Touring the Factory in Holland that is Driving Moore's Law

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During the last week of October, I visited ASML's factory in Veldhoven, Netherlands, where NXE3400C EUVL scanners are being assembled. In this blog I will give you my impressions of the factory.

My visit to ASML was long overdue, as my last tour there was over 14 years ago. At that time, ASML was looking into building EUV sources, and I had toured their source research lab. The only EUV scanners in the field at that time were MET tools. Recently, while working on my new book, EUV Lithography Explained, a tutorial text to be published by SPIE press, I realized that it would be very nice to see the latest EUV scanner in person to get a first-hand impression, especially now that EUVL is in high volume production (HVM). The last EUV scanner I had access to was an alpha level scanner in Albany, and a lot has changed since then. As I was in Amsterdam to organize the EUV Source Workshop at ARCNL, it was good timing.

Sander Hoffman of corporate communications hosted me for the tour. Max Damen, the person incharge of the entire factory production, with a title of "Output Leader for the EUV factory," gave me and Sander a tour. He was a great guide, as he was very familiar with the manufacturing process and had access to all modules in the factory. We looked at various modules (parts of scanners) which were being assembled and observed one assembled NXE 3400C scanner (the latest version of an EUV scanner today), as well as a couple of older versions of the NXE3400. We toured the assembly room for projection optics and saw them in various stages of construction. In another bay, we saw the module for EUV mask. It was pretty cool that I was able to slide under the module with the engineering team lead and look at the new mask holder assembly for NXE3400C, surrounded by several turbo pumps (Fig. 1)! This mask module is going to print a lot of cool advanced chips in coming years and make a difference. So here I was looking at it as it was coming into existence – Wow! The tour ended with a demonstration of a completed and operating NXE3400C, which had side panels removed so we could look closely at various parts (Fig. 2). So here are my main impressions.

My major overall impression about ASML's campus was that it has grown considerably in the last 15 years. I got a great view from a tower of the new buildings that are coming up, with new construction for high NA modules visible in the background. Tools will be too large for current assembly rooms, so we will need rooms with higher ceilings – as was evident from buildings under construction. Yes, fabs will be needing new

buildings as well. I have seen photos from Zeiss on the very large chambers for metrology of these large mirrors, so I know it is a work in progress. High NA scanners will be assembled in these new buildings in the near future.

It was exciting to see that what some called a crazy science experiment with tons of wires and tubes, hanging around a huge chamber that had to be filled with hydrogen, has now turned into a very spiffy machine that is continuing to extend Moore's Law. I got to see a team of people at work who are producing almost two finished scanners a month, or ~ 24 a year. TSMSC just announced that in the 5 nm node they will use EUV for 14 layers, as compared to just five or six for the 7 nm node, and these machines are powering the innovation that reduces feature size and power consumption and ramps up the speed of computer chips.

My first main impression from the factory was how much the latest version 3400C has improved from the previous version in terms of a cleaner design and better serviceability. Max showed me the difference between older and newer versions of scanners, where serviceability has been greatly improved by having very organized wiring and assembly for lines – as compared to previous models which indeed looked like an experimental setup. One of the main benefits of this improvement has been reduced downtime and reduced time to repair. New doors have been added that allow one to access the collector mirror more readily; previously, a big part of the scanner had to be taken apart to exchange the collector. I also saw a new system for tin delivery that allows the user to add tin (in the form of solid tin bars instead of a liquid tin cylinder), without needing to depressurize the chamber. Droplet generator has been a major source of downtime for the scanner, so this will for sure help with tool uptime. It was very nice that I got to see first-hand the changes that will raise uptime to 90% or more!

My second major impression involved the size of a CO2 laser module. When a user is buying an EUV scanner, the biggest part by volume is not the scanner itself, but one of the biggest CO2 lasers that exist today. They are much larger than the scanner, but they appeared to be smaller than what I had imagined from the photographs of these modules. We did not know the power of these lasers, but I expect that they were able to supply 20 kW of CO2 laser power. The lasers and scanners were operational, and I was warned to be careful and not bump into any of those red buttons that shut down the lasers!

My last impression was the focused but relaxed, spacious and non-cluttered environment of the factory. I could see that they have space for modules to ramp up production to more than two scanners a month, which will be needed in coming years. I also very much appreciated the openness and willingness of my tour guide to let me climb around various modules and have a look at the assembly process. They also answered several of my questions about manufacturing.

Other news that I gathered at the factory: the next series of scanners after NXE3400 will be NXE3600, with throughput of >150 WPH. The new high NA scanners will have a new series name, EXE. I am still imagining their size from the photographs of HUGE optics that have been shared by Zeiss in the EUVL Workshops. I'll bet that tours of these scanners and future high NA scanners and what they can do at the forefront of technology today will excite many kids to join STEM programs, and become part of the teams of scientists and engineers that will continue the EUVL revolution in coming decades.

Sanders and Max were great hosts and I look forward to a future visit to their factory when High NA scanners will be getting ready. It is pretty exciting to imagine how big these machines will be, and how small the transistors that they will be able to print!