Defectivity Solutions for Topcoat-Free Photoresists at the 22nm Node

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The addition of topcoats to chemically amplified photoresists has been known for many years[1] and is a critical material used for immersion lithography. The focus of these materials has been controlling the diffusion of resist components in and now out of solution. Recent advances in immersion lithography have required topcoat materials to not only protect the photoresist but the exposure tool as well. These topcoats have assisted in improvements in defectivity through limiting the leaching of critical components out of the resist, along with controlling the advancing and receding contact angles during the imaging scan. Over the past four to five years, material suppliers have been able to provide these types of advanced topcoat solutions that not only have quenched leaching concerns, but have also reduced defectivity levels of immersion processes to make them similar to those of dry processes[2].

The same surface property characteristics that are applied to advanced topcoats are also used in topcoat-less resist development. The main challenge for topcoat-less resists is increasing the hydrophobicity of the resist surface without causing too much inhibition at the resist surface – which can lead to bridging or residue defects. Topcoat-less resists may include additives that prevent water penetration and will increase the solubility of the surface after exposure in order to prevent defects. The key to such a design is in the balance between leaching control versus dissolution characteristics of the resist. Much like topcoat designs, it is critical that the surface of the resist is not too hydrophobic which leads to lack of performance and increased defectivity.

The industry has incorporated this new knowledge, as well as learning from previous programs, and applied it to next generation immersion materials[3]. The addition of materials into existing ArF photoresists systems have been shown to modulate the contact angle in water-based immersion lithography. The focus of this work is to understand the relationship between contact angles (advancing and receding) and the resulting defectivity of topcoat-less immersion photoresist systems. The authors have focused this work on the reduction of defects to achieve defectivity levels that are equal to or better then existing systems. An assessment of the industry's progress and a future outlook will be provided.

References

1. US Patent # 5,240,812
2. Hiroki Nakagawa et al., "Improvement of Watermark Defect in Immersion Lithography: Mechanism of Watermark Defect Formation and its Reduction by Using Alkaline Soluble Immersion Topcoat", Proc. of SPIE, 6153-64 (2006)
3. US Patent # 7,217,496