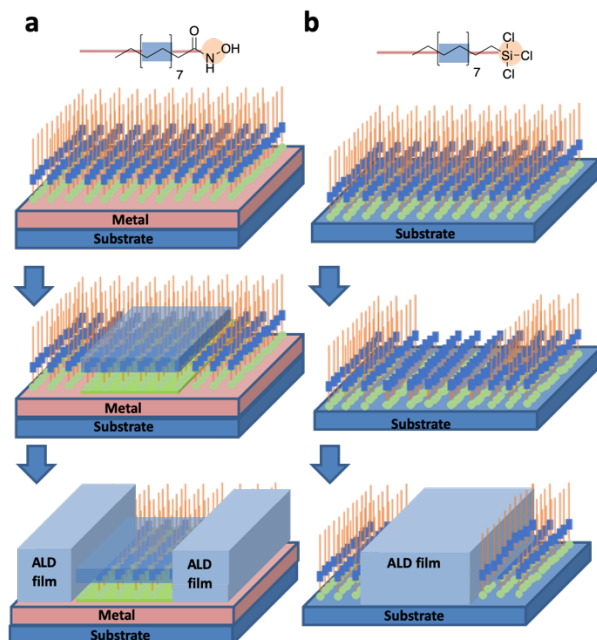


## Emerging Concepts in Patterning Science – Monolayer Lithography: Exploiting Inhibition Contrast from the Extreme Ultraviolet Irradiation of Organic Monolayers for Area Selective Depositions

The enablement and miniaturization of technologies, such as electronic devices, are largely dependent on patterning materials. For instance, polymer resists can be used to create a broad range of desired feature geometries that continue to extend the capabilities of nanoscale fabrication at a remarkable rate. The 7nm technology node, which is reliant on extreme ultraviolet exposures ( $\lambda = 13.5\text{nm}$ ) exposures, may still rely on chemically amplified resists (CARs) from previous technology nodes. However, at critical dimensions (CDs) and below, CARs reveal increasingly difficult challenges to achieve the resolution and line edge roughness demanded by future technology generations. These include: the low absorbance of organic polymeric materials can lead to low aerial image contrast and may require higher dose exposures that reduce throughput. An alternative bottom-up approach to patterning using an organic monolayer and subsequent area selective deposition technique that can be tuned to a positive or negative-tone image generation. The method of aerial image generation in monolayer lithography takes advantage of two processes that can be used to build contrast in image development as the sensitivity of the organic itself is not alone sufficient for high contrast imaging: (i) removal of a desired organic material after exposure and (ii) a post exposure area selective deposition. These organic materials exhibit a non-linear relationship in a subsequent area selective deposition (ASD) image development step using atomic layer deposition (ALD), a key component for the development of a high-resolution system. This approach provides a method that utilizes the thinnest possible organic material and a pattern development step that produces an effective etch mask for pattern transfer.



**Figure 1:** Schematic representations of monolayer lithography with two different tones based only on changes to head group chemistries (a) a positive tone system that utilizes a hydroxamic acid head group and selective growth is confined to unexposed regions (b) a negative tone system based on a trichloro-silane head group where selective growth is confined to exposed regions.