

A 331-Beam Scanning Electron Microscope

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The continuous shrink of semiconductor patterns imposes many challenges on the fabrication of semiconductor devices, not only on the patterning process itself, but also on the inspection of these patterns. The required resolution is becoming increasingly difficult to achieve with current optical inspection techniques. Inspection technologies based on scanning electron microscopy (SEM) can resolve the relevant patterns and defects but have not been able to achieve the throughput requirements for screening large areas yet. This article reports on a 331-beam SEM that increases the throughput of existing multi-beam technology by another factor of more than three.

Recently, we have reported on a multi-beam SEM that uses 61 parallel electron beams in a single column [1] and its extension to 91 beams [2]. The setup of this multiple beam electron microscope (Figure 1) has been described in detail in [1].

The existing multi-beam SEM architecture allows for the extension from 91 beams to 331 beams by exchanging few parts only. These include an upgraded multi-beam generator for 331 electron beams, as well as adding more detectors and image acquisition units.

Figure 1 also shows an image of the 331 beams at the detector plane, demonstrating that the existing electron optics supports an enlarged field of view (FoV) of 252 μm at the sample plane. The software operating the multi-beam SEM is parametrized by the number of beams. Thus, the 331-beam system can be operated with the standard software.

Figure 2 shows a snapshot of a de-processed integrated circuit using the standard user interface of the ZEN imaging software that is commercially available for the 61-beam and the 91-beam ZEISS MultiSEM. At 5 nm pixel size, the entire set contains 1.7 Gigapixel and has been acquired in 0.6 s. The sub-image indicates that the beam parameter variation across the FoV is low.

References:

- [1] Eberle, A. L. et al., *J. Microsc.* 259, p.114 (2015) [doi:10.1111/jmi.12224]
- [2] Kemen, T., et al., *Proc. SPIE*, 94241U (2015) [doi:10.1117/12.2188560]

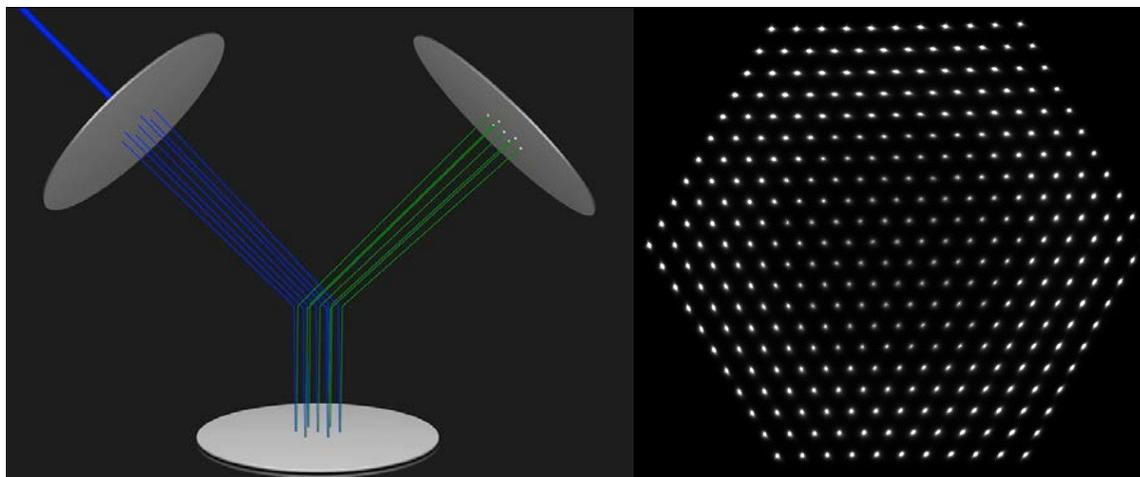


Figure 1. Left: schematics of the multi-beam scanning electron microscope. For simplicity, only seven beams are shown. Multiple primary electron beams (depicted as blue) are scanned within a single column in parallel over a sample (right image); one detector per secondary electron beam (depicted as green) enables parallel detection of all beams. Right: image of 331 secondary electron beam spots at the detector plane.

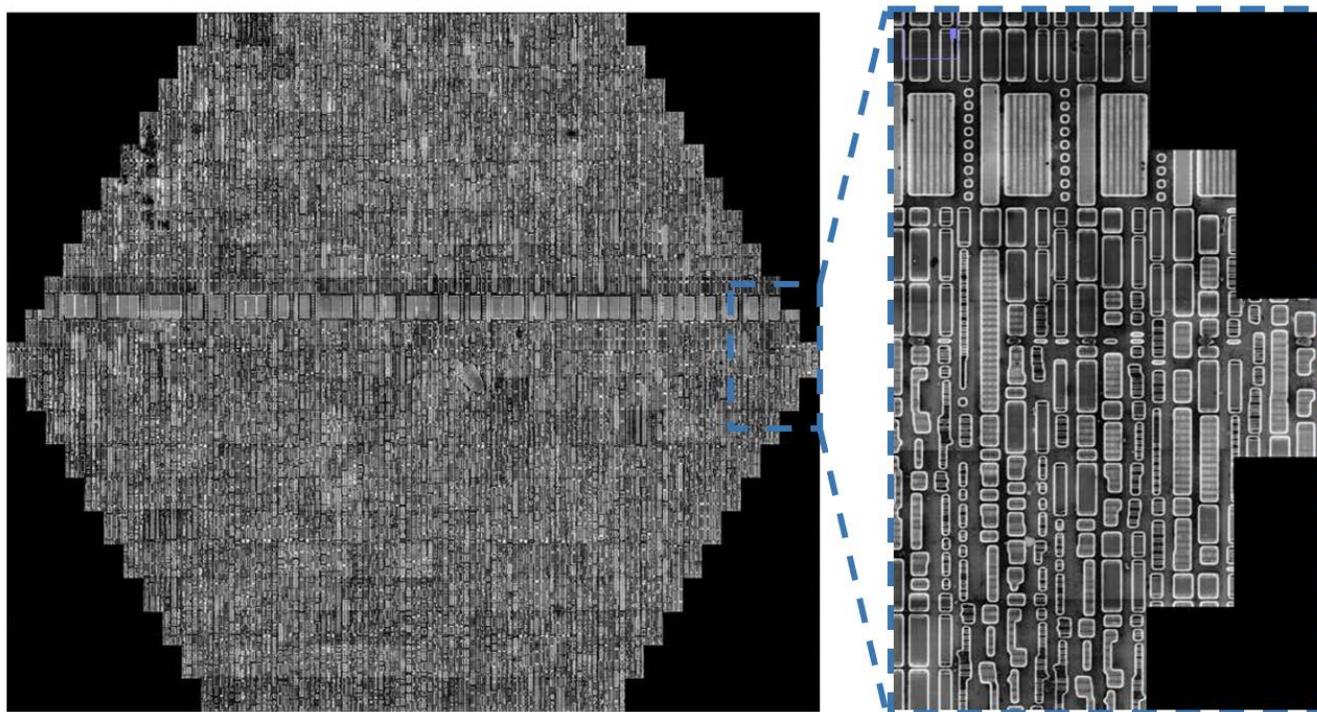


Figure 2. Left: image of a de-processed graphics processor acquired with the 331-beam SEM setup. The FoV size is 252 μm across the horizontal axis. Right: 27 μm x 45 μm sub-image of the full 331-beam multi-beam FoV.