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MicroChem S1818 Contrast Curve Optimization

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QNF QUATTRONE NANOFABRICATION FACILITY	Technical Report	Document No:
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Goal:

To obtain an optimized contrast curve for MicroChem S1818 positive resist using the SUSS MicroTec MA6 Gen3 Mask Aligner and MicroChem MF-319 developer through a design of experiment.

Materials:

- MicroChem S1818 Photoresist
- MicroChem MF-319 Developer
- Benchmark mask
- 365 i-line filter
- 4 inch Silicon Wafers

Equipment:

- ReynoldsTech Spinner
- Torrey Pines Scientific hotplate
- SUSS MicroTec MA6 Gen3 Mask Aligner
- KLA Tencor P7 2D profilometer

Protocol:

Coat

1. Mount wafer and ensure that it is centered.
2. Deposit 7 milliliters of S1818 photoresist in the center of the wafer.
3. Spin on photoresist at 5000 RPM for 60 Seconds.

Soft Bake

1. Bake wafer according to the following table

Baking Temperature(°C)	Baking Time(s)	i-line filter
90	60	Y
115	60	N
125	180	N
130	180	N
130	240	N
130	180	N

Expose

1. Expose wafer using Benchmark mask.

Development

1. Dispense approximately 150 milliliters of MF-319 developer into a six inch cylindrical container.
2. Fully submerge the exposed wafer.
3. Agitate and develop the wafer according to the following table:

Experiment	Baking Temperature [°C]	Baking Time [s]	Development Time [s]	i-Line filter	Gamma
1	90	60	180	Y	-37.29
2	115	60	30	N	-51.93
3	125	180	240	N	-84.89
4	130	120	180	N	-77.79
5	130	240	120	N	-39.66
6	130	180	300	N	-128.57

4. Measure the step height using the KLA Tencor P7 2D profilometer

Results:

Results from experiments 1 – 5 are shown in figs. 1 – 5. In these experiments, as mentioned before, baking time, baking temperature and development time was changed to find any possible trend and an optimized process.

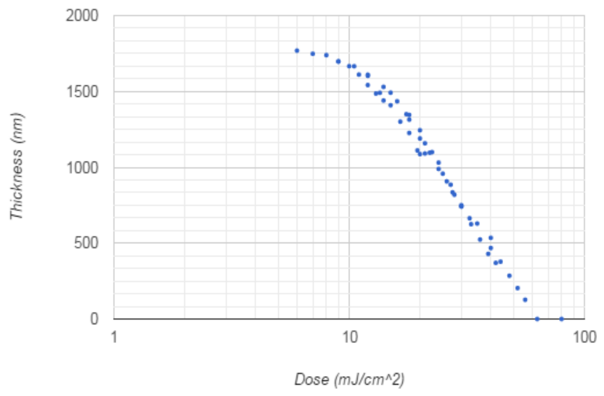

Fig. 1 – Experiment 1 (Baking temp. 90C, Baking time 60s, Dev. time 60s)

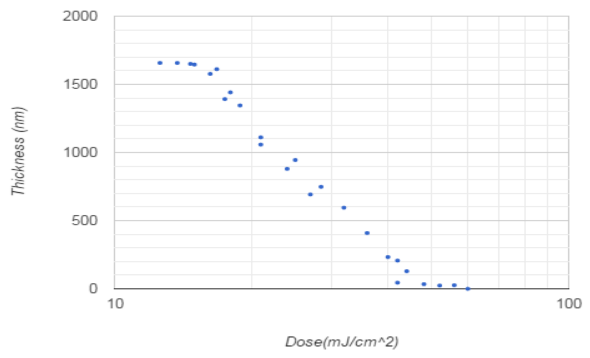

Fig. 2 – Experiment 2 (Baking temp. 115C, Baking time 60s, Dev. time 30s)

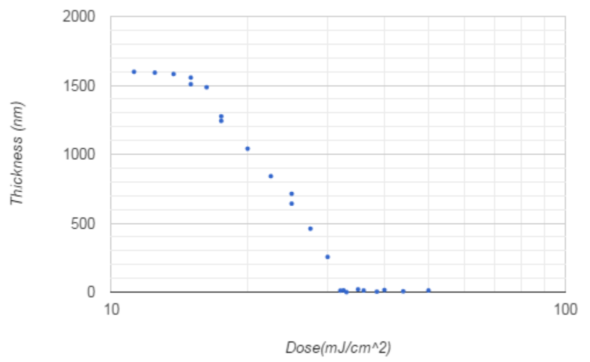

Fig. 3 – Experiment 3 (Baking temp. 125C, Baking time 180s, Dev. time 240s)

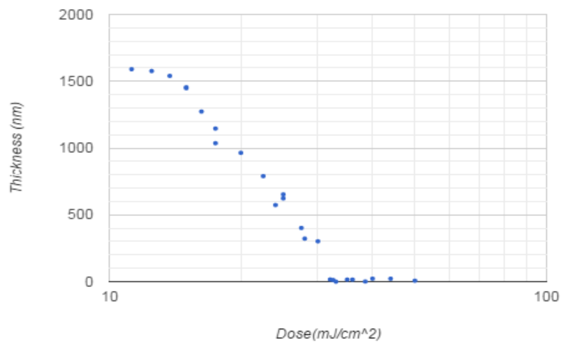

Fig. 4 – Experiment 4 (Baking temp. 130C, Baking time 120s, Dev. time 180s)

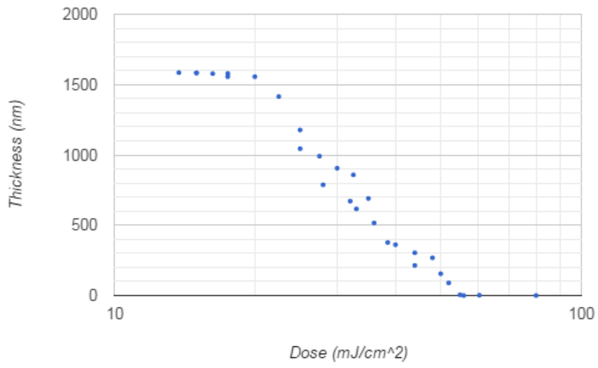

Fig. 5 – Experiment 5 (Baking temp. 130C, Baking time 240s, Dev. time 120s)

A cursory glance of the results in figures 1 to 5 revealed two trends:

1. The higher the baking temperature, the higher the dose needed to reach the end of the dark exposure loss.
2. The longer the development, the steeper the slope (higher Gamma) of the contrast curve. Gammas are reported in the table under the Development section.

Experiment 6 was conducted and repeated to test the trend and redundancy.

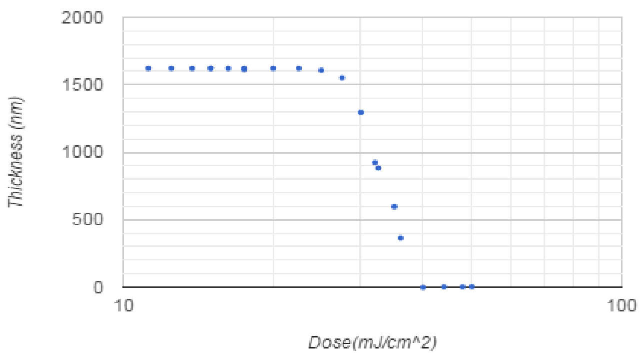

Fig. 6 – Experiment 6 (Baking temp. 130C, Baking time 180s, Dev. time 300s), first attempt

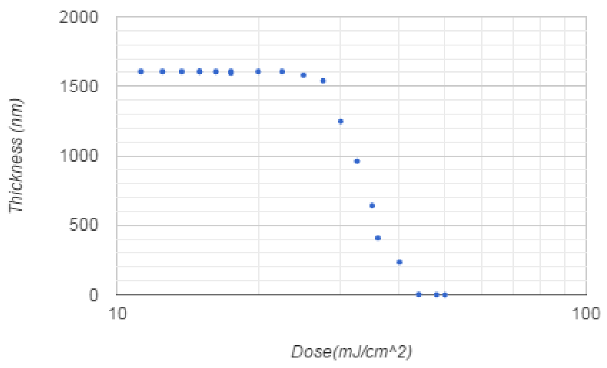

Fig. 7 – Experiment 6 (Baking temp. 130C, Baking time 180s, Dev. time 300s), second attempt

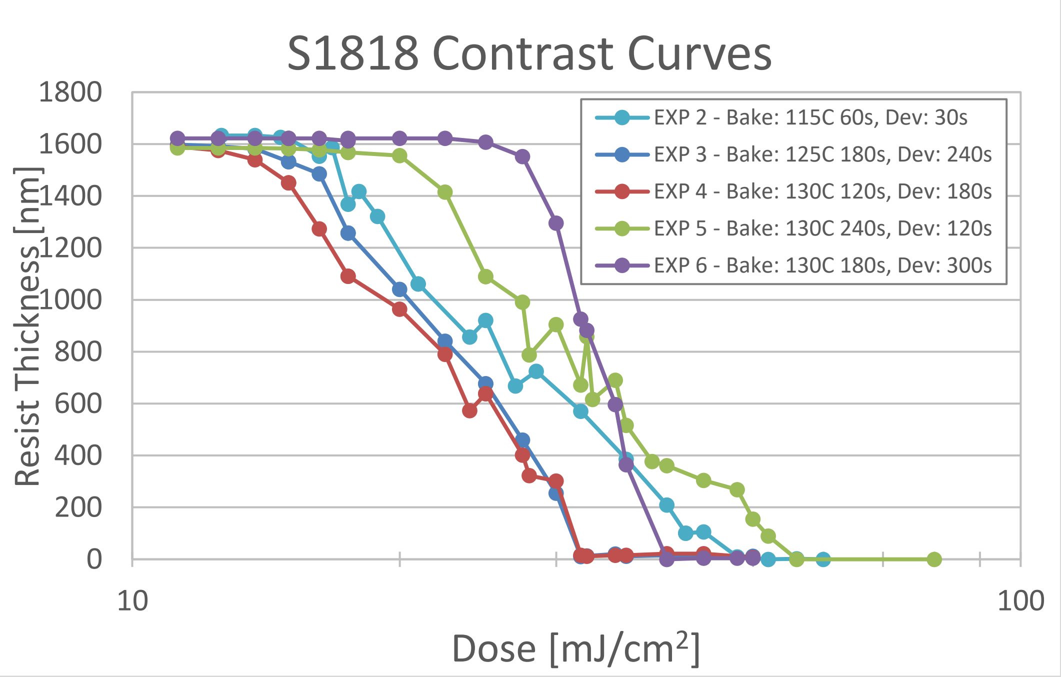

Fig. 8 – Contrast curves for experiments 2, 3, 4, 5 and 6

Fig. 8 to 16 show the trend between E_0, Dark Exposure Loss (DEL), Gamma and Baking Time, Baking Temperature, Development Time.

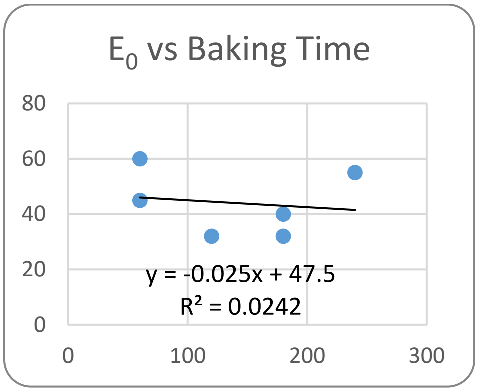

Fig. 9

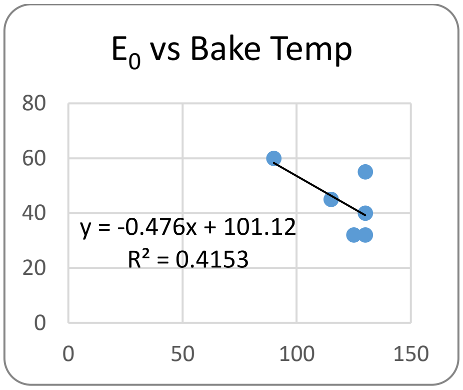

Fig. 10

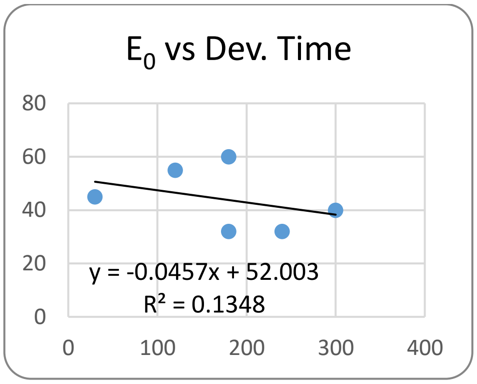

Fig. 11

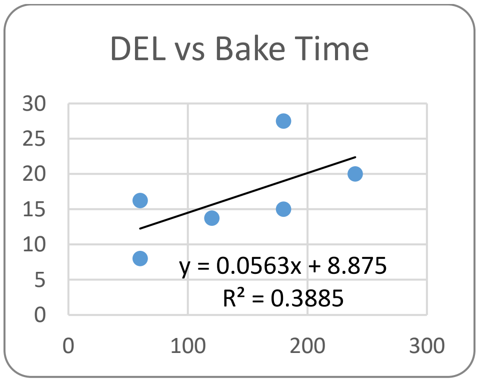

Fig. 12

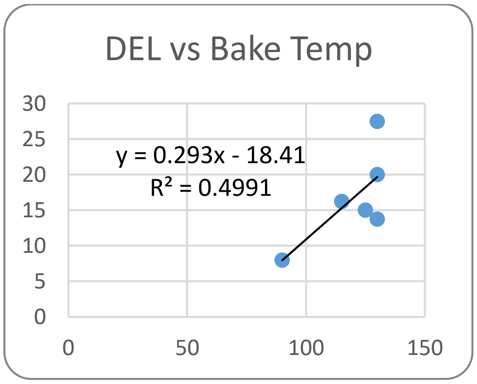

Fig. 13

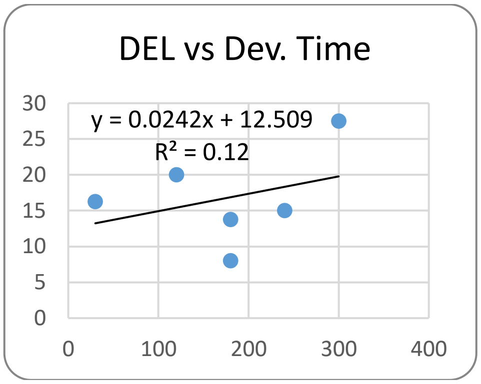

Fig. 14

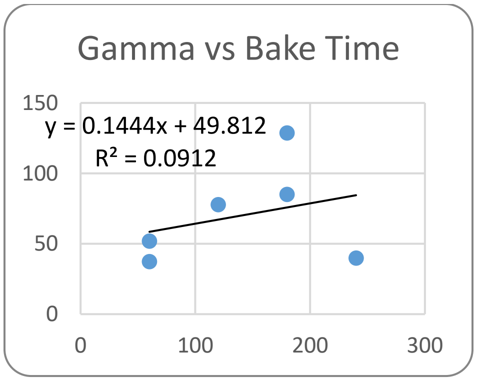

Fig. 15

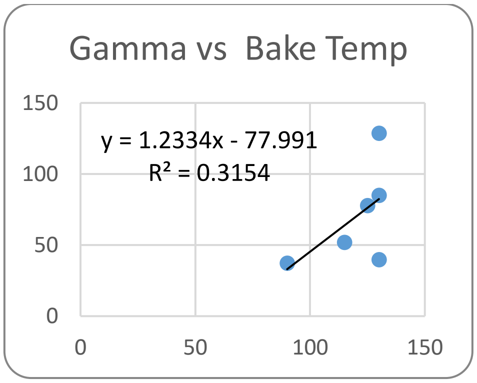

Fig. 16

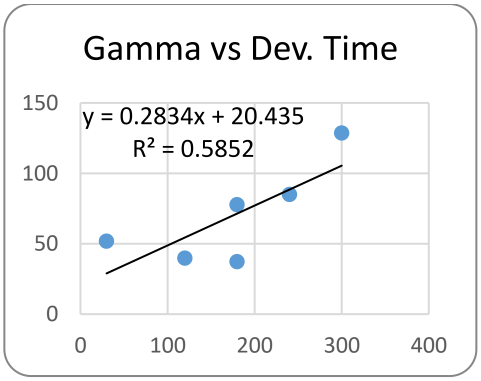

Fig. 17

Summary:

Figures 13 and 17 statistically confirm our previous assumptions of dark exposure loss and Gamma (R^2=0.50 and R^2=0.59, respectively). From the analysis, the increase in bake temperature extends the range of the dark exposure loss while subsequently decreasing the E_0 and improving Gamma (Fig. 16). Figure 17 shows that Gamma is proportional to development time (R^2=0.59). Figure 8 plots all contrast curves from experiments 2-6. Thus far, experiment 6 demonstrates to be the most optimal process for MicroChem S1818.

Finally, it was shown at higher baking temperature (150°C), a high (8000mJ/cm^2) prohibits resist development. Thus, experiment number 7 was conducted:

Experiment	Baking Temperature [C]	Baking Time [s]	Dose [mJ/cm^2]	Development Time [s]	i-Line filter
7	150	60	8000	60	N

Fig. 18 shows the result of experiment 7. The wafer does not develop since the baking temperature is too high.

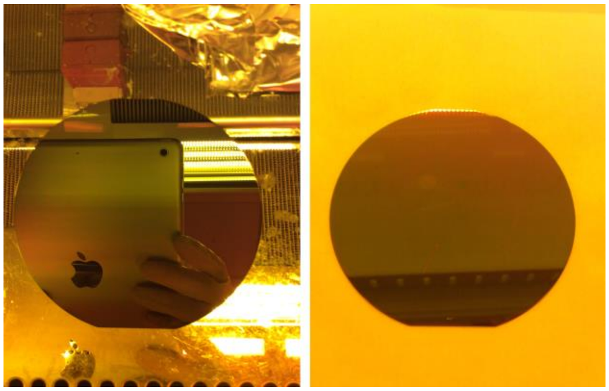

Fig. 18 – experiment 7 (Baking temp. 150C, Baking time 60s, Dev. time 60s), the wafer before exposure (left) and after development

Fig. 19 shows the wafer used for experiment 1 (Baking temp. 90C, Baking time 60s, Dev. time 60s), before exposure and after development.

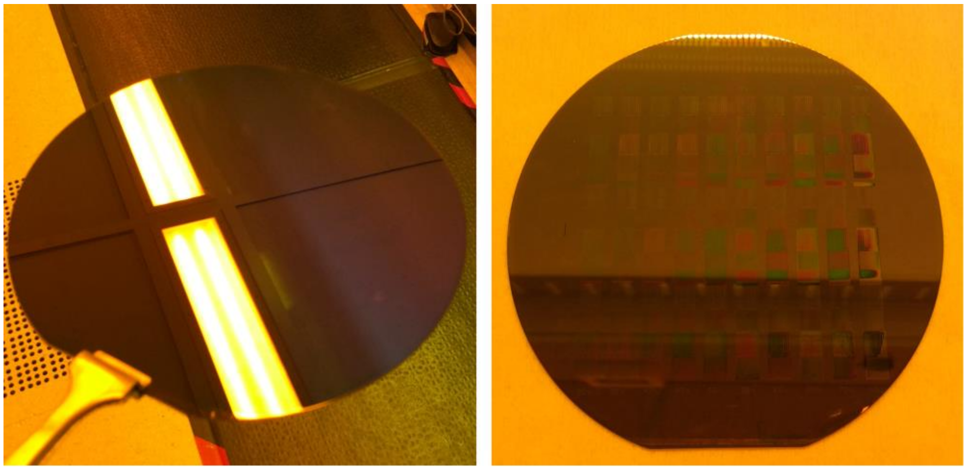

Fig. 19 – experiment 1 (Baking temp. 90C, Baking time 60s, Dev. time 60s), the wafer before exposure (left) and after development (right)