HIGH PRECISION DISPENSE SYSTEM

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Presisely controlled dispensing of photoresist is one of the key process steps in photo-lithography. Beside basic requirements like a bubble free dispense, the accuracy and flowrate profile influence the uniformity of a coating. Up to date, high precision dispensing was an exclusive domain of positive displacement pump-systems.
SUSS MicroTec recently introduced a pressure based dispense system, which breaks into this area. A dispense volume repeatability of ±1 % (3 σ) and accuracy of ±2 % was made possible by means of sophisticated monitoring and control mechanisms. Furthermore a flow-sensor located at the latest possible point allows for monitoring the real flow and controlling the system accor-dingly. Software algorithms act as back bone of the system performance. The system can be used to dispense chemicals with viscosities from 1 cps to 10,000 cps.

Accuracy of a high end pump built with off-the-shelf parts

Usage of smart sensors at critical places combined with optimized control algorithms leads to the system's superior performance.

- Flow sensor: Measuring at the point of dispense.
- Bubble sensor: Placed at a location where enough resist is left to finish the current dispense. In a next step the bubble can be purged out without affecting the wafer.
- Strategically reducing the tube size down the line leads to increased resistance against bubbles.
- Usage of less pressure (<1 bar) to attain a required flow. When compared to other pumps which require up to 5 bar.

Figure 1 shows the performance over complexity of the SUSS dispense systems vs. other systems available and well known on the market.

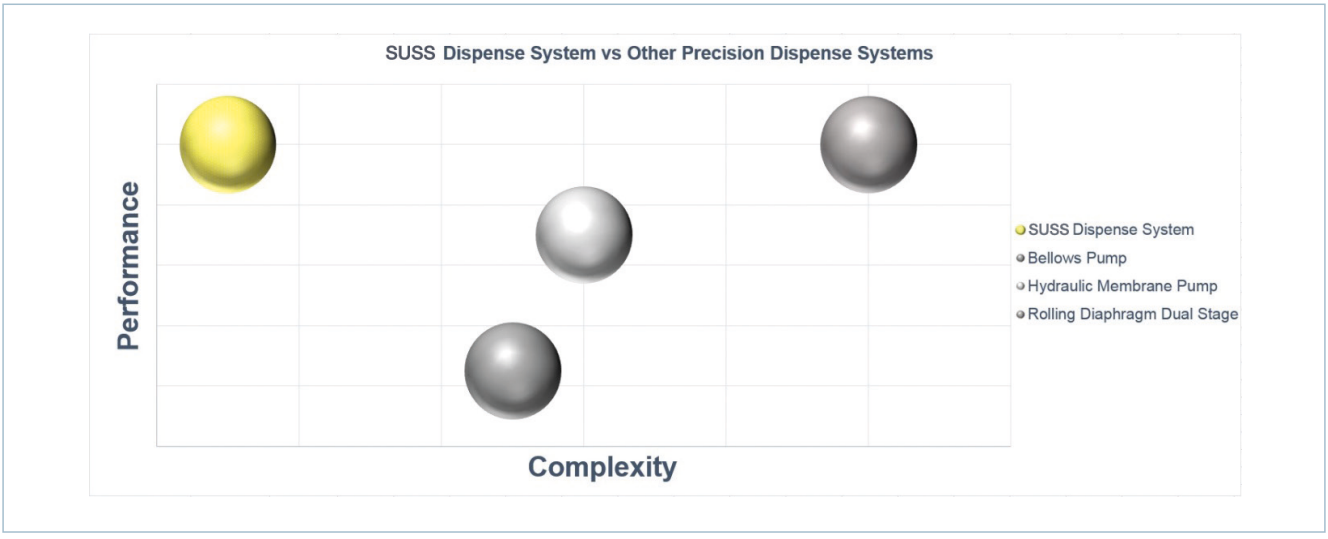


Figure 1 *Comparison of SUSS Dispense System to other systems on the market*

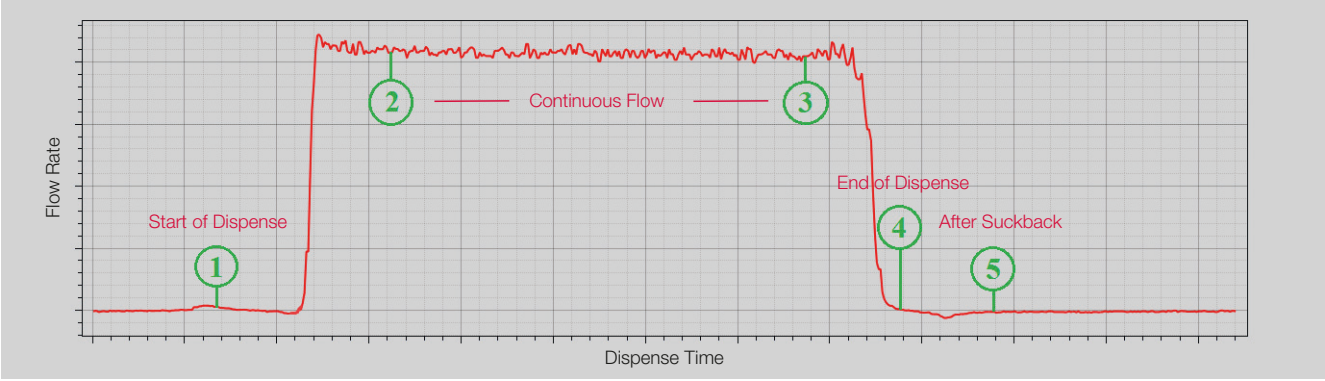
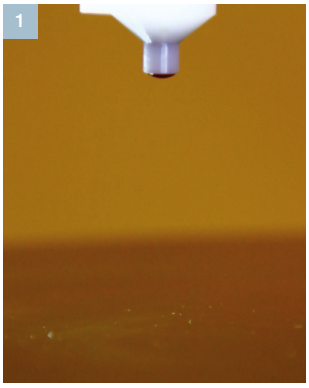
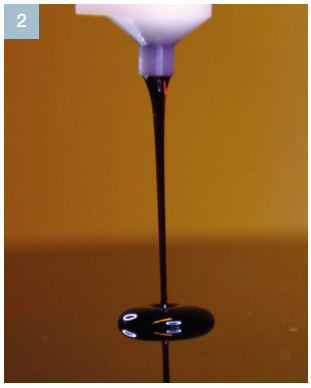
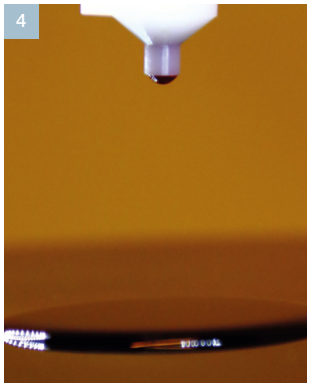


Figure 2 *Actual screen-shot of the control software showing the flow rate over time*







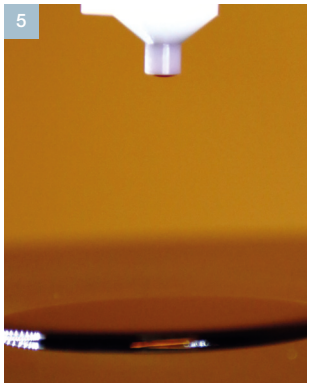


Figure 3 *The different phases of a dispense at the nozzle – see figure 2 for correlation*

Logging of real flow

The dispense system is monitoring and logging each dispense in real time.
In figure 2, an actual screen-shot of the control software is shown. The different phases of the dispense are marked and described.

In figure 2, the different phases of a typical dispense are shown. The dispense is being spilt into 5 sections:

1) **Start** – The suck-back volume is being pushed out almost simultaneously with the ramp up of the dispense flow. This ensures that the precision of the dispense amount is not affected in any means.
2) **and 3) Continuous flow** – The picture shows the constant flow rate over the period of the dispense.
4) **End of dispense** – Ramp down of the dispense rate by closing of the dispense valve. As can be seen in the picture there is a small drop of resist hanging out before the last step.
5) **After suck back** – By activating the suck back valve this small drop is pulled back into the line as can also be seen in the graph.

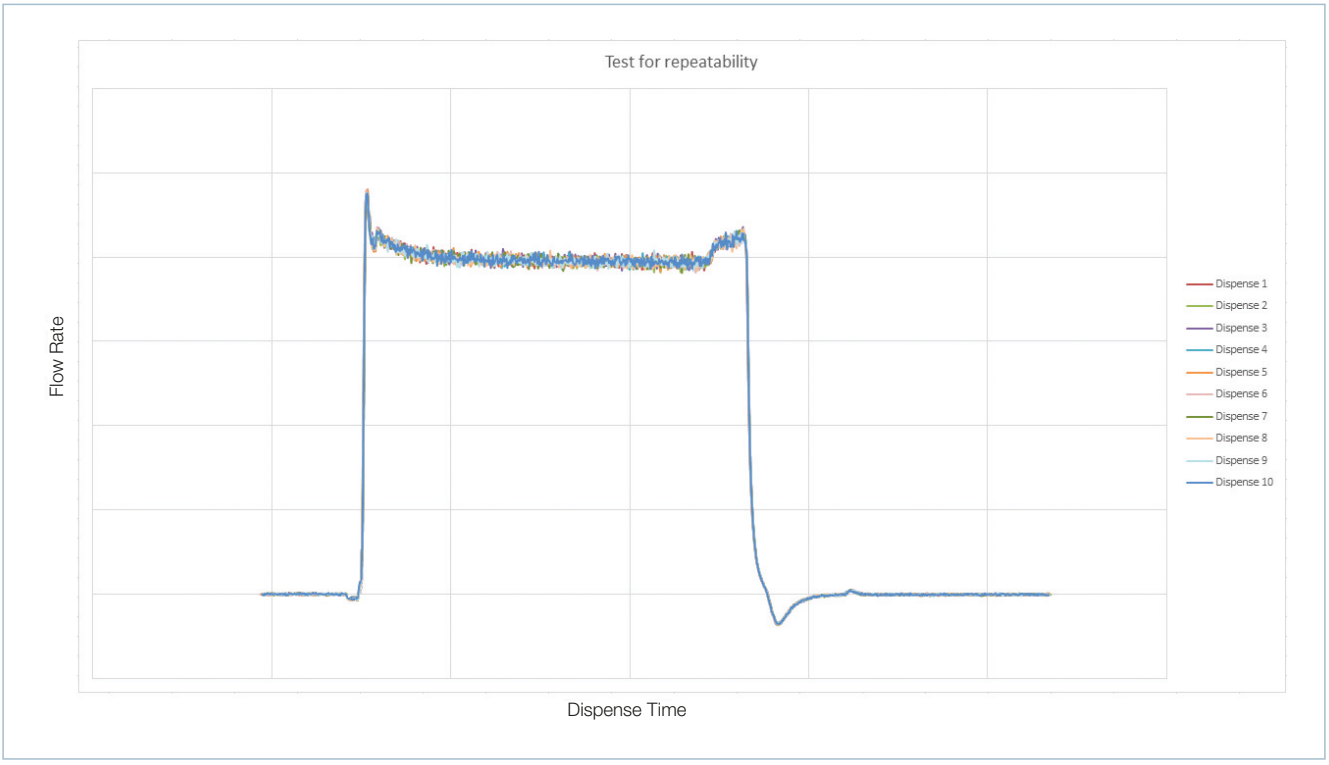


Figure 4 *Overlay of 10 dispense graphs*

The suck-back rate and amount are programmable via software which helps to optimize a dispense to e.g. various viscosities and specific requirements. All of this shows the precision monitoring and control capabilities of the SUSS Dispense System.

By overlapping multiple dispense graphs the repeatability of the system is shown in Figure 4.

Adaptability of system (temperature and viscosity changes)

The SUSS dispense system is designed to be insensitive to temperature changes and changes in viscosities. The accuracy of the system stays inside the specification range even at notable change in temperatures. This makes the system less dependent on a temperature controlled environment, thereby lowering the total cost of ownership of the system.

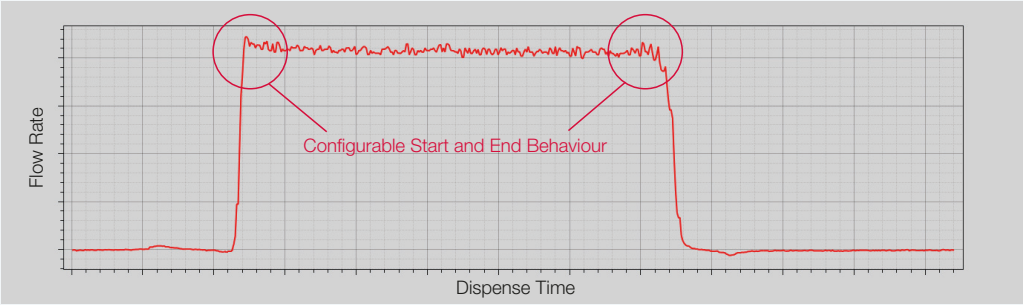


Figure 5 (1) *Optimized to get square wave dispense*

Figure 5 (2) *Optimized to get overshoot in the start and end*

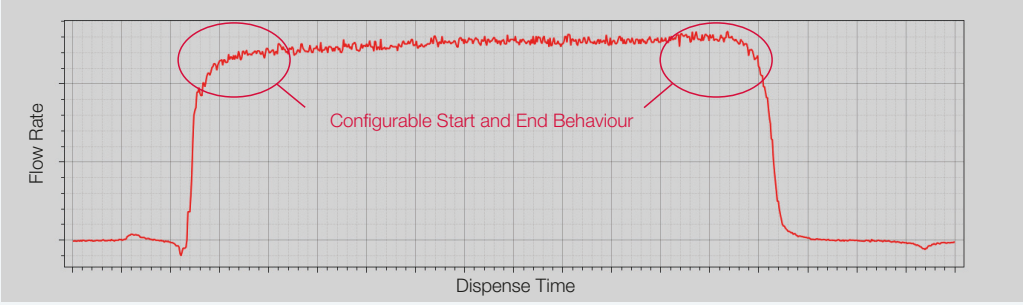


Figure 5 (3) *Optimized to have slow opening and closing behaviour*

Complete control of dispense (adjustment of START and END slope):

As different processes may require different flow behavior, the SUSS dispense system gives possibilities for all sort of variations. This opens up the door for optimization of the dispense profile. The user can ensure that the process is optimized to the specific needs and the system is immune to various drifts.

Figure 5 gives a basic idea of how the dispense characteristics can be changed.

Figure 5 (1):
Shows a dispense similar to a digital square form.

Figure 5 (2):
Shows a dispense with a spike in the beginning and also at the end of dispense. The slope of the spike can also be optimized to match the customer process.

Figure 5 (3):
Shows dispense with smoothened open and closing behaviour.

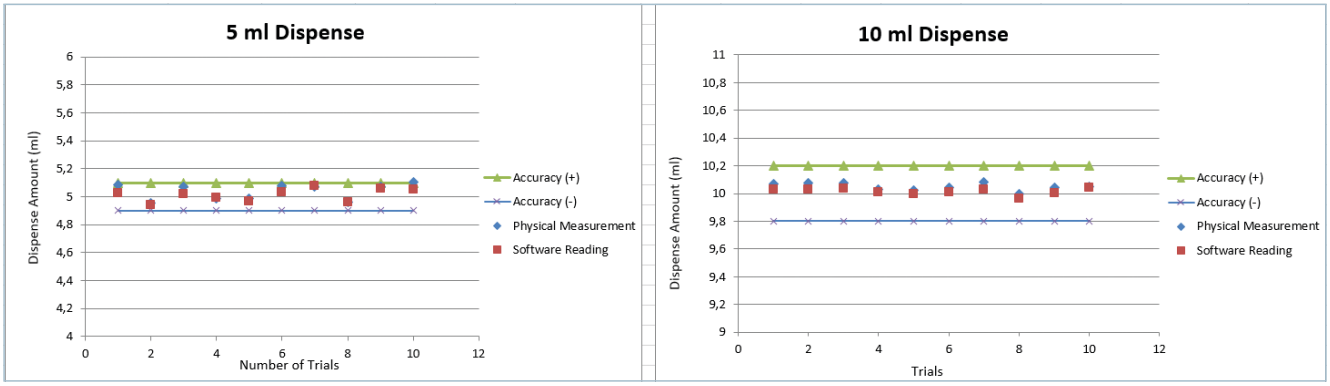


Figure 6 *Results*

Accuracy and repeatability over a range of flow:

The system accuracy and the repeatability is being specified as ± 2 % and ± 1 % respectively. The results of 5 ml and 10 ml dispenses are given in figure 6. The results show that the readings are well within the specification.

Summary

The SUSS dispense system is designed with focus on performance and easy operation. It can be used for resist volumes between 5 ml and 25 ml with ± 2 % dispense volume accuracy and ± 1 % repeatability. The system features great possibilities of monitoring and controlling the dispense profile at the point of dispense in real time. Since the system allows various optimizations such as optimization of start and end of dispense, the entire dispense profile can be adjusted for a specific process. This helps the user to adapt the system to various range of viscosities and optimize the dispense for a specific process requirement.

Acknowledgement

I am very thankful to Dr. Oliver Treichel for giving me an opportunity to work under him in this project. In his guidance, which helped me to accomplish the given task. Also I am very much thankful to Kader Mekias and Bjoern Boeckle for being very supportive and friendly throughout the project work. It was the project from Oliver and Kader and I am part of the team. Finally thank you Gary Choquette for giving me the opportunity to address the project on behalf of our team.

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