It's all about **particle control**

As Micro LED device sizes continue to shrink to just a few or even submicron proportions, so does the manufacturing yield due to unwanted particles in the same size range generated during processing. Evatec's Process Engineer, **Nino Crameri**, and Senior Strategic Marketing Manager, **Dr. Chongqi Yu**, remind us how the basic design concept for CLUSTERLINE® 200 BPM is already a great start for reducing particles and explain how the latest Evatec process know-how can deliver the excellent particle control performance required for high-yield mass production.

The CLUSTERLINE® 200 BPM – a proven workhorse in the LED industry

When the Batch Process Module (BPM) platform concept was first developed over 10 years ago and introduced to an emerging LED industry, the goal was clear – to deliver high deposition rates, low particle levels, and excellent single layer or stack thickness control and uniformity. At that time, customers were typically handling batches with small substrate sizes of 2- or 4-inches on carriers. The engineering and process team set about designing a solution without the use of uniformity shields typically required in deposition systems to manage uniformity, bringing two immediate advantages:

- Higher basic deposition rates
- Elimination of a major source of unwanted particles

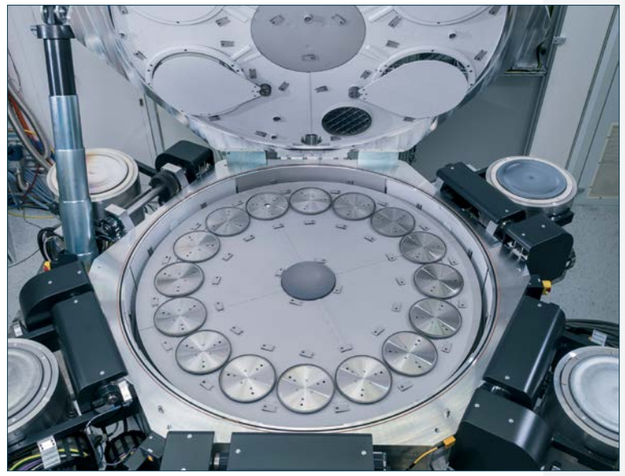
Today, Evatec's CLUSTERLINE® 200 BPM is already a proven workhorse for mass production in the LED industry. Fully automated "cassette-to-cassette" handling combined with batch module configuration processing up to 15 pieces of 8-inch substrates simultaneously make it an ideal starting concept for high throughput and low cost of ownership in mass production of Micro LED as well.

The latest generation of CLUSTERLINE® 200 BPM, integrating a turntable with individual rotating chucks, proprietary cathode magnet technology, and in-situ broadband monitoring, has become an industry-leading platform for mass production of the typical metals, TCOs and DBRs required, known for low-damage deposition on sensitive materials like GaN.

The latest results – Staying ahead of the game

Our customers need tighter and tighter particle specifications. Since the early times of 2- and 4-inch production, these days customers work more on 4- or 6-inch and we see a trend of manufacturers demanding process performance over 8-inch.

The same basic advantages of the BPM concept apply, but we need to work together with customers to optimize process technologies, especially as device sizes get smaller in the world of Micro LED. ITO is one of the most commonly specified materials. Work reported here therefore focuses on a typical, cold 40 nm ITO deposition process developed by our process specialists in collaboration with customers.



The latest generation of CLUSTERLINE® 200 BPM integrating a turntable with individual rotating chucks, proprietary cathode magnet technology and in-situ broadband monitoring.

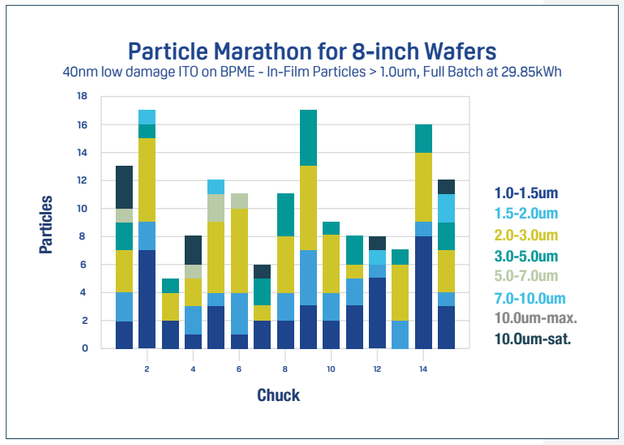


Figure 1: In-film particle levels larger than 1 micron per chuck.

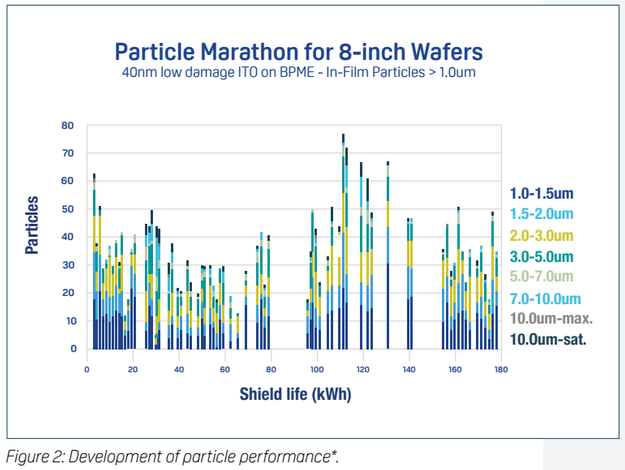


Figure 2: Development of particle performance.*

Variation from chuck to chuck

Comparison of particle levels between the 15 chuck positions of the BPM was measured as a baseline. Figure 1 shows "in-film particle levels" for particle sizes of 1 microns and above part way through target and shield life (at 30kWh) for each substrate position of the batch module turntable. We see that in-film particle levels are consistently low in the sub-20 total range across the full 8-inch substrate areas for every substrate in the batch. Compared to the complete marathon data, which is shown in Figure 2, this example shows an exceptionally low particle level. Normally, the particle count is around 40.

Variation over target/shield life

Having established no significant difference in particle performance between chucks, a single chuck position was chosen to verify the particle performance for the process over a much wider range of shield / target life. Figure 2* shows how the particle performance for chuck position 3 varies over 180kWh for particles in the same sizes range of 1 micron and above, relevant to the device manufacturer. We see that total particle numbers remain in the typical range between 20 and 80 over a whole 8-inch substrate.

Particle distribution over the wafer

Measurements were also made to verify the typical distribution of particles. To distinguish between any particles arising as a result of handling rather than during sputtering, baseline measurements were taken.

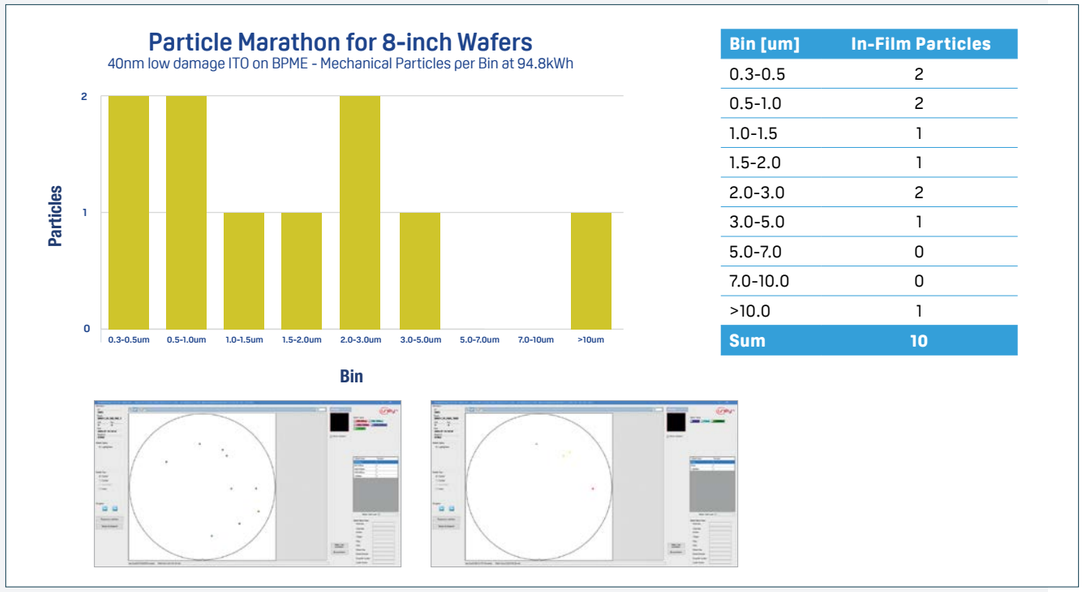
Base values

In a so-called "Mechanical Particles" test, substrates are loaded into the system within a cassette. The system is pumped, substrates are picked, loaded to the turntable, and rotated with process gases and process times as per a process recipe, but with no plasma ignition before being returned to the cassette and vented. Figure 3 illustrates the distribution after a target/shield life of 95kWh for chuck position 12 using the "precoated shields" typically used by customers to reduce shedding. As can be seen, the particle count on the substrate is very low after the mechanical test, including particle sizes starting from 300nm.

In-film particles

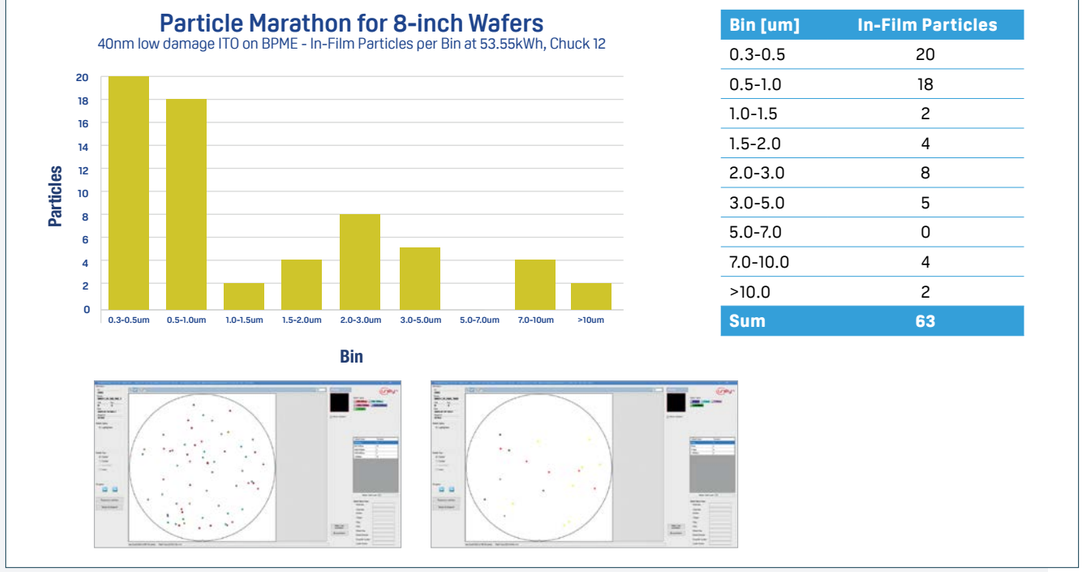
Figure 4 shows the distribution of in-film particles for the same chuck position, but at a lower shield life and also starting from 300 nm particle size.

NEXT STEPS →→



Bin [um]	In-Film Particles
0.3-0.5	2
0.5-1.0	2
1.0-1.5	1
1.5-2.0	1
2.0-3.0	2
3.0-5.0	1
5.0-7.0	0
7.0-10.0	0
>10.0	1
Sum	**10**

Figure 3: Particle distribution over the wafer for mechanical particles using typical production LED / Micro LED BKM.



Bin [um]	In-Film Particles
0.3-0.5	20
0.5-1.0	18
1.0-1.5	2
1.5-2.0	4
2.0-3.0	8
3.0-5.0	5
5.0-7.0	0
7.0-10.0	4
>10.0	2
Sum	**63**

Figure 4: Particle distribution over the wafer for in-film particles using typical production LED / Micro LED BKM.

NEXT STEPS

Whether it's metals, TCOs, or dielectrics, every customer works with different layer thicknesses, stack designs, and process conditions including temperature – and hence also different particle performance specifications. However, with more than 15 years of experience in supporting customers with sputter processes for LED, our engineers are ready to help you optimize your own specific processes.

**Footnote: Tool running continuously, processing batch after batch. A small number of outliers with high particle counts caused by random arcing events have been removed from the graph.*