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Smoothing EUVL mask substrate defects with an emphasis on real-world pits.

Paul B. Mirkarimi[a], Eberhard Spiller[a], Sherry L. Baker[a], and Jeffrey C. Robinson[a], Farhad Salmassi[b], Seh-jin Park[c], Ted Liang[c], Alan R. Stivers[c], and Erdem Ultanir[c].

a) Lawrence Livermore National Laboratory, Livermore, CA. 94550
b) Lawrence Berkeley National Laboratory, Berkeley, CA. 94720
c) Intel Corporation, Santa Clara, CA. 95052

For EUVL mask blanks, small particles or pits on the substrate which can nucleate printable Mo/Si phase defects are a very serious concern. We have developed a process for mitigating the effect of small substrate defects that relies on sequentially depositing and etching silicon layers to reduce the height or depth of the resulting defect to approximately 1 nm, below the EUVL printability threshold. It has been observed that on incoming state-of-the-art mask substrates, pit defects dominate. These real-world pits have aspect ratios << 1, making them more challenging to smooth; they tend to be roughly 18 nm deep and 100 nm wide. We have advanced our smoothing process to reduce the depth of these low aspect ratio pits to < 1 nm, rendering them noncritical; this has been achieved with a process time of less than two hours (not including mechanical motion). We are close to being able to simultaneously smooth these pits along with 50 nm particles and expect to report that this has been achieved at the time of the symposium. We also plan to show results from the application of the smoothing process to real-world pits and particles on state-of-the-art mask substrates.

It is not certain yet whether the smoothing process, which relies on sequential coating and etching, will be made clean enough for mask manufacturing (this effort is beginning in earnest at Albany). Therefore it is of interest whether pit defects can be sufficiently smoothed without etching, i.e., with just the coating process steps. We shall present results showing that under a variety of process conditions it was not possible for us to smooth relatively small pits, i.e., 9 nm deep by 100 nm wide, to a noncritical size without etching.

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