Improving registration metrology by correlation methods based on alias-free aerial image simulation

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ABSTRACT

The increased industry requirements for pattern registration tools in terms of resolution and in-die measurement capability lead to the development of the new photomask registration and overlay metrology system PROVE™ at Carl Zeiss. Performance measures of the tool are actually driven by double exposure/ double patterning approaches which will help to extend the 193nm lithography platforms while keeping the semiconductor industry conform to ITRS roadmap requirements. To achieve the challenging specifications, PROVE™ features beside a highly stable hardware system new image analysis methods which are designed to meet the requirements both for standard markers as for in-die features.

For that, in addition to conventional threshold-based image analysis, PROVE™ will provide a more accurate correlation analysis to measure pattern placement errors with respect to design images. This correlation is based on an aerial image simulation of the corresponding reference design patterns. Since reproducibility and accuracy specifications at camera level are far below the pixel size of the CCD, sophisticated algorithms have to be used to avoid super-pixelling effects. It will be shown that super-pixelling effects of discretized design images will either lead to placement errors or to unrealistic small design pixel dimensions, connected with huge image sizes. The solution is an alias-free forward transform that performs the discretization in Fourier space and will not disturb the pattern placement. It is indicated by simulations that this allows the detection of an arbitrary sub-pixel placement error with high accuracy. Furthermore, it is demonstrated that correlation methods reduce the impact of camera noise compared to threshold methods, in particular for small in-die features as contact holes.

Keywords: photomask metrology; registration; pattern placement; aerial image simulation; image analysis; super-pixel effects