Templated DSA vias in sub-7 nm circuits: Design strategy and DSA-aware via decomposition

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In recent years, major advancements have been made in the directed self-assembly (DSA) of block copolymers (BCPs). As a result, the insertion of DSA for IC fabrication is being actively considered for the sub-7 nm nodes. At these nodes the DSA technology could alleviate costs for multiple patterning and limit the number of lithography masks that would be required per metal layer. One of the most straightforward approaches for DSA implementation would be for via patterning through templated confinement of cylindrical phase BCP materials (Fig. 1).

Our studies show that decomposition of via layers with 193 nm immersion lithography in realistic circuits below the 7 nm node would require a prohibitive number of multi-patterning steps (Fig. 3). Even the use of EUVL would require double patterning below the 5 nm node. The grouping of vias through templated DSA can resolve local conflicts in the high density areas. This translates to a significant reduction of the maximum number of colors for immersion lithography. On the other hand, it enables the extension of the single patterning scheme for EUV Lithography.

To implement this approach, a DSA-aware mask decomposition is required. In this study, a design method for the integration of DSA via patterning in sub-7 nm nodes is discussed. We present options to expand the list of DSA-compatible via patterns (DSA letters). Additionally, we define cost formulas and we develop a tool for the optimal DSA-aware layout decomposition (Fig. 2). This method is tested on a fully routed processor, demonstrating a reduction of up to four lithography masks, when compared to conventional non-DSA-aware decomposition (Fig. 3).

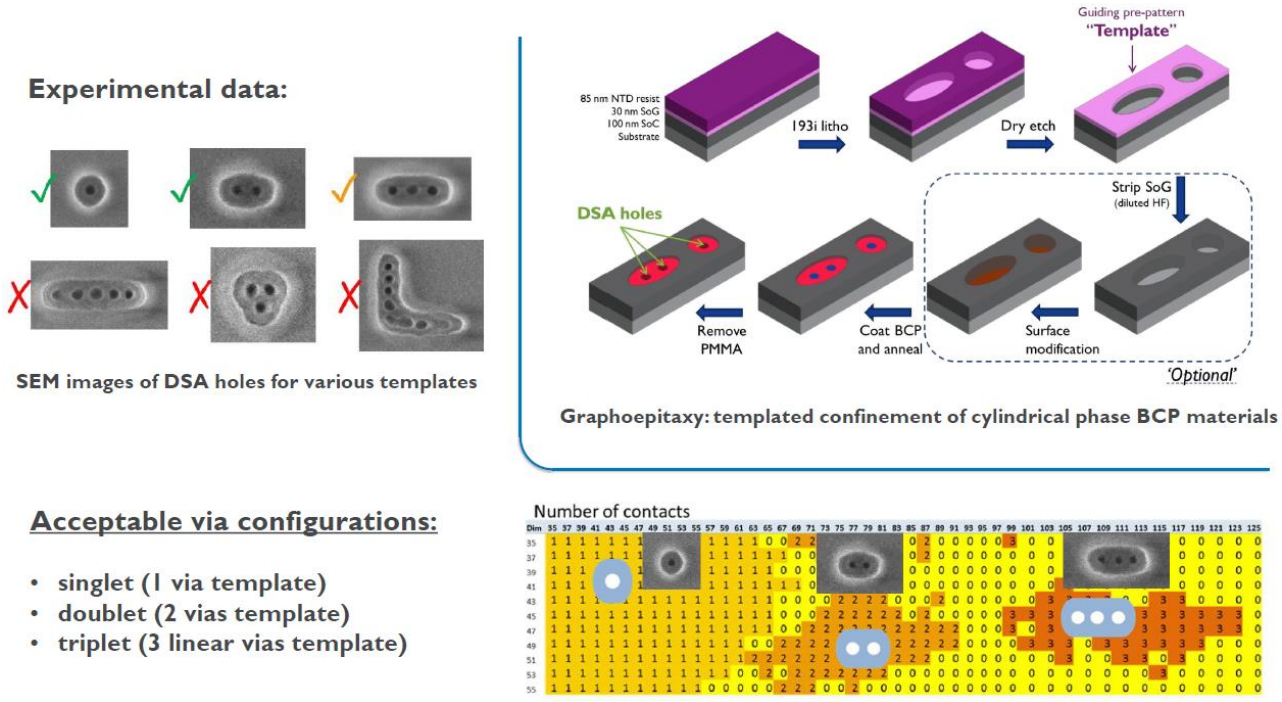

Figure 1: imec templated DSA via flow

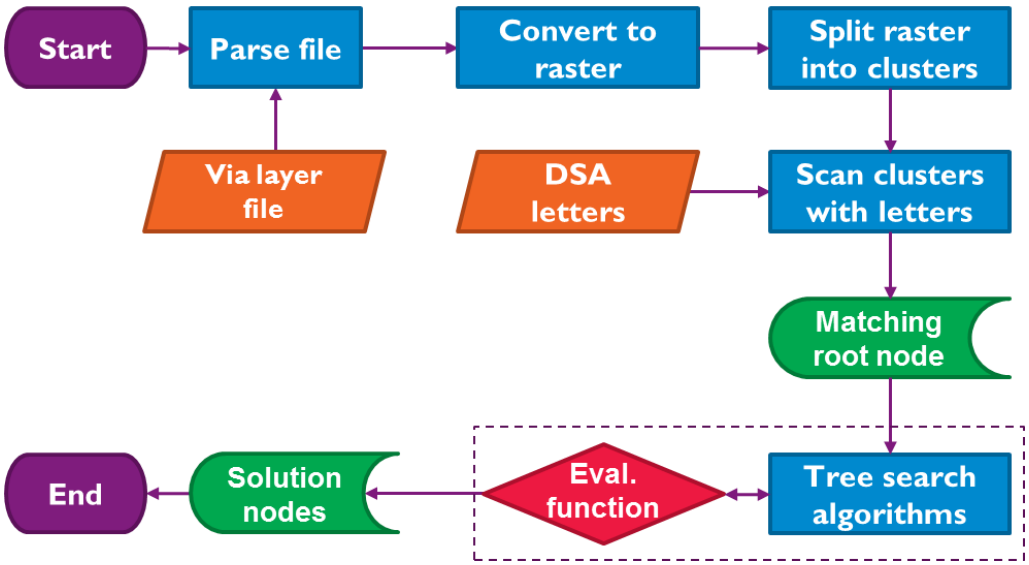

Figure 2: DSA-aware via layout decomposition tool

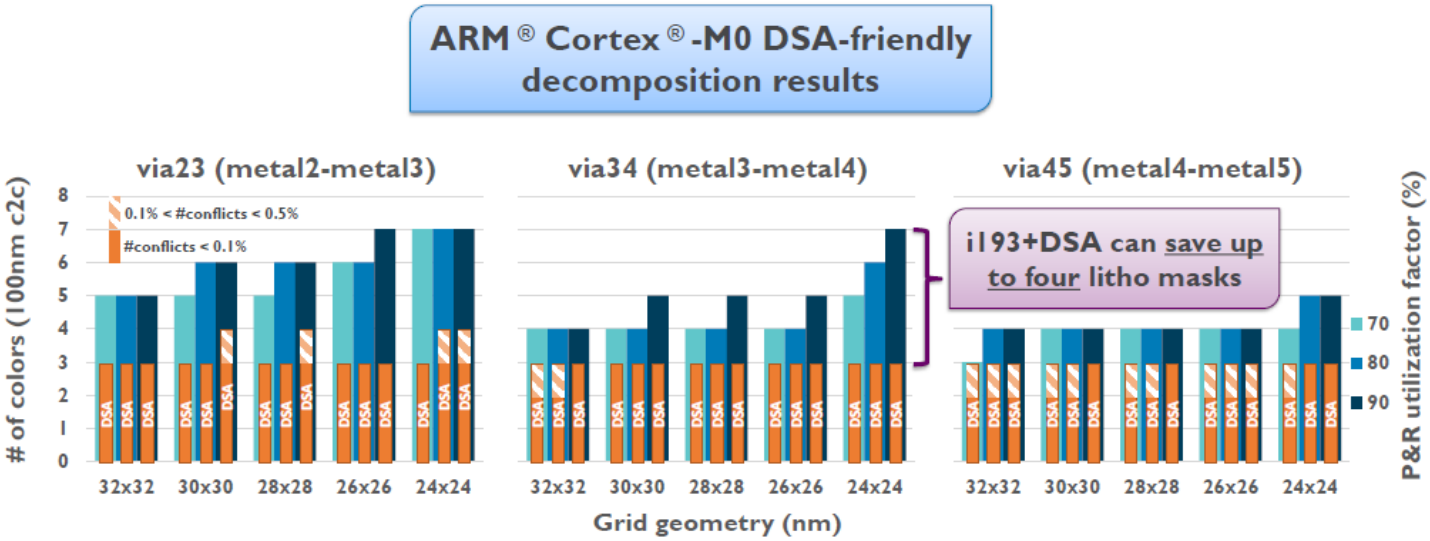

Figure 3: ARM Cortex-M0 via decomposition results. Comparison of conventional (turquoise/blue/dark-blue bars) vs DSA-aware (orange bars) decomposition

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