Investigation of Silicon Etching Process with COMSOL®

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INTRODUCTION: Silicon etching in aqueous KOH solutions can lead to different surfaces: polished or micro-structured [1]. This depends on process parameters as etchant composition, temperature and agitation. Thus we performed experiments with a nozzle jetting etchant at the surface and compared the results to COMSOL® simulations.

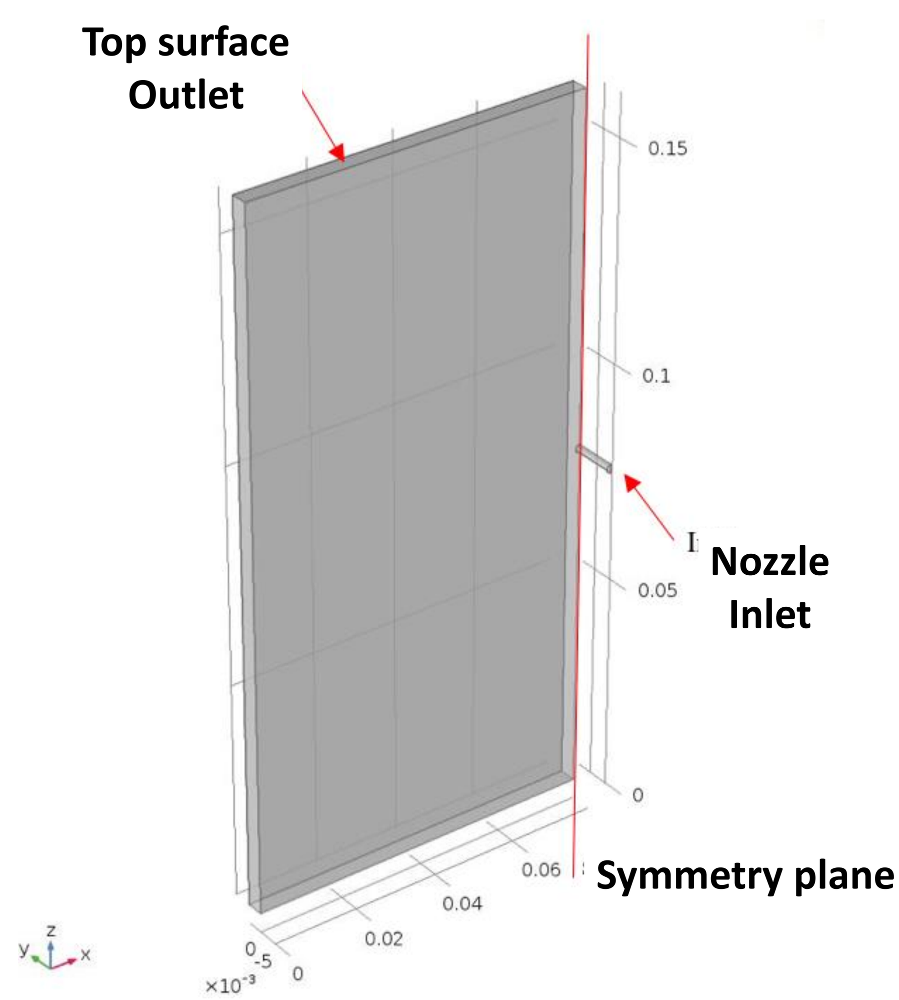

Figure 1. Geometry of the experimental setup

EXPERIMENTAL RESULTS: After some minutes of etching, round spots appear on the wafers which we describe by an inner circle, a first and second ring and an outer region. For every experimental condition, we measure the corresponding extents of the structures.

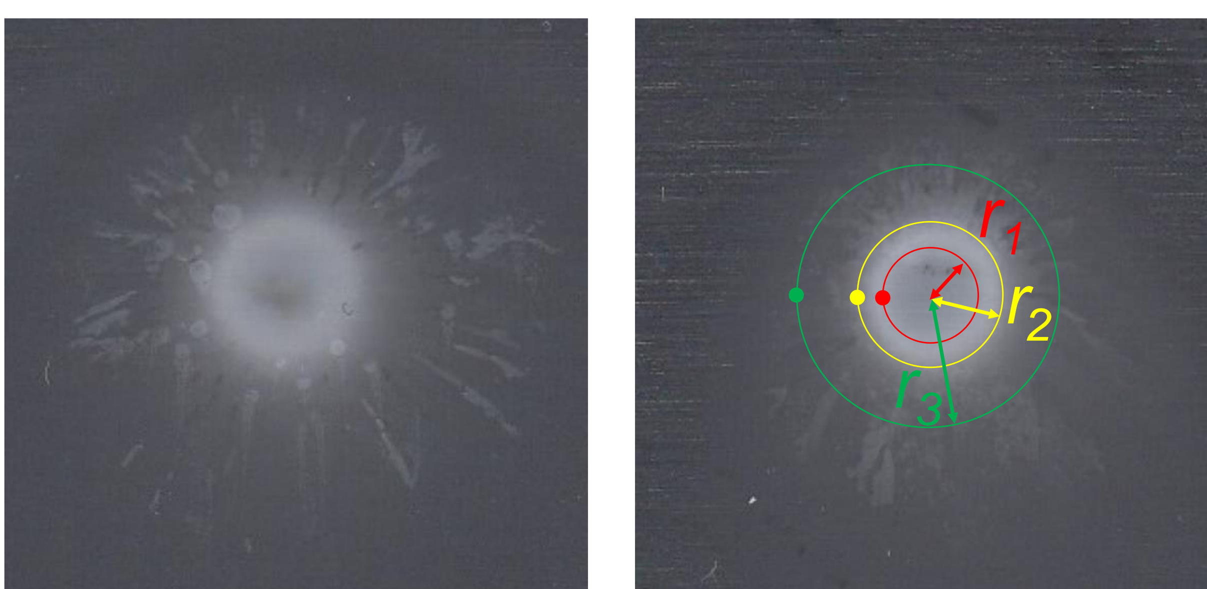

Figure 2. Typical etch spots

We investigated the surface microstructure by confocal laser scanning microscopy. A clear distinction of the four different regions is possible.

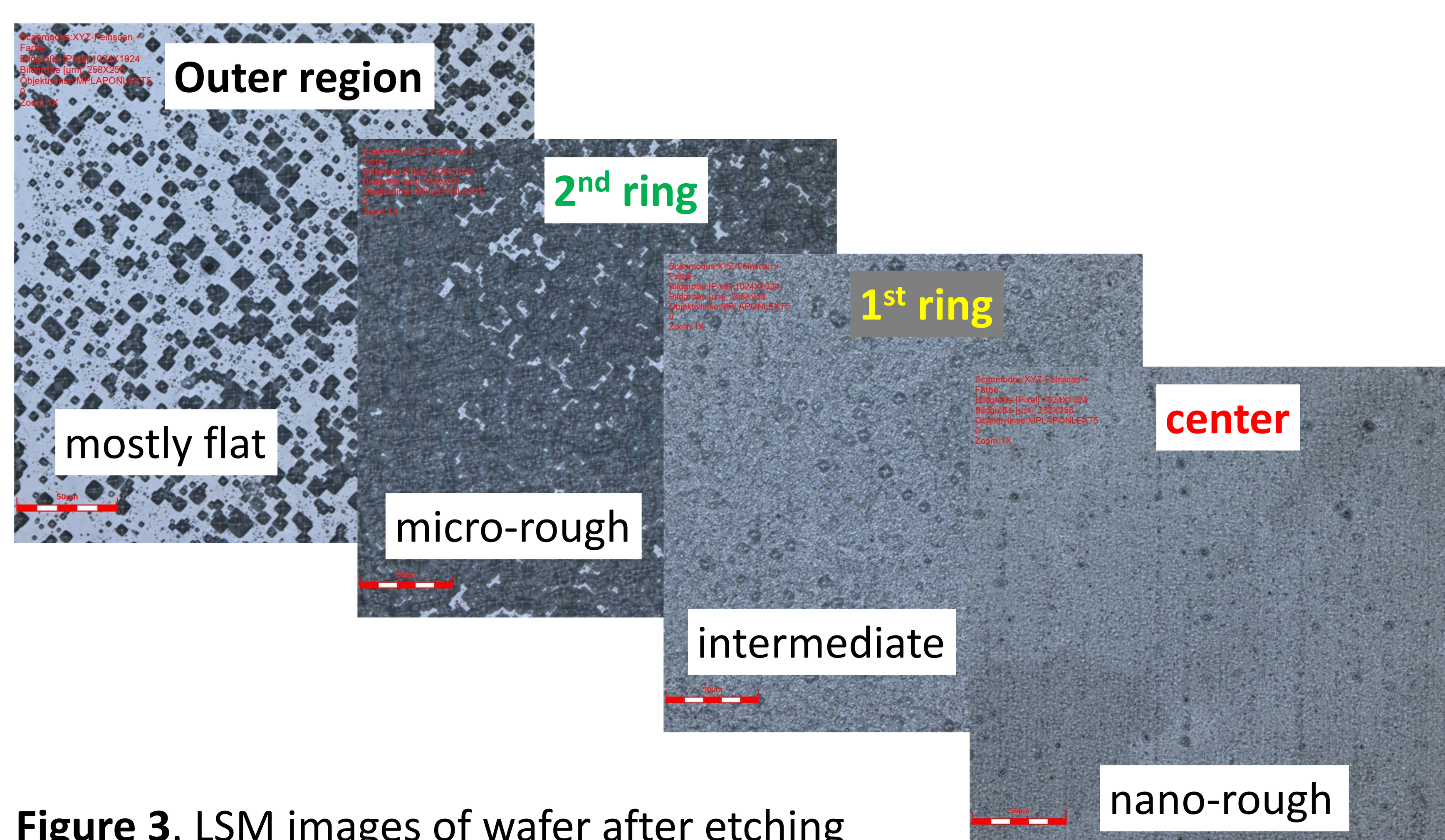

Figure 3. LSM images of wafer after etching

COMPUTATIONAL METHODS: We used the CFD module with *yPlus* turbulence model to simulate the etchant flow pattern for four different sets of parameters. Extraction of p and U at 100 µm distance to wafer surface and distances r_1, r_2, r_3 to center.

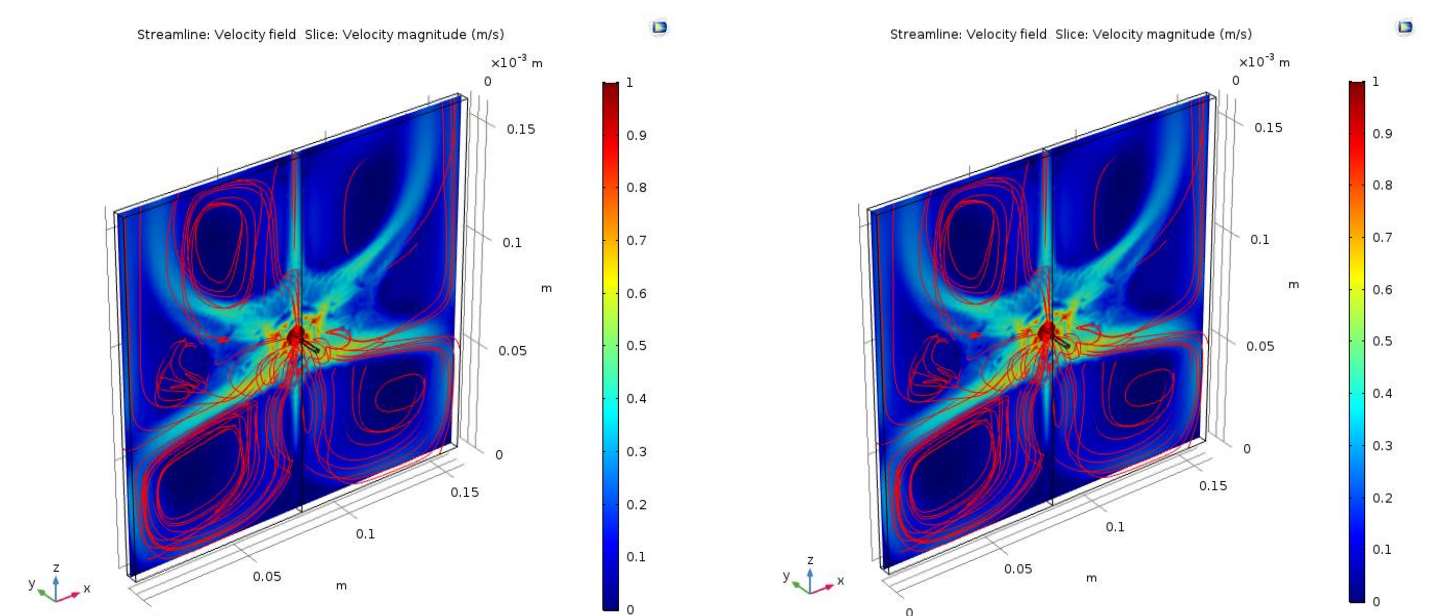

Figure 4. Typical flow pattern in etch basin

d / mm	v_{in} / m/s	r_1 r_2 r_3 / mm	p_1 p_2 p_3 / bar	U_1 U_2 U_3 / m/s
4	19.4	1.5 3 7.5	0.12 0.02 -0.003	0.58 0.56 0.39
4	28.4	2.2 5 10	0.099 -0.002 -0.004	0.83 0.72 0.49
6	19.4	0 3 7.5	0.19 0.03 -0.002	0.63 0.45 0.36
6	28.4	1.1 3.5 9	0.26 0.05 -0.005	0.64 0.66 0.45

Table 1. Experimental and simulation results for etch spots. *d*: distance nozzle-wafer, v_{in}: inlet velocity

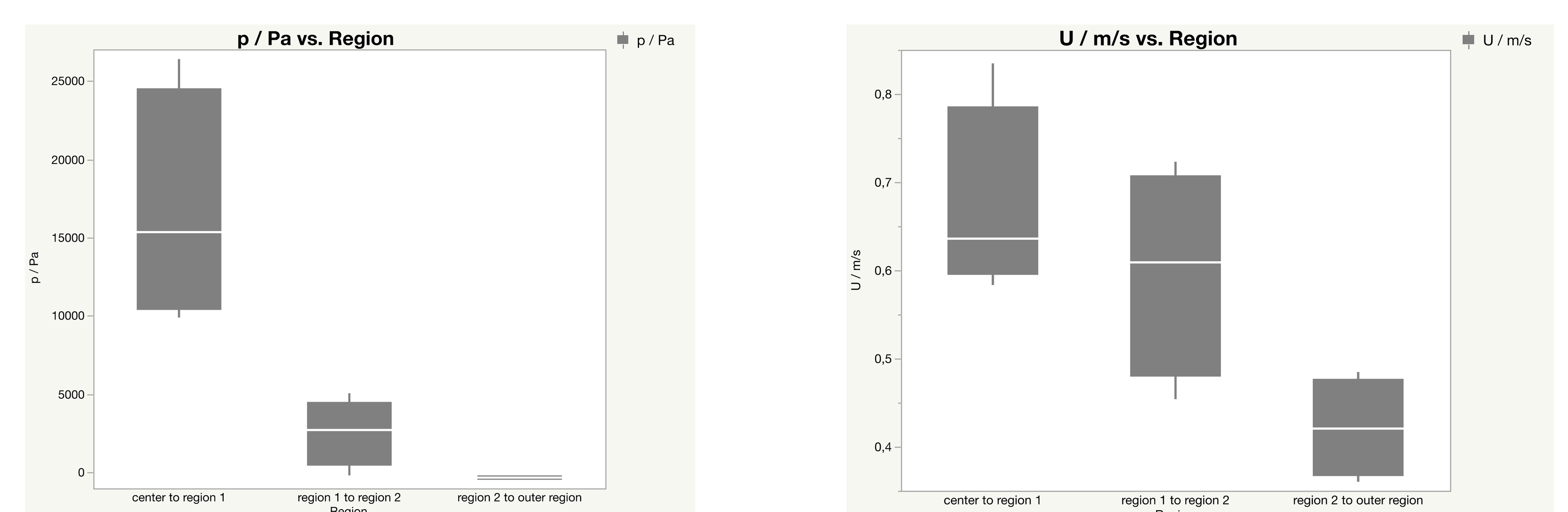

Figure 5. Average p and U at the different regions edges from COMSOL®.

CONCLUSIONS: We extracted p and U values at the edges of the different etch regions and found reasonable data match for the different etch parameters. Thus we could derive approximations for p and U values that lead to the respective surface qualities. We will further investigate the optimum distance from the wafer and average volume for best approximation of p and U limits.

REFERENCES:

1.H. Seidel, Der Mechanismus des Siliziumätzens in alkalischen Lösungen, PhD thesis, FU Berlin, 1986

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