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Immobilization of biotin and streptavidin on APTES functionalized silicon surface for on-chip photonic biosensors

Abstract

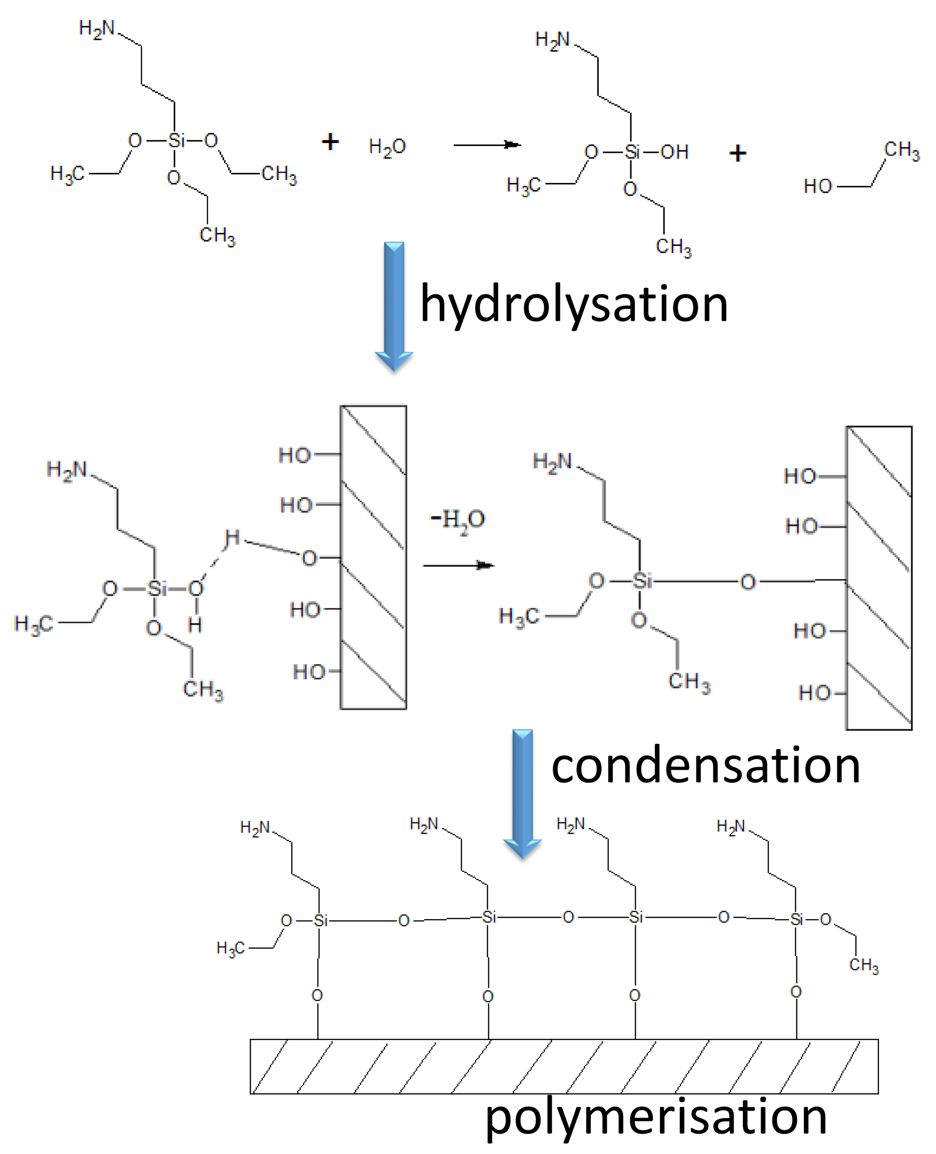
On-chip photonic biosensors are often based on silicon ring resonators[1,*] and the working principle is based on refractive index sensing, i.e. the measurement of the resonance wavelength shift due to a specific immobilization of analytes on the surface. Towards a specific surface functionalization of silicon ring resonators, we present here our investigation of 3-aminopropyltriethoxysilane (APTES) attachment to a silicon surface and the immobilization of biotin and streptavidin. This layer system is intended for the detection of C-reactive protein, which is an acute-phase protein of hepatic origin. Deposition conditions are comprehensively studied in terms of atomic force microscopy, contact angle technique and spectroscopic ellipsometry. We report on the evaporation of APTES, the biotinylation and the deposition of streptavidin as linker. The experimental findings in this study provide a guideline to functionalize silicon ring resonators based on silicon-on-insulator technology. Therefore, special emphasizes is given to obtain a quasi-monolayer of APTES and to reduce its surface roughness, which in turn reduces optical losses.

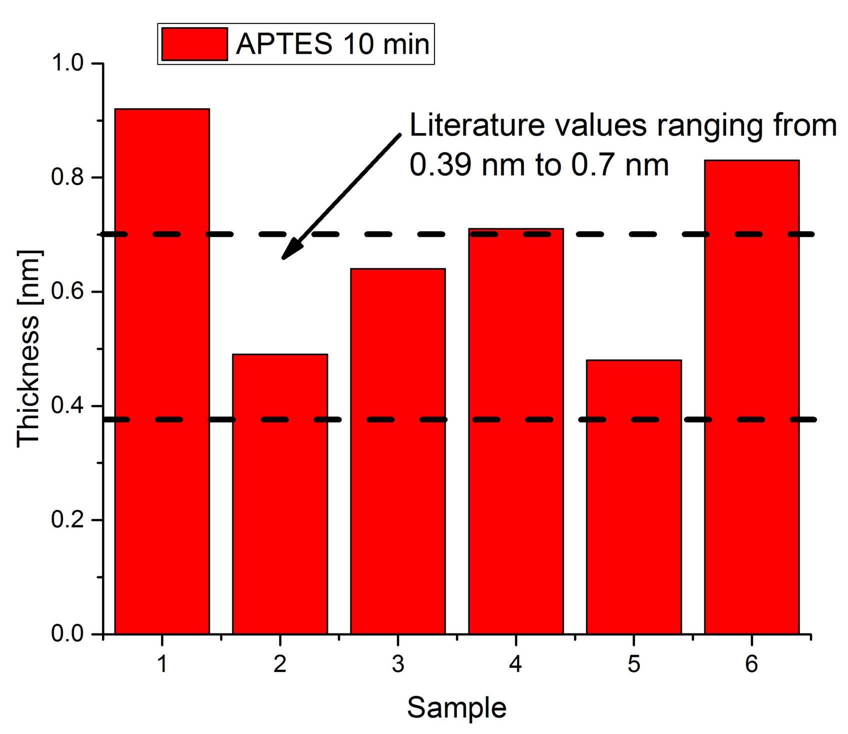
Silanization

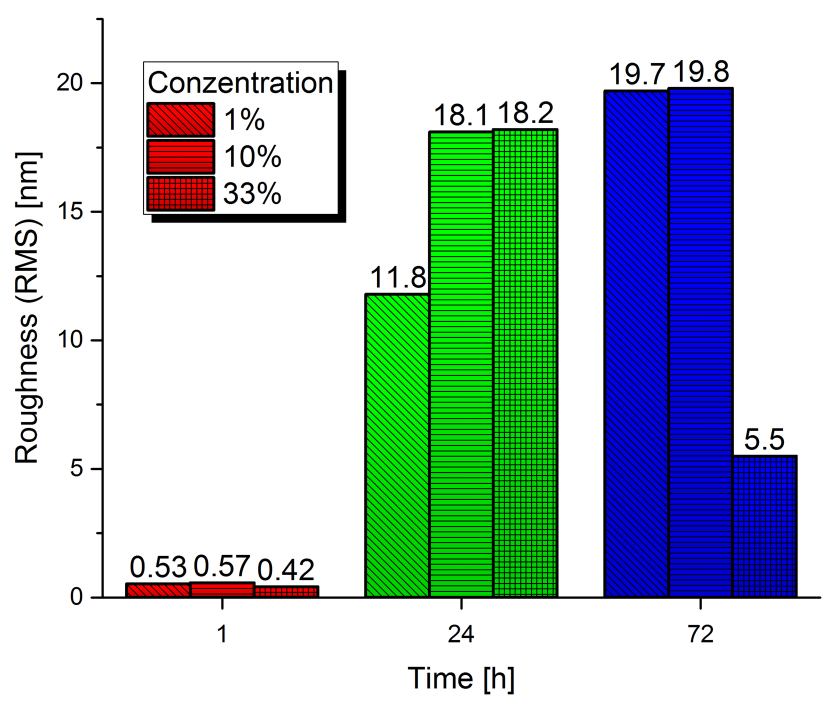
In general, there are three different deposition methods:

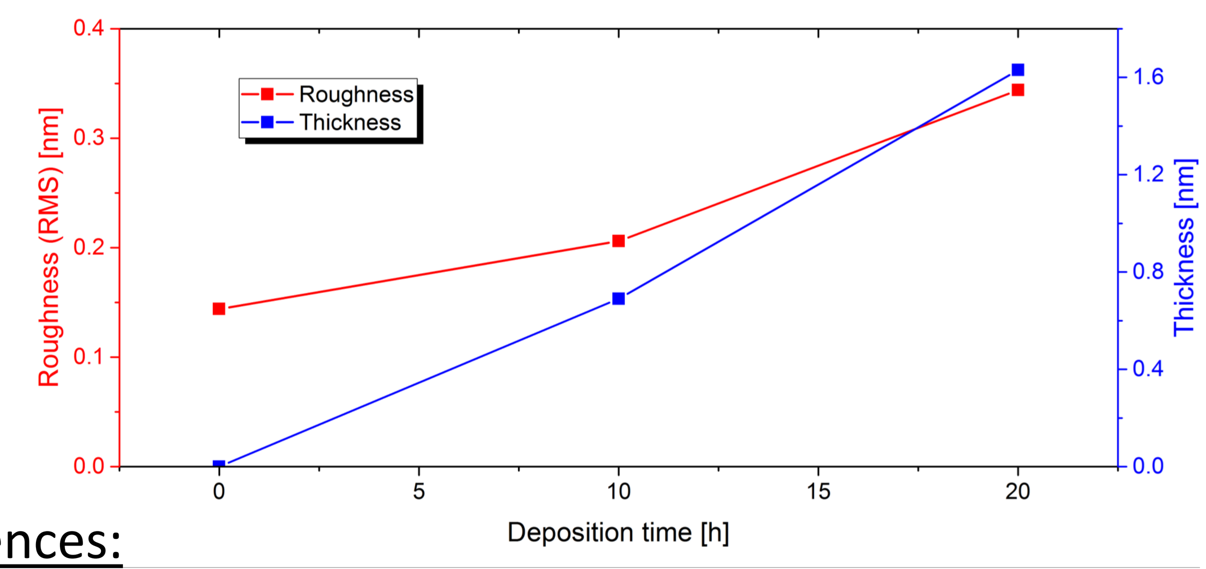
1) Using acetone as solution.
2) Using Tuluole as solution.
3) Vapour deposition.

→ Our experiments suggest that vapour deposition is the most promising candidate for quasi-monolayer with low roughness.
→ We obtained APTES films with 0.62 nm thickness, which is near to the theoretical value of 0.68 nm.
→ Contact angle is 39.9° - 51.5°.
→ Film roughness is 0.2 nm.









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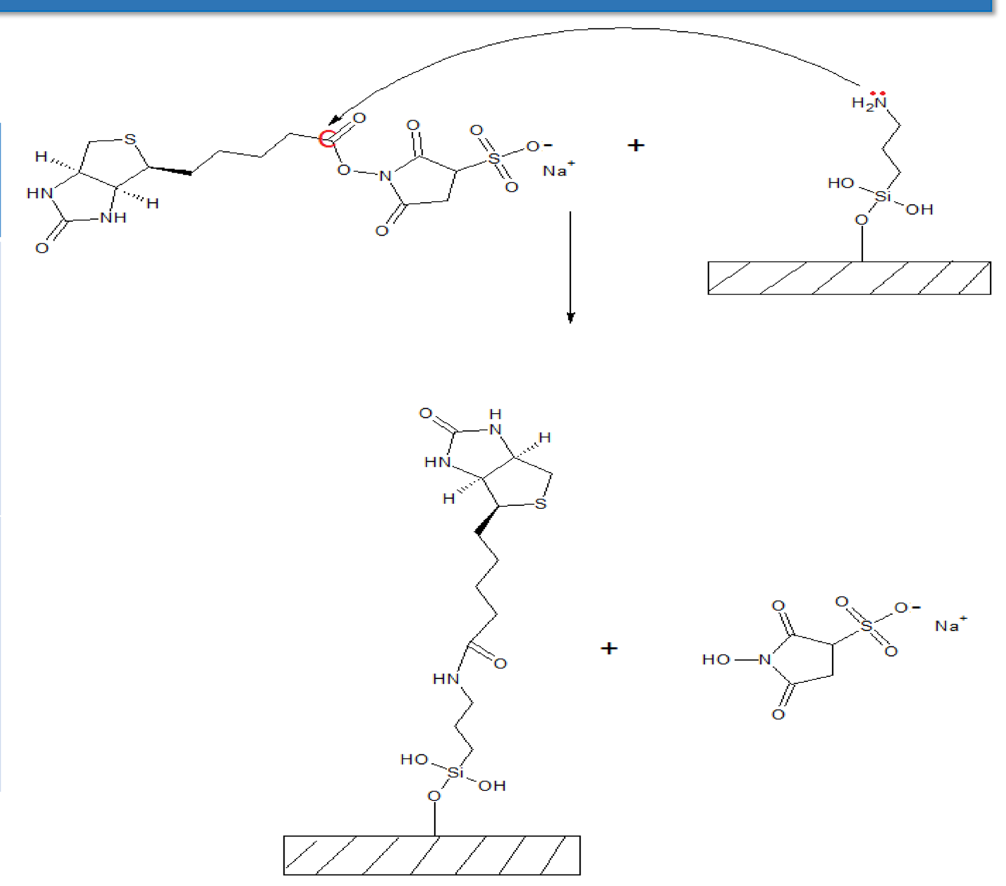
Biotinylation

Biotin (literature = 1.4 nm [3])

Sample	Biotin [nm]	Conditions
1	1,45	DMF, RT, t: 24h, C: 10mg/ml, C_{DCC}:11mg/ml, C_{DMAP}:1mg/ml
2	1,16	
3	1,60	
1	0,33	LM: DMSO, RT, t: 24h, C: 5mg/ml, C_{DCC}: 6,5mg/ml, C_{DMAP}: 6,5mg/ml
2	0,07	
3	0,77	



Biotin N-succinimidyl Ester (literature = 3,6 nm [2])

Probe	Biotin [nm]	Reaktionsbedingung
5	2,96(4h)	DMF, RT, C: 1mg/ml, C_{DCC}: 0,5mg/ml, DMAP: kleine Menge
6	0,47(6h)	
7	0,55(6h)	
8	4,03(24h)	
9	1,2(24h)	
10	1,52(24h)	

sulfo-NHS-Biotin (literature = 0,837 nm)

Sample	Thickness [nm]	Conditions
1	0,72	Phosphat-Puffer(0,01M), C: 1mg/ml, Raumtemperatur, t: 2h
2	0,71	
3	0,63	
4	0,70	

Conclusion

	Thickness [nm]	Theoretical Thickness [nm]	Roughness [nm]	Contact Angle [°]
APTES	0.62	0.668	0.21	39.9 – 51.5
Biotin	0.70	0.837	0.60	58.5

- Towards the functionalization of silicon on-chip sensors we have deposited APTES and Biotin.
- Vapour deposition is preferred for quasi-monolayer of APTES.
- 0.62 nm APTES layer with a relatively low roughness of 0.2 nm is obtained.
- Biotin is deposited and phosphat buffer has been found to be most appropriated.
- 0.7 nm Biotin layer is obtained with a roughness of 0.6 nm.
- Next step is deposition of streptavidin and the detection of C-reactive proteins as proof of principle.

More information can be found at **www.th-wildau.de/photonik**

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