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Capturing Die Layout of Obsolete ASIC Using Extreme Field of View SEM.

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Recently extreme field of view (XFOV) imaging has become available for scanning electron microscopy (SEM) images across a variety of platforms. Assembly of multiple, high-resolution, high magnification images into Giga-pixel size arrays can now be accomplished with accuracy. The technique recently allowed capture of 32x32 Giga pixel images of brain tissue either with transmitted or back-scattered electron imaging [1, 2]. It had also been previously applied at much smaller scale in materials research for crack plastic zone evaluation [3], corrosion studies [4], and ceramic materials research [5]. In these materials studies few images (<10) were either manually assembled or a dedicated software and stage control solution from microscope vendor was used to handle larger data sets (<100). In this presentation, we report on application of the technique to evaluate layout and functionality of microelectronic devices. We present an example acquired from an obsolete application specific integrated circuit (ASIC) device with semiconductor die size of 10x10mm. This work was conducted for the purpose of documenting and recreating the device layout and behavior. The data set required to image the whole area of the device with ~10nm resolution results in approximately 10,000 images per layer of interconnects. Images from multiple layers of the device were acquired. The images from each layer required nearly 100GB of storage capacity.

Image acquisition was facilitated through build-in scripting facility of an FEI microscope. A script was used to direct the system's main sample stage to travel in serpentine fashion across the desired field of view and to capture SEM images that had slight overlap to facilitate cross-correlation and assembly. An example of script work flow is shown in Figure 1. The resulting 4000x4000 pixel images can be stored on either network attached storage appliance or sent over internet to web server running assembly and presentation software. The resulting image collage, or XFOV image, can then be displayed using dedicated web-pages allowing for overlay of multiple layers, design data, zoom functionality, and annotations. The web-page image collection is essentially an XFOV, Giga-pixel image viewer [6]. Single assembled layer is illustrated in the example in Figure 2.

Once the data set is assembled into a XFOV image, processing can be applied to that composite image at once. In the example shown in Figure 2, we used Smart Imaging Technology's ChipInsight™ to recognize specific semiconductor device features such as metal interconnects and vias. These proprietary image processing algorithms were developed for analyzing secondary electron SEM images. The ChipInsight XFOV can produce GDSII format files of the metal, via or other layers for use in re-engineering, patent infringement or obsolete IC re-generation [7]. The ChipInsight functionality was also developed to facilitate mask error review and assist in evaluation of success of proximity correction algorithms for immersion and extreme-UV masks used in modern semiconductor manufacturing.

Similar Giga-pixel images could be generated with BSE signals to capture whole cross-sections of spent nuclear reactor fuel rods [8], corrosion coupons, or whole slides of biological tissue sections for contrast phase analysis currently evaluated by montage of optical microscopy images.

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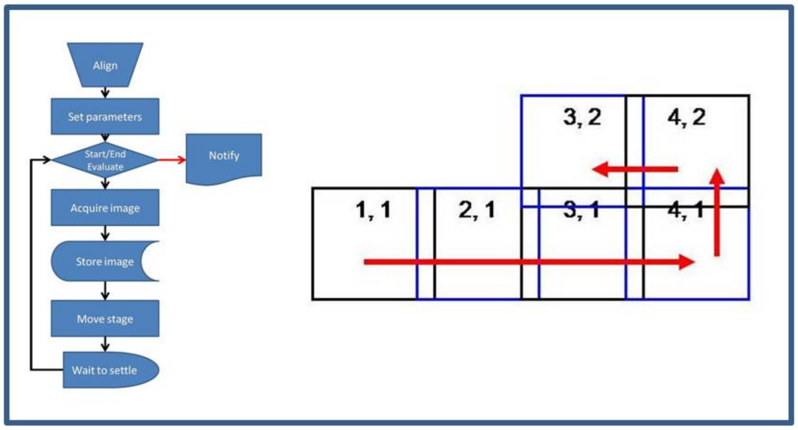

Figure 1. Image capture script flow-chart and a serpentine image capture path.

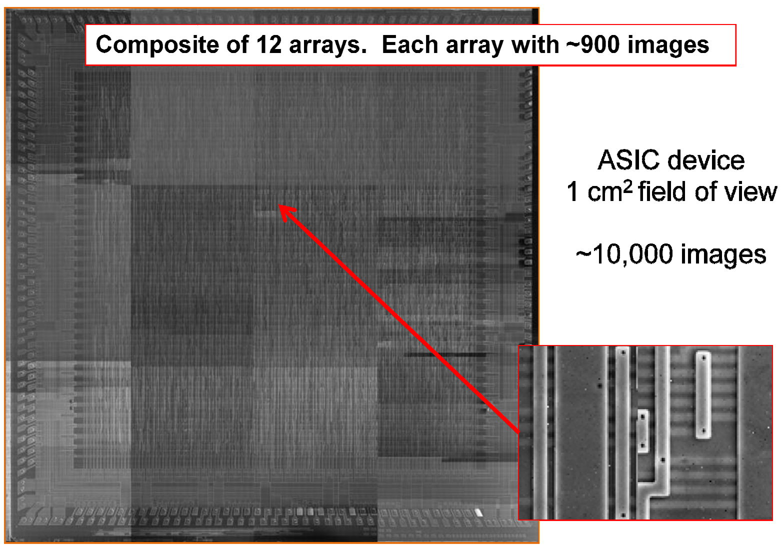

Figure 2. Extreme-field-of-view (XFOV) scanning electron composite image of an ASIC device. It is composed of 12 image arrays, with ~900 images each, assembled into Giga-pixel image with ~10,000 SEM micrographs taken with 2 um field-of-view and ~10nm resolution.

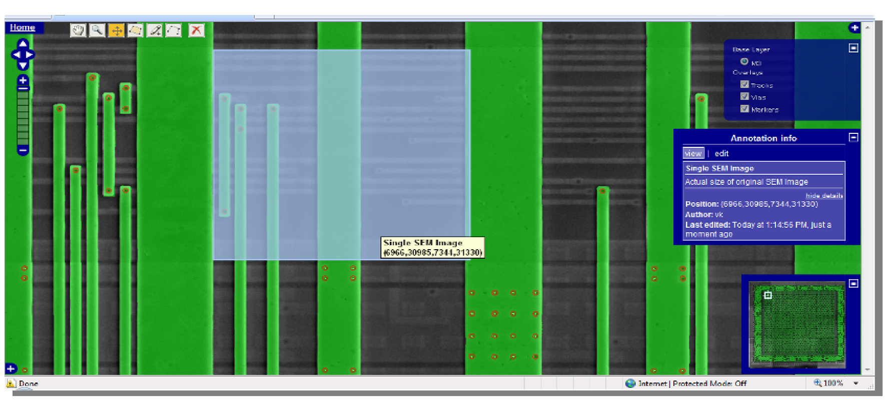

Figure 3. Screen capture of image analysis software used to extract features from Giga-pixel SEM composite with an overlay of tracks and vias auto-recognized in the interconnect structure.

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