

University of Groningen

## Toward controlled ultra-high vacuum chemical vapor deposition processes

Dresscher, Martijn

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*

Publisher's PDF, also known as Version of record

*Publication date:*

2019

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Dresscher, M. (2019). *Toward controlled ultra-high vacuum chemical vapor deposition processes*. Rijksuniversiteit Groningen.

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

*Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.*

---

## Bibliography

- Abou-Moustafa, K. T. and Ferrie, F. P.: 2012, A note on metric properties of some divergence measures: The gaussian case, *Proceedings of the 4th ACML*.
- Adam, T., Bedell, S., Reznicek, A., Sadana, D., Venkateshan, A., Tsunoda, T., Seino, T., Nakatsuru, J. and Shinde, S.: 2010, Low-temperature growth of epitaxial (100) silicon based on silane and disilane in a 300mm UHV/CVD cold-wall reactor, *Journal of Crystal Growth* **312**(23), 3473–3478.
- Ali, S. M. and Silvey, S. D.: 1966, A general class of coefficients of divergence of one distribution from another, *Journal of the Royal Statistical Society. Series B (Methodological)* **28**(1), 131–142.
- Ames, A. D., Grizzle, J. W. and Tabuada, P.: 2014, Control barrier function based quadratic programs with application to adaptive cruise control, *53rd IEEE Conference on Decision and Control*, pp. 6271–6278.
- Andrieu, V., Jayawardhana, B. and Praly, L.: 2016, Transverse exponential stability and applications, *IEEE Transactions on Automatic Control* **61**(11), 3396–3411.
- Andrieu, V., Jayawardhana, B. and Tarbouriech, S.: 2015, Necessary and sufficient condition for local exponential synchronization of nonlinear systems, *54th IEEE Conference on Decision and Control (CDC)*, pp. 2981–2986.
- Angeli, D.: 2002, A lyapunov approach to incremental stability properties, *IEEE Transactions on Automatic Control* **47**(3), 410–421.
- Antoulas, A.: 2005, *Approximation of Large-Scale Dynamical Systems*, Society for Industrial and Applied Mathematics.
- Arnold, L.: 1990, *Stochastic Differential Equations as Dynamical Systems*, Birkhäuser Boston, Boston, MA, pp. 489–495.
- Aström, K.: 1970, *Introduction to stochastic control*, Academic press.

- Berry, R. W., Hall, P. M. and Harris, M. T.: 1968, *Thin film technology*, D. van Nostrand Company, Inc.
- Bertsekas, D. P.: 1976, *Dynamic programming and stochastic control*, Academic Press.
- Buehler, E. A., Paulson, J. A. and Mesbah, A.: 2016, Lyapunov-based stochastic nonlinear model predictive control: Shaping the state probability distribution functions, *American Control Conference (ACC)*, pp. 5389–5394.
- Cale, T. and Raupp, G.: 1990, Free molecular transport and deposition in cylindrical features, *Journal of Vacuum Science & Technology B: Microelectronics Processing and Phenomena* **8**(4), 649–655.
- Chang, L., Esaki, L., Howard, W. and Ludeke, R.: 1973, The growth of a gas-gas superlattice, *Journal of Vacuum Science and Technology* **10**(1), 11–16.
- Cho, A. Y. and Arthur, J.: 1975, Molecular beam epitaxy, *Progress in solid state chemistry* **10**, 157–191.
- Crouch, P. E. and Van der Schaft, A. J.: 1987, *Variational and Hamiltonian control systems*, Springer-Verlag New York, Inc.
- Dresscher, M., Jayawardhana, B., Barradas-Berglind, J. J. and Scherpen, J. M. A.: 2017, A modeling framework and flux controller for free molecular flow deposition processes, *2017 American Control Conference (ACC)*, pp. 2164–2170.
- Du, Y., Droubay, T. C., Liyu, A. V., Li, G. and Chambers, S. A.: 2014, Self-corrected sensors based on atomic absorption spectroscopy for atom flux measurements in molecular beam epitaxy, *Applied Physics Letters* **104**(16), 163110.
- Eckertová, L.: 1977, *Physics of thin films*, Springer.
- Edgar, T. F., Butler, S. W., Campbell, W., Pfeiffer, C., Bode, C., Hwang, S. B., Balakrishnan, K. and Hahn, J.: 2000, Automatic control in microelectronics manufacturing: Practices, challenges, and possibilities, *Automatica* **36**(11), 1567–1603.
- Fliess, M. and Join, C.: 2013, Model-free control, *International Journal of Control* **86**(12), 2228–2252.
- Forni, F. and Sepulchre, R.: 2014, A differential Lyapunov framework for contraction analysis, *IEEE Transactions on Automatic Control* **59**(3), 614–628.
- Fossum, J. G., Ortiz-Conde, A., Shichijo, H. and Banerjee, S. K.: 1985, Anomalous leakage current in LPCVD polysilicon MOSFET's, *IEEE Transactions on Electron Devices* **32**(9), 1878–1884.
- Gardiner, C. W.: 1985, *Handbook of stochastic methods for physics, chemistry and the natural sciences*, Springer-Verlag GmbH.

- Greve, D. and Racanelli, M.: 1991, Growth rate of doped and undoped silicon by ultra-high vacuum chemical vapor deposition, *Journal of The Electrochemical Society* **138**(6), 1744–1748.
- Grimmett, G. and Stirzaker, D.: 2001, *Probability and random processes*, Oxford university press.
- Ilchmann, A., Ryan, E. P. and Sangwin, C. J.: 2002, Tracking with prescribed transient behaviour, *ESAIM: Control, Optimisation and Calculus of Variations* **7**, 471–493.
- Ilchmann, A., Ryan, E. P. and Townsend, P.: 2007, Tracking with prescribed transient behavior for nonlinear systems of known relative degree, *SIAM Journal on Control and Optimization* **46**(1), 210–230.
- Inamdar, S., Bovolo, F., Bruzzone, L. and Chaudhuri, S.: 2008, Multidimensional probability density function matching for preprocessing of multitemporal remote sensing images, *IEEE Transactions on Geoscience and Remote Sensing* **46**(4), 1243–1252.
- Isidori, A.: 2013, *Nonlinear control systems*, Springer Science & Business Media.
- Itô, K., Henry Jr, P. et al.: 2012, *Diffusion processes and their sample paths*, Springer Science & Business Media.
- Jouffroy, J. and Fossen, T. I.: 2010, A tutorial on incremental stability analysis using contraction theory, *Modeling, identification and control* **31**(3), 93–106.
- Kailath, T.: 1967, The divergence and bhattacharyya distance measures in signal selection, *IEEE transactions on communication technology* **15**(1), 52–60.
- Kárný, M.: 1996, Towards fully probabilistic control design, *Automatica* **32**(12), 1719–1722.
- Kasai, Y. and Sakai, S.: 1997, Atomic absorption spectroscopy system for flux monitoring and atomic-layer control of molecular beam epitaxial growth of bisr-cacuo, *Review of scientific instruments* **68**(7), 2850–2855.
- Khalil, H. K.: 1996, *Nonlinear Systems*, Prentice-Hall, New Jersey.
- Klausmeier-Brown, M., Eckstein, J., Bozovic, I. and Virshup, G.: 1992, Accurate measurement of atomic beam flux by pseudo-double-beam atomic absorption spectroscopy for growth of thin-film oxide superconductors, *Applied physics letters* **60**(5), 657–659.
- Knudsen, M.: 1909, Die Gesetze der Molekularströmung und der inneren Reibungsströmung der Gase durch Röhren, *Annalen der Physik* **28**, 75–130.
- Knudsen, M.: 1915, The cosine law in the kinetic theory of gases, *Annalen der Physik* **48**, 1113–1121.

- Kullback, S.: 1997, *Information theory and statistics*, Courier Corporation.
- Lohmiller, W. and Slotine, J.-J. E.: 1998, On contraction analysis for non-linear systems, *Automatica* **34**(6), 683–696.
- Lu, C. and Guan, Y.: 1995, Improved method of nonintrusive deposition rate monitoring by atomic absorption spectroscopy for physical vapor deposition processes, *Journal of Vacuum Science & Technology A: Vacuum, Surfaces, and Films* **13**(3), 1797–1801.
- Lu, C., Lightner, M. and Gogol, C.: 1977, Rate controlling and composition analysis of alloy deposition processes by electron impact emission spectroscopy (EIES), *Journal of Vacuum Science and Technology* **14**(1), 103–107.
- Meyerson, B. S.: 1986, Low-temperature silicon epitaxy by ultrahigh vacuum/chemical vapor deposition, *Applied Physics Letters* **48**(12), 797–799.
- Meyerson, B. S.: 1992, UHV/CVD growth of Si and Si:Ge alloys: chemistry, physics, and device applications, *Proceedings of the IEEE* **80**(10), 1592–1608.
- Middlebrooks, S. A. and Rawlings, J. B.: 2007, Model predictive control of  $\text{Si}_{1-x}\text{Ge}_x$  thin film chemical-vapor deposition, *IEEE Transactions on Semiconductor Manufacturing* **20**(2), 114–125.
- Nesmeyanov, A. N.: 1963, *Vapor pressure of the chemical elements*, North-Holland.
- Nijmeijer, H. and Van der Schaft, A.: 1990, *Nonlinear dynamical control systems*, Springer.
- Ohring, M.: 2001, *Materials science of thin films*, Academic press.
- Primbs, J. A., Nevistić, V. and Doyle, J. C.: 1999, Nonlinear optimal control: A control Lyapunov function and receding horizon perspective, *Asian Journal of Control* **1**(1), 14–24.
- Rausch, N. and Burte, E.: 1993, Thin  $\text{TiO}_2$  films prepared by low pressure chemical vapor deposition, *Journal of The Electrochemical Society* **140**(1), 145–149.
- Reyes-Báez, R., van der Schaft, A. and Jayawardhana, B.: 2017, Tracking control of fully-actuated port-hamiltonian mechanical systems via sliding manifolds and contraction analysis, *IFAC-PapersOnLine* **50**(1), 8256–8261. 20th IFAC World Congress.
- Risken, H.: 1989, *Fokker-planck equation: methods of solution and applications*, Springer.
- Romdlony, M. Z. and Jayawardhana, B.: 2014, Uniting control lyapunov and control barrier functions, *53rd IEEE Conference on Decision and Control*, pp. 2293–2298.

- Romdlony, M. Z. and Jayawardhana, B.: 2015, Passivity-based control with guaranteed safety via interconnection and damping assignment, *Proc. 5th IFAC Conf. Analysis and Design of Hybrid Systems*.
- Romdlony, M. Z. and Jayawardhana, B.: 2016a, On the new notion of input-to-state safety, *55th IEEE Conference on Decision and Control*, pp. 6403–6409.
- Romdlony, M. Z. and Jayawardhana, B.: 2016b, Stabilization with guaranteed safety using Control Lyapunov–Barrier function, *Automatica* **66**, 39–47.
- Schlom, D. G., Chen, L.-Q., Pan, X., Schmehl, A. and Zurbuchen, M. A.: 2008, A thin film approach to engineering functionality into oxides, *Journal of the American Ceramic Society* **91**(8), 2429–2454.
- Shapiro, L. and Stockman, G. C.: 2001, *Computer vision*, Prentice Hall.
- Slotine, J.-J. E. and Wang, W.: 2005, *A Study of Synchronization and Group Cooperation Using Partial Contraction Theory*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 207–228.
- Sun, J.: 2006, *Stochastic dynamics and control*, Elsevier.
- Vidyasagar, M.: 2002, *Nonlinear systems analysis*, SIAM.
- Vignaud, D. and Mollot, F.: 2007, Real-time in-situ flux monitoring by wavelength-modulated atomic absorption spectroscopy in molecular beam epitaxy: Application to ga flux measurement, *Journal of Crystal Growth* **301**, 79–83.
- Vossen, J. and Kern, W.: 1978, *Thin film processes*, Academic Press, New York.
- Wang, W. and Slotine, J. E.: 2005, On partial contraction analysis for coupled nonlinear oscillators, *Biological cybernetics* **92**(1), 38–53.
- Xu, X., Tabuada, P., Grizzle, J. W. and Ames, A. D.: 2015, Robustness of control barrier functions for safety critical control, *IFAC-PapersOnLine* **48**(27), 54–61.