Extending Multibeam SEM Technology to 331 Beams

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The shrink of semiconductor pattern size imposes many challenges on the fabrication of semiconductor devices, such as on the patterning process itself, but also on the inspection of the corresponding patterns. The required resolution is becoming increasingly difficult to achieve with optical inspection techniques. Inspection technologies based on scanning electron microscopes (SEM) can resolve the relevant patterns and defects, but have not been able to achieve the throughput requirements for screening large areas so far. We demonstrate a 331-beam SEM that increases the throughput of existing multi-beam technology by another factor of more than three.

We have reported on a multi-beam SEM that uses 61 electron beams in parallel within a single column [1] to bypass throughput limitations in electron beam inspection in the past already. We have also reported how to extend the number of beams to 91 [2]. The setup of the multiple beam electron microscope (fig. 1) has been described in detail in [1].

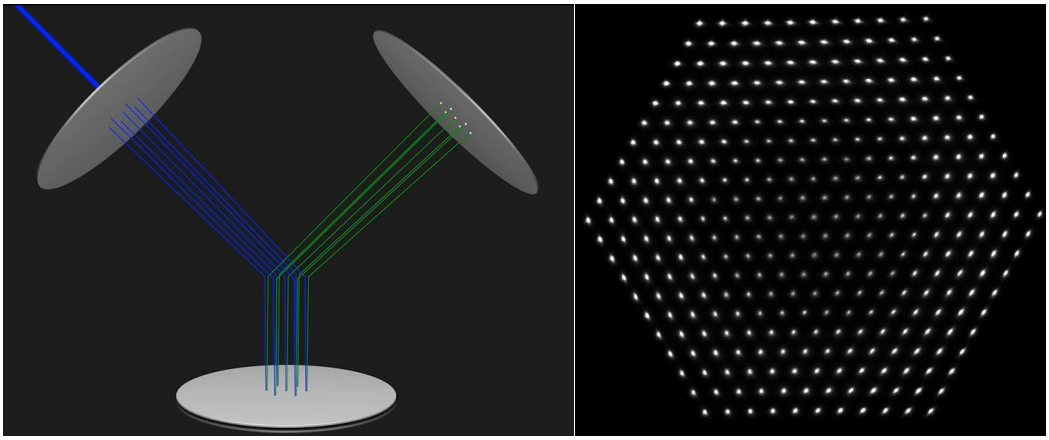

Figure 1: left: schematics of the multi-beam scanning electron microscope. We show only seven beams for simplicity. Multiple primary electron beams (blue) are scanned within a single column in parallel over a sample; one detector per secondary electron beam (green) enables parallel detection of all beams. Right: image of the signal from 331 secondary electron beams at the detector plane.

Exchanging a limited number parts is sufficient to extend the number of beams from 91 to 331 with the existing multi-beam SEM architecture. 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 a field of view (FoV) of 252 µm at the sample plane. The software operating the multi-beam SEM as well as the calibration routines are parametrized by the number of beams. Thereby, the 331-beam system can be operated with the standard software.

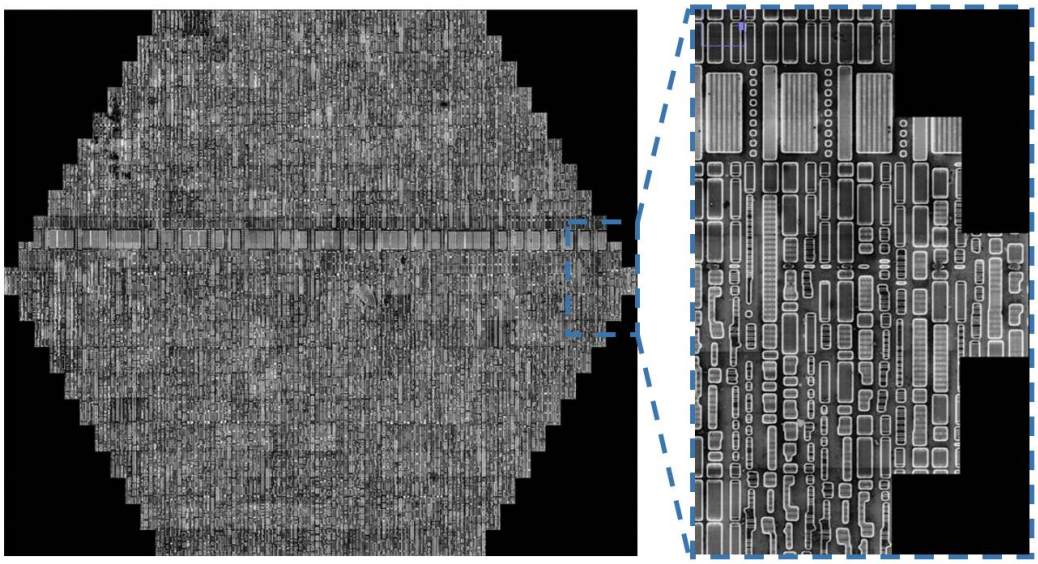

Figure 2, left: image of a de-processed graphics processor acquired with the 331-beam SEM setup. The FoV size is 252 µm across the horizontal axis. Right: 27 µm x 45 µm subset of the full 331-beam multi-beam FoV.

Figure 2 shows a snapshot of a de-processed integrated circuit. It has been acquired with the standard user interface of the ZEN imaging software of the 91-beam multibeam tool in 0.6s. At 5 nm pixel size, the entire set contains 1.7 Gigapixel. The beam parameter variation across the FoV is low, as can be seen in the sub-figure.

[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]