Exploring the manufacturability of using block copolymers as resist materials in conjunction with advanced lithographic tools

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In the photolithographic process, information encoded in the aerial image of the exposure tool is transferred to the photoresist through a series of processing steps that culminate in the creation of patterned three-dimensional features. As feature dimensions shrink below 30 to 50 nm, however, the fidelity of the transferred information using current resists may not meet manufacturing requirements, particularly with respect to control over the size and shape of the patterned features (e.g. critical dimension control and line edge roughness). We are investigating the integration of self-assembling block copolymers into the lithographic process such that the materials themselves contribute valuable information towards the desired ends. At the same time we aim to retain essential process attributes such as pattern perfection, registration and the ability to pattern non-regular device-oriented structures.

Our approach is to lithographically define chemically patterned surfaces to direct the assembly of overlying films of block copolymers and block copolymer/homopolymer blends (see Figure 1). Previously we demonstrated that through tailored interfacial interactions, it is possible to pattern sub 25 nm features with perfection and registration [1, 2] and with thermodynamic and precise (sub 1 nm) control over their dimensions and shapes [3]. Here we show that through this approach, almost the entire set of essential features required for integrated circuit fabrication (as defined by the semiconductor industry) can be created (see Figure 2). Furthermore, we also have optimized the directed assembly of block copolymers such that the processing time is similar to a post exposure bake (~1-2 minutes), shown that it is possible to assembly features with very high aspect ratios(>5), nd adelineated design parameters for the materials with respect to pattern transfer properties.

1. Kim, S. O. et. al., Nature, Vol, 424, (2003), pp. 411-414.
2. M. P. Stoykovich et al., Science, Vol. 308, 3 June (2005), pp. 1442-1446.
3. Edwards, E.W., et. al., Macromolecules, Vol. 40, (2007), pp. 90-96.

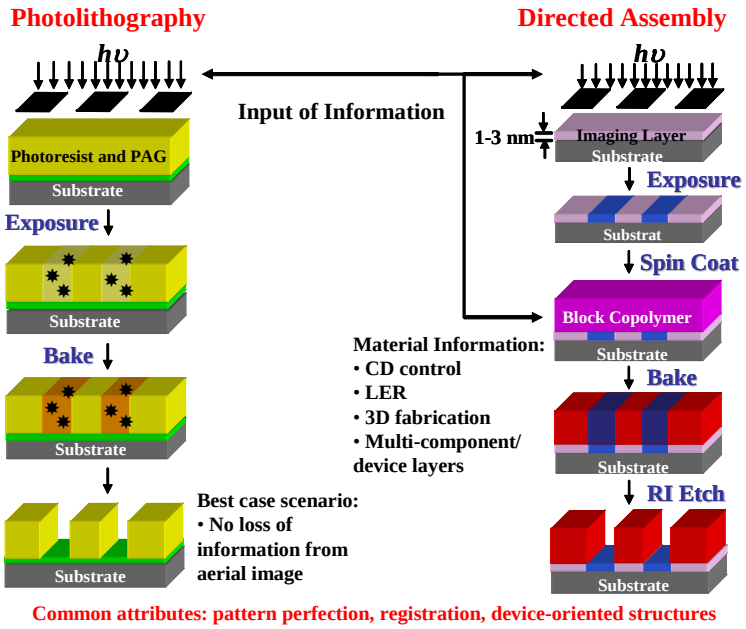

Figure 1. Comparison of the processing of chemically amplified resists and block copolymer resists in advanced lithography.

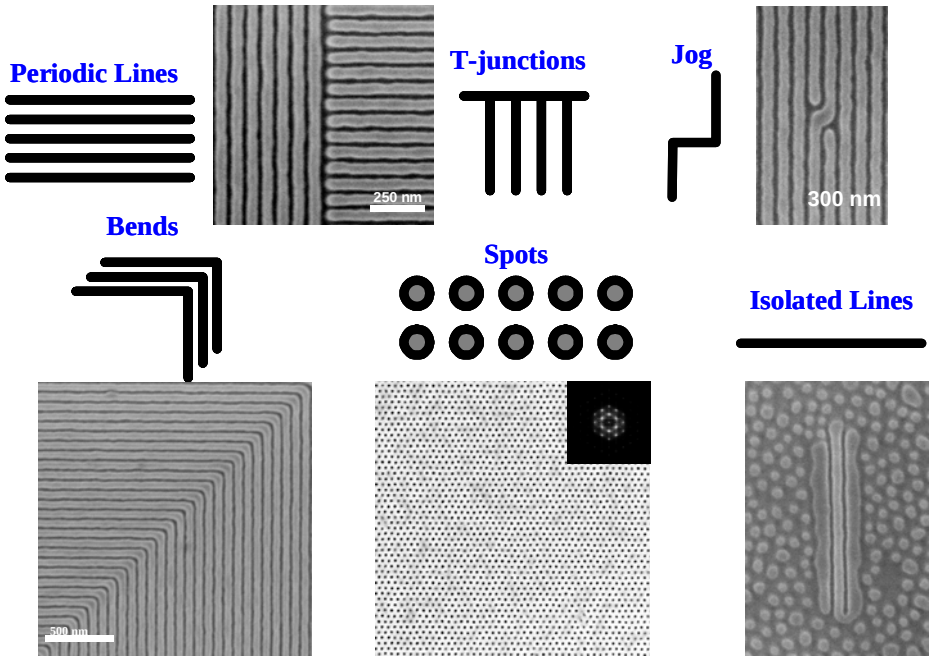

Figure 2. Directed assembly of features used in the fabrication of integrated circuits.