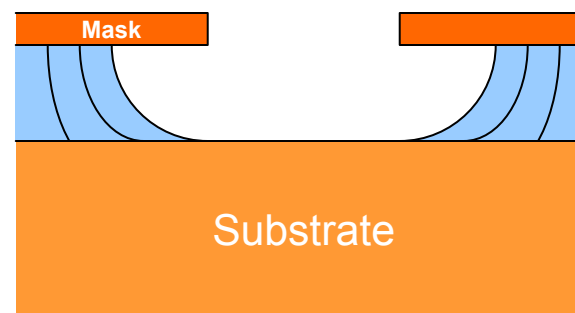


($R_f = 0.5$, pattern dimension is better defined)



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}):

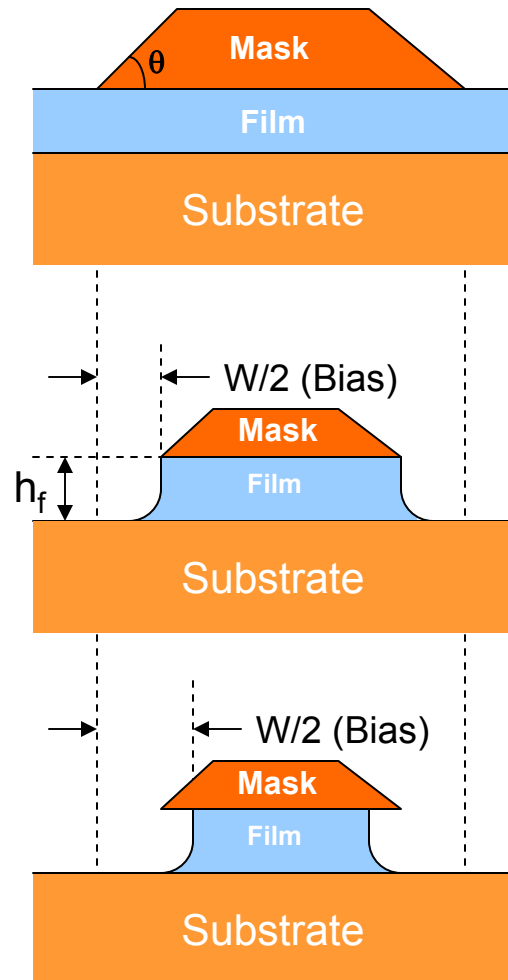
$$\frac{W}{h_f} (\%) = \frac{2}{S_{fm}} (\cot \theta + R_m)$$

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

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

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

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



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