TECHNISCHE UNIVERSITÄT DRESDEN

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IN-SITU REAL-TIME MONITORING AND CONTROL OF KINETIC PROCESSES IN ATOMIC LAYER DEPOSITIONS BY SPECTROSCOPIC ELLIPSOMETRY WITH >1 HZ SAMPLING RATE

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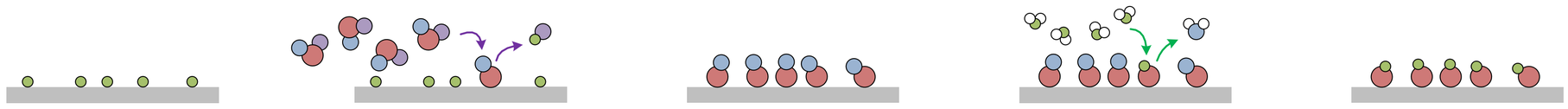
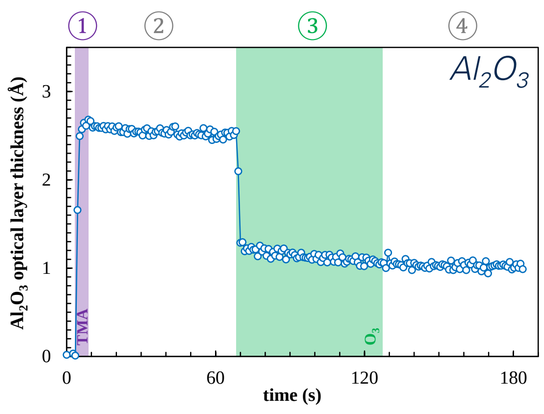
MOTIVATION

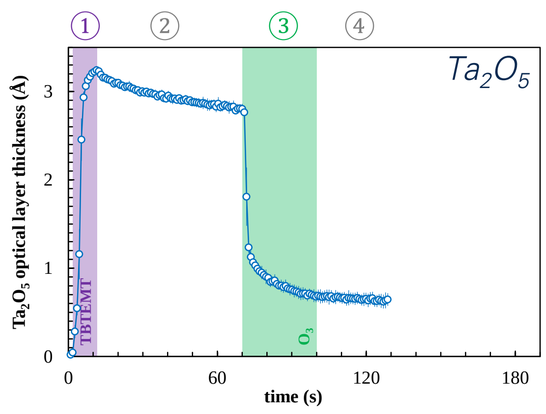
All present as well as future strategies in semiconductor manufacturing for next-generation nanoelectronics will progressively implement ultra-thin films that scale no more than a few nanometers and still meet their application-specific functionality, especially, on highly complex three dimensional (3D) structures and on large area substrates. However, the reliable manufacturing and accurate control of such a film's ultra-thin thickness in connection with its desired functional properties remains a critical challenge. This applies equally to the entire development chain from basic research to mass production.

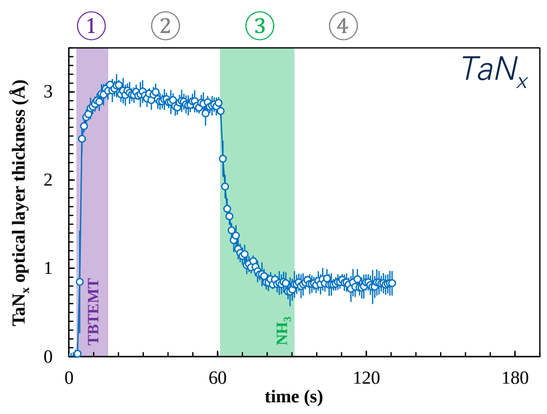
OPTICAL LAYER THICKNESS IN THE REAL-TIME COURSE OF ONE ALD CYCLE

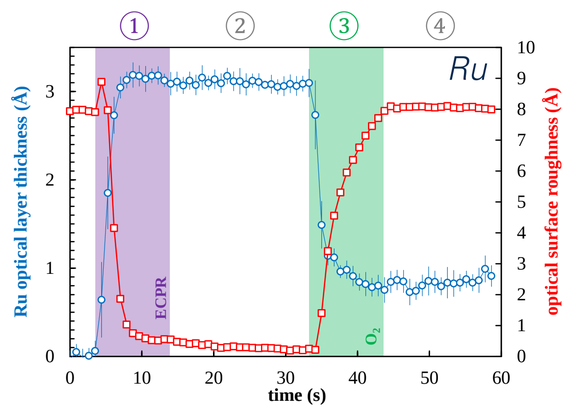
To the right: Atomic Layer Deposition (ALD) process sequence.



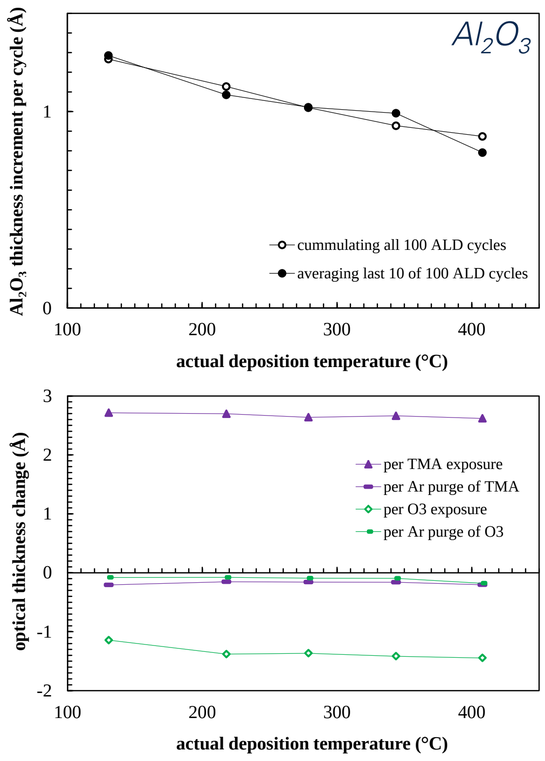








TEMPERATURE IMPACT ON OPTICAL THICKNESS CHANGES



ACHIEVEMENT

In conclusion, we investigated kinetic processes (precursor adsorption, ligand removal, and purging behavior) for the ALD of Al_2O_3, Ta_2O_5, TaN_x, and Ru, respectively, by applying a novel irtSE algorithm that enabled a sampling rate of ~1.25 Hz and thus a desired high time resolution in conjunction with a mean-averaged thickness deviation of < 0.01 nm.[4]

The capability to extend these studies, in order to reveal the impact of various process parameters as well as their (inter)dependencies, was exemplarily outlined here for the temperature (in)dependence of the Al_2O_3 ALD process. Consequently, our irtSE approach might be ideally suited for a much more detailed and at the same time more efficient ALD process development that could screen smaller amounts of innovative precursors in shorter time.

In principle, this could even extend to other deposition or etch processes.

Beyond a process development in basic research or industry, the use of SE for in-situ real-time process control in manufacturing was also possible as SE would detect even smallest deviations from a defined standard in less than one second.

[1] M. Junige *et al.*: *8th Workshop Ellipsometry* (Arbeitskreis Ellipsometrie – Paul Drude e.V., Dresden, 2012)

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