Sub-millisecond Post Exposure Bake of Chemically Amplified Resists by CO_2 Laser Spike Annealing

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Pattern formation in a chemically amplified photoresist requires a post-exposure bake (PEB), typically on a hot-plate at 100-140°C for 30-120 seconds, to catalytically deprotect the polymer backbone. During this PEB step, diffusion of the photo-generated acid results in loss of line edge definition, blurring of latent images, and changes in the line edge roughness (LER). Both acid diffusion and deprotection are thermally activated processes, with the relative rates impacted by the time/temperature profile of the PEB. While hot plate PEB is limited to the seconds time regime, we have instead explored sub-millisecond PEB using a CO_2 laser-based scanned annealing system.

Laser spike annealing is primarily used for shallow junction formation following ion implantation. A scanned "line source laser" heats the surface to a controlled temperature (up to ~1400 °C), followed by a thermal quench into the bulk substrate as the line source passes. The profile of such spike anneals can be controlled by beam shape and scan speed between 50 μs and ~2 ms.

Several polymer and photoacid generator (PAG) resist systems have been studied under 500 μs spike annealing at temperatures estimated between 300 and 600°C. All of the resist systems exhibit remarkable stability at these temperatures – a direct consequence of the short thermal duration. However, while thermally stable, the maximum useful temperature is limited by thermal deprotection of the backbone. At lower temperatures, high-resolution patterns with sub-100 nm features are formed, comparable to a 130°C hotplate reference sample. Resist sensitivity (dose to clear) is impacted significantly for some resist systems while others are relatively insensitive to the PEB conditions. One ESCAP resist and triarylsulfonium hexafluoroantimonate salts (PAG) exhibited a 6-fold sensitivity enhancement under 365 nm exposure. Quantitative determination of the acid diffusion rates and activation energies were obtained using resist bilayers (PAG loaded / PAG free).[1] Independent control of the diffusion and deprotection groups using this high temperature regime may lead to sensitive DUV/EUV resists with higher resolution and improved line edge definition.

[1]Shuhui Kang *et al*., Proc. of SPIE, 6923, 692317-1 (2008)

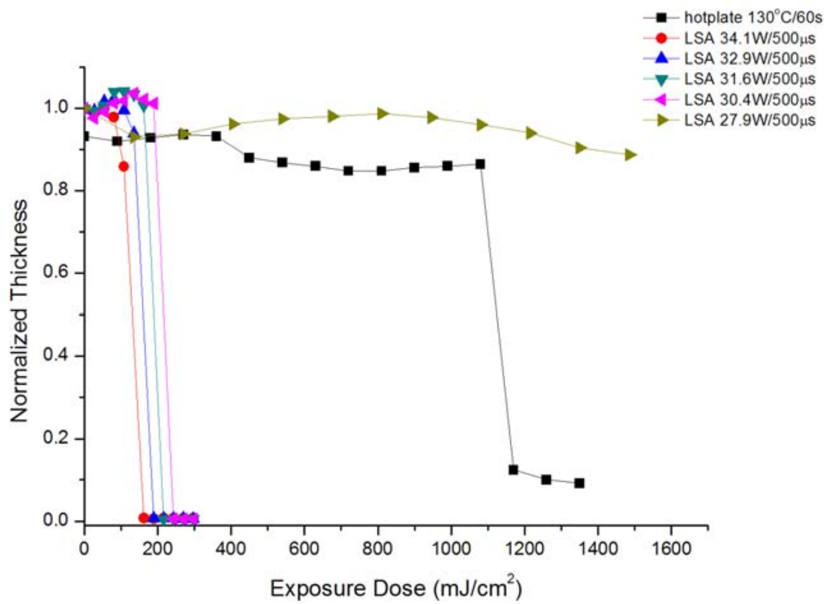

Figure 1: Contrast curves measured for ESCAP based resist under laser spike anneal at various temperatures (powers). Compared to the reference hotplate PEB, resist sensitivity in increased by almost a factor of 6.

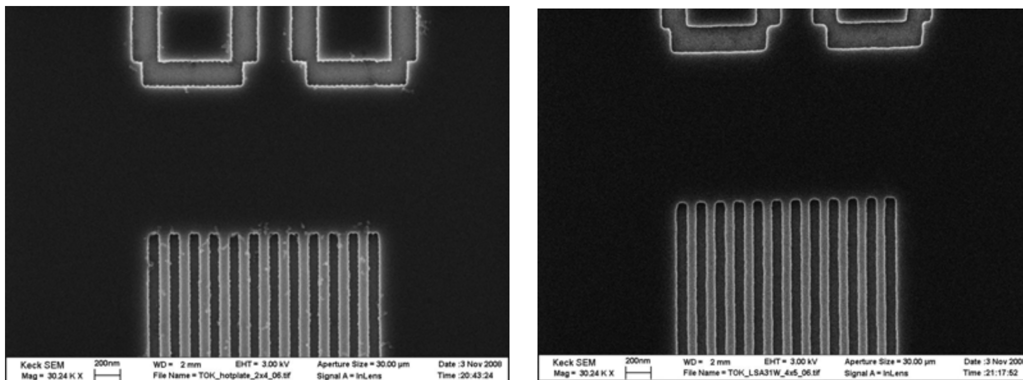

Figure 2: Comparison of 80 nm L/S patterns formed by conventional hotplate PEB (left) and 500 µs laser spike anneal (right).