Image Processing Using Shape Recognition for Alignment to Damaged Registration Marks in Electron Beam Lithography

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Highly scaled FinFET SRAM cells of area down to 0.128 um^2 were fabricated using all e-beam lithography to demonstrate the scalability of FinFET technology /1/. The solution to resolve alignment challenges involved in these aggressive lithography levels required the application of a novel image processing technique to locate the damaged alignment marks. The achievable overlay using traditional registration hardware and software is ultimately limited by the quality of the registration marks and any changes in the registration signals caused by device process steps between overlay critical exposure levels. This paper discusses the details in the shape locate algorithm and results achieved for the device program.

A Vistec Vectorbeam electron beam lithography tool has been equipped with an integrated mark locate capability based on optimized image acquisition and the Cognex PatMax image-recognition software. This system is more fault tolerant than line-scan contrast-threshold searching, successfully coping with scale changes, multiple contrast bands, missing sections of the mark edge or other damage. It is also significantly faster and more accurate in the case of process-induced asymmetry than full-image correlation techniques.

The system is capable of locating geometric shapes in images of registration marks, even in the presence non-uniform damage across the area of the marks. Using simple geometric shape templates or images of template marks, the shape locate system finds the position of the template (shown in Fig 1a) within a registration mark image as is shown by the outlined area in Fig 1b.

We will show the application of this shape locate system in registered write electron beam lithography for 32 nm node and beyond device programs, fig.2. The shape locate mark registration system has been found to be significantly more tolerant of mark damage than either line-scan or image-correlation techniques. The use or re-use of existing alignment features removes the need for several additional process steps otherwise required to re-create high-quality registration marks, and leads to significantly reduced cycle-time and cost.

/1/ H. Kawasaki et al., IEDM Tech. Dig. pp. 237-240, 2008

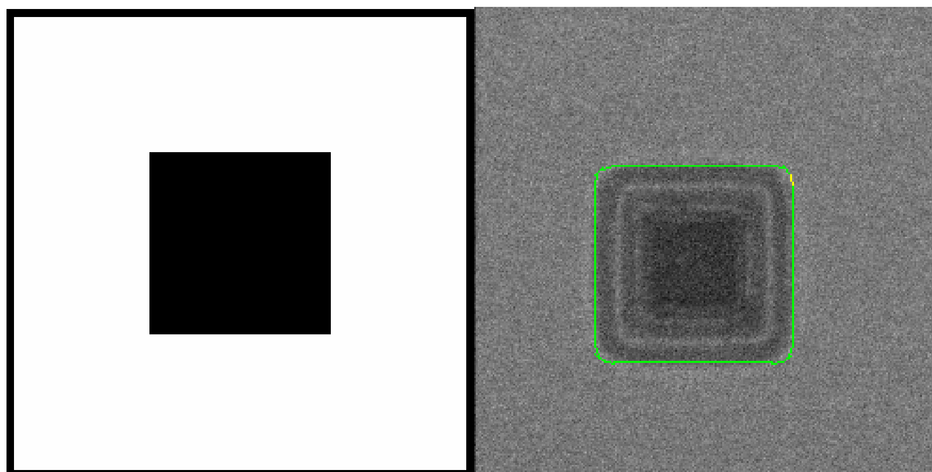

Fig. 1. Template image (left) and BSE image (right) of a registration mark. The shape locate registration software finds the mark position of the original 2 x 2 um^2 etched mark as outlined.

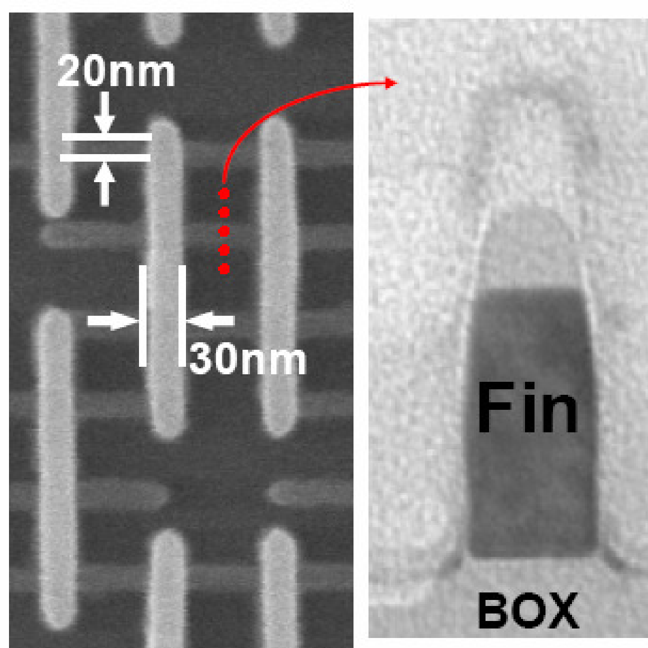

Fig. 2 SEM (left) image and TEM (right) image of FinFET devices after gate stack formation