Overview of doctoral theses on Atomic Layer Deposition collected in the Virtual Project on the History of ALD

ALD history

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Intro: Virtual Project on the History of ALD

The Virtual Project on the History of ALD (VPHA) is a worldwide collaborative Open Science initiative started in summer 2013, set up to clarify the early days of Atomic Layer Deposition (ALD), especially related to its two independent discoveries. In this VPHA, early ALD publications are overviewed up to 1986 in an atmosphere of Openness, Respect and Trust. Also, four scientific journal articles have resulted [1-4]. The VPHA is still open for more volunteers; for the invitation to participate, please see the supplementary information in Ref. 3, or browse through the VPHA website [5].

ALD thesis list

In the VPHA, we are compiling a worldwide list of doctoral theses (and "professor's theses") and analyse trends in it. Anyone is allowed to browse the list and propose entries to it; please find links via the VPHA website [5]. At the time of creating this poster, VPHA's thesis collection contains 511 entries. The PhD-equivalent theses in the collection, up to year 2018, are listed in Table 1. Here, included is: year published, name of author, title in English (translated in the VPHA, if needed), and original language of the thesis. The VPHA website [5] contains additional material such as the thesis title in the original language and name of the university. The cumulative number of PhD-equivalent theses per country is shown in Figure 1, and a map of theses per city in Figure 2.

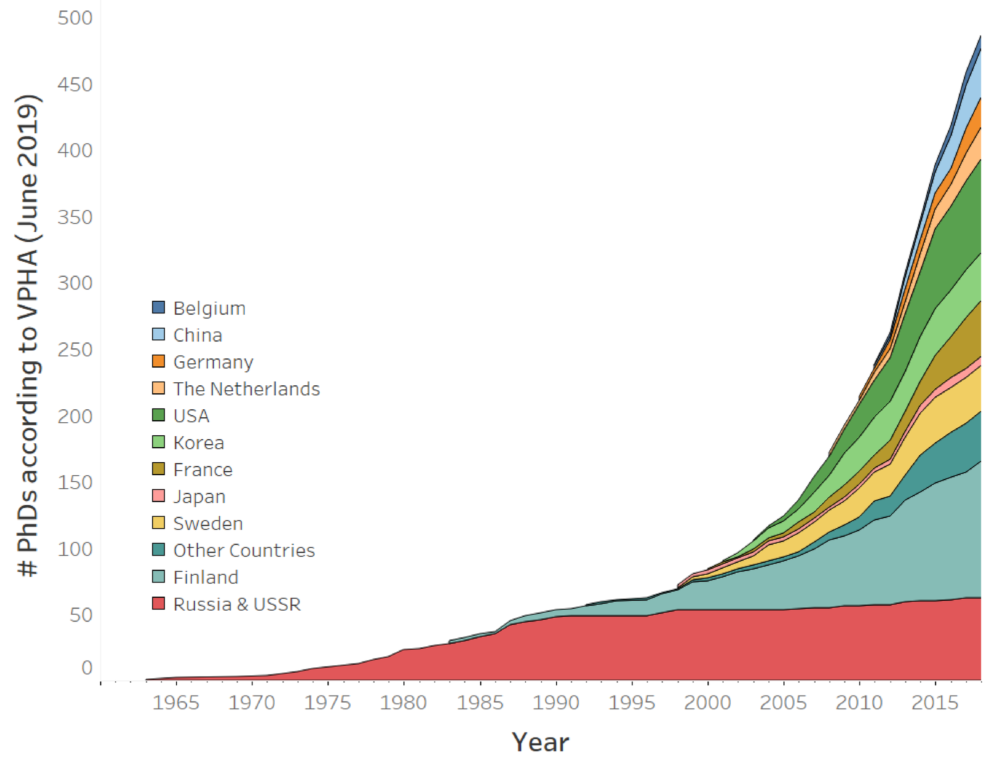

Figure 1. Cumulative plot of doctoral theses on ALD-related topics collected in the VPHA, up to end of year 2018 (date: 18.6.2019).

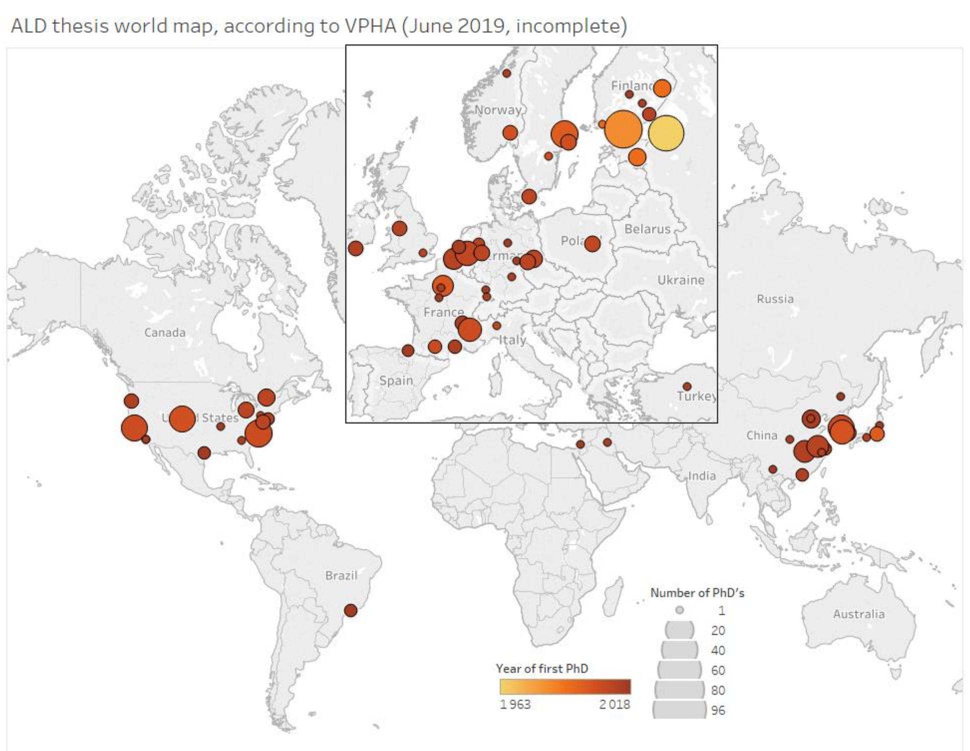

Figure 2. A world distribution plot of doctoral theses on ALD-related topics collected in the VPHA, up to end of year 2018 (date: 18.6.2019). The size of the circles represents the number of records, while the colour represents the first thesis originating from that location.

Conclusion

One way to overview the worldwide development of ALD throughout the decades is to analyse the list of ALD theses worldwide, presented in this work. Currently, the ALD thesis list collected in the VPHA contains over 500 entries from 28 countries. The list is likely to be incomplete; we expect that theses are missing at least from Japan, Italy and Australia. While building a 100% complete worldwide thesis list is probably impossible, we try to approach that situation; to perfect the list, we ask the readers to send us information of missing theses (email preferred: info@vph-ald.com). The aim is to publish the thesis list later as part of a joint scientific journal article.

Acknowledgements: R.L.P. thanks Tuomo Suntola for his support during the VPHA. Aziz Abdulagatov and Annina Titoff are acknowledged for significant help during the initiation of VPHA. The authors are grateful for all volunteers, who in addition to the current authors have shared at least one comment in the ALD-history-evolving-file during VPHA, in alphabetical order (as of June 14, 2019): Simon D. Elliott, Aitor Arandia Gutierrez, David C. Smith. The author list is intentionally in alphabetical order.

Disclaimer: The comments expressed herein are done so as private individuals. Any opinions are the person's own and do not represent the views of the companies/institutes the individual is employed by/affiliated with.

References:

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[5] VPHA website: http://vph-ald.com; thesis list found via http://vph-ald.com/VPHAopenfiles.html

Table 1. List of PhD-equivalent theses on ALD

Year;Author name;Thesis name in English;Language of the thesis

1963;S. I. Koltsov;The study of interaction of carbon tetrachloride with silica gel;Russian
1965;G.N. Kuznetsova;Study of a reaction products between hydrated silica and metal ions by IR spectroscopy;Russian
1969;A. N. Volkova;Interaction of some chlorides with silica gel - reaction of molecular layering;Russian
1971;G.V. Sveshnikova;Synthesis and study of thin oxide layers on the silicon surface;Russian
1972;R. R. Rachkovskii;Synthesis and study of thin oxide layers on the surface of single-crystal silicon;Russian
1973;A. A. Malygin;Interaction of oxychlorides of vanadium, chromium and phosphorous with silica gel - reaction of molecular layering;Russian
1973;V. M. Smirnov;Synthesis and activity study of a thin oxide layers on the silica gel surface;Russian
1974;E. P. Smirnov;Synthesis of carbon and titanium oxide layers on carbon surface by the molecular layering method;Russian
1974;T. V. Tuz;Synthesis and stability of thin oxide layers on the silica gel surface;Russian
1977;M. A. Eremeeva;Synthesis and research by IR - ATR spectroscopy methods and ellipsometry of ultrathin oxide films on the surface of single crystal silicon and germanium;Russian
1977;V. B. Kopylov;Synthesis of carbon layers on the silica gel surface by molecular layering and study of their properties;Russian
1977;V. I. Kovalkov;Synthesis of fine powder with desired structural and chemical properties of their surface using molecular layer deposition and the study of their properties;Russian
1977;A. A. Malkov;Synthesis by molecular layering method of metal oxide layers on the surface of the carbon fibers and study of their properties;Russian
1978;V. E. Drozd;Synthesis and study of oxide coatings obtained by molecular layer deposition technique on the surface of semiconductors;Russian
1978;A. M. Postnova;Study of the structure and reactivity of vanadium containing silica gel obtained by molecular layer deposition;Russian
1978;N. A. Stepanova;Synthesis of iron and zinc-containing layers on the surface of silica gel;Russian
1979;V. K. Gromov;Synthesis by the molecular layering method of titanium oxide layers on the surface of quartz, silicon, copper and ellipsometric study of substrate/ synthesized layer boundary;Russian
1979;V. N. Postnov;Synthesis of inorganic matrices using the molecular layering method and the study of their reactivity in the process of adsorption of amino acids;Russian
1980;S. K. Gordeev;Synthesis of carbon, titanium, and chromium oxides on the diamond surface and study of their physicochemical properties;Russian
1980;V. D. Ivin;Synthesis of carbon and of phosphorus-carbon coatings on the carbon fiber surface and the study of their physico-chemical properties;Russian
1980;B. D. Sokolov;Effect of physical and chemical properties of carbon fiber surface on the reinforcement of composite materials;Russian
1980;V. P. Tolstoy;Synthesis and physicochemical study of ultrathin oxide layers on metal surfaces;Russian
1980;M. N. Tsvetkova;Molecular layering of active structures on the surface of the glass microspheres and study of their physical and chemical properties;Russian
1981;A. V. Krasnobryzhii;Reaction of titanium (IV) and iron (III) chlorides, vanadium (V) and chromium (VI) oxychlorides with various graphite materials;Russian
1982;V. F. Dergachev;Development of technology for gas phase silica gel modification by vanadium;Russian
1982;N. N. Kopylov;Structure and properties of ultrathin titanium oxide layers synthesized on the monocrystalline silicon surface in an electric field;Russian
1983;A. V. Brykalov;Synthesis of silica gel based hemosorbents by molecular layering method and their physico-chemical properties;Russian
1983;A. L. Egorov;Synthesis of thin oxide films on the surface of tantalum and gallium arsenide, their structure and properties;Russian
1983;Veli-Pekka Tanninen;X-ray diffraction studies of aluminium powder and electroluminescent zinc sulphide thin films;English
1983;Runar Törnqvist;Electroluminescence in ZnS:Mn thin film structures grown by atomic layer epitaxy;English
1984;Yu. M. Artemyev;Physico-chemical properties of iron polysilicates synthesized by chemical assembly;Russian
1984;S. E. Kurashvili;The reaction of ammonia with a copper-titanium and copper-vanadium films synthesized on the surface of copper;Russian
1985;A. V. Evdokimov;Synthesis of multicomponent metal oxide monolayers on the silica gel surface and characteristics of their structure and inter-functional interactions;Russian
1985;A. A. Seitmagzimov;Chemical modification and the surface properties of the anode aluminum and titanium oxides;Russian
1985;T. A. Vitkovskaia;Surface modification of photoluminophors by the molecular layering technique;Russian
1986;T. B. L'vova;Chemical modification of coal from the gaseous phase by vanadium (V), chromium (VI), and phosphorus (III) compounds and study of their absorptive properties;Russian
1986;A. B. Zhidkov;Gas phase kinetics of heterogeneous synthesis of titanium carbide and nitride on the surface of carbon materials;Russian
1987;V.I. Gubaidullin;Synthesis and investigation of multilayer regular structures based on A2B6 compounds;Russian
1987;A. N. Kriulkin;Physico-chemical properties of multilayer titanium-vanadium oxide films synthesized by molecular layering method on the surface of silicon;Russian
1987;A. I. Kudryashova;Acid-base properties of silicon, aluminum, zinc, and magnesium oxide surfaces and their changes in the process of structural and chemical transformations;Russian
1987;Jukka Lahtinen;Electro-optical studies of semiconductor compounds for electroluminescent and laser devices;English
1987;V. A. Mitnikov;Synthesis, formation and some properties of zinc chalcogenide films produced by atomic layering;Russian
1987;A.I. Romanychev;Precision synthesis of thin films of zinc and cadmium sulphides and multilayer periodic structures on their basis;Russian
1987;S. A. Trifonov;Synthesis and thermal-oxidative stability of reaction products of phosphorus trichloride and phenolformaldehyde epoxy materials;Russian
1987;A. S. Yakovlev;Properties of interface boundaries between monocrystalline silicon and ultra-thin layers of titanium and silicon oxides synthesized by molecular layering method;Russian
1988;S. V. Murashov;Synthesis and formation of cadmium chalcogenide films by surface chemical assembly;Russian
1988;Markku Oikkonen;X-ray diffraction and ellipsometric studies of zinc sulfide thin films grown by atomic layer epitaxy;English
1988;E. Yu. Popova;Gas phase modification of the dispersed silicon dioxide material by Zn, Fe, Ti containing structures and the use of these synthetic products in polymer composites;Russian
1988;Markku Tammenmaa;The atomic layer epitaxy growth and characterization of zinc sulfide and alkaline earth sulfide thin films for electroluminescent applications;English
1989;E. A. Avrutina;Physico-chemical properties of the optically active titanium oxide structures synthesized by the molecular layering method on the surface of highly dispersed silica and zinc;Russian
1989;V. D. Kupriyanov;Synthesis on the dispersed silicon dioxide surface and modification of the luminescent zinc sulfide type structures;Russian
1990;A. I. Klusevich;The synthesis and properties of thin film structures based on aluminum and tantalum oxides;Russian
1990;P. V. Rogowskii;Physico-chemical properties and reactivity of multilayer vanadium, phosphorus and titanium oxide systems obtained by the molecular layering method;Russian
1991;Structural-chemical transformations on the surface of silicon dioxide by molecular layering, titanium- and silicon-nitrogen structures in the temperature range 200-800°C;Structural-chemical transformations on the surface of silicon dioxide by molecular layering, titanium - and silicon-nitrogen structures in the temperature range 200–800°C;Russian
1992;Pipsa Helena Hirva;Theoretical studies on adsorption interactions on inorganic surfaces: Applications to semiconductors and inorganic oxides;English
1992;Marina Lindblad;Cluster models for chemisorption on non-metallic surfaces;English
1992;Hele Siimon;Atomic layer molecular beam epitaxy of A2B6 compounds described on the basis of kinetic equations model;English
1993;Markku Åberg;An electroluminescent display simulation system and its application for developing grey scale driving methods;English
1993;Suvi Haukka;Characterization of surface species generated in atomic layer epitaxy on silica;English
1994;Lars-Peter Lindfors;Hydrogenation of toluene on supported nickel - from catalyst preparation to reaction kinetics;English
1994;Mikko Ritala;Atomic layer epitaxy growth of titanium, zirconium and hafnium dioxide thin films;English
1996;Markku Ylilammi;Preparation and analysis of thin film electroluminescent devices;English
1997;S. D. Dubrovenskii;Synthesis of vanadium titanium oxide nanostructures on the surface of silica gel and pyrographite and simulation of the processes of their formation;Russian
1997;Janne Jokinen;Time-of-flight spectrometry of recoiled atoms in the analysis of thin films;English
1997;Zh. N. Ishutina;Phase formation and properties of materials in the compositions on the basis of the system Al2O3-SiO2-TiO2;Russian
1997;Arla Kytökivi;Growth of ZrO2 and CrOx on high surface area oxide supports by atomic layer epitaxy;English
1998;I.O. Nikiforova;Formation and investigation of charge properties of MOS structures based on alumina;Russian
1998;Yasutoshi Ohtake;Study of high efficiency Cu(InGa)Se2 thin-film solar cells with various buffer layers;English
1998;O. V. Osipenkova;Local physico-chemical transformations on the surface of silica in the processes of interaction with TiCl4, VOCl3, CrO2Cl2 and H2O;Russian
1998;Baosheng Sang;Study of transparent conducting ZnO grown by atomic layer deposition and its applications to amorphous silicon solar cells;English
1998;Per Tägtström;Vapor phase deposition of WO and WC;English
1998;Marja Tiitta;Studies on precursors and their application in the atomic layer epitaxy growth of thin films for electroluminescent devices;English
1999;Arja Hakuli;Preparation and characterization of supported CrOx catalysts for butane dehydrogenation;English
1999;Kaupo Kukli;Atomic layer deposition of artificially structured dielectric materials;English
1999;Maria Kurhinen;Interactions of Mo(CO)6 and Co2(CO)8 with alumina and silica supports: IR spectroscopic, modelling and temperature programmed studies;English
1999;Per Mårtensson;Atomic layer epitaxy of copper;English
1999;Sari Myllyoja;"Chromium hexacarbonyl supported on alumina and silica surfaces by gas phase adsorption; characterisation and activity in hydrodesulphurisation";English
1999;Sari Suvanto;Co2(CO)8 adsorbed on SiO2 and MCM-41: Gas phase preparation and characterisation;English
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2000;Wei-Min Li;Characterization and modification of SrS based blue thin film electroluminescent phosphors;English
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2000;El Bekkaye Yousfi;Study of Atomic Layer Epitaxy (ALE) of oxides (ZnO, Al2O3) and sulfides (ZnS, In2S3) thin films: In situ quartz crystal microgravimetry and application for Cu(In,Ga)Se2 solar cells;French
2001;Katarina Forsgren;CVD and ALD of Group IV- and V-Oxides for Dielectric Applications.;English
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2002;Jung-Hun Chae;A study on the nickel thin films formed by oxidation-reduction ALD;Korean
2002;Jin-Seong Park;A study on the plasma-enhanced atomic layer deposition of Ta-N, Ti-N and Ti-Si-N thin films;English
2002;Matti Putkonen;Development of low-temperature deposition processes by atomic layer epitaxy for binary and ternary oxide thin films;English
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2002;Timo Sajavaara;Heavy ion recoil spectroscopy of surface layers;English
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2003;Frédérique Donsanti;Comparative study of deposition process of semiconductor thin films from metalorganic precursors : ALCVD reactor and PACVD reactor;French
2003;Woo-Seok Jeon;A study on the Al2O3 thin film deposition by ALD and PEALD;Korean
2003;Jaana Kanervo;Kinetic analysis of temperature-programmed reactions;English
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2006;Oh Seong Kwon;Atomic layer deposition and characterization of SrTiO3 thin films;English
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2007;Igor Arvidsson;Theoretical Investigations of Boron Related Materials Using DFT;English
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2007;Xiaohua Du;Understanding and optimization of gas sensors based on metal oxide semiconductors;English
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2007;Christopher Alvin Wilson;Aluminum oxide and tungsten atomic layer deposition on polymers and nanoparticles;English
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2008;Abuduwayiti Aierken;Passivation of GaAs surfaces and fabrication of self-assembled In(Ga)As/GaAs quantum ring structures;English
2008;Messaoud Benamira;Nanostructured Mixed Conductor for Solid Oxide Fuel Cells (SOFC): Elaboration and Electrochemical Performances of new architectures;French
2008;Beau Bernard Burton;New surface chemistries for the atomic layer deposition of oxides and nitrides;English
2008;Hoi-Sung Chung;A study on the ALD modeling for process design of multi-component thin films;English
2008;Kai-Erik Elers;Copper diffusion barrier deposition on integrated circuit devices by atomic layer deposition technique;English
2008;Stephan Heil;Plasma-Assisted Atomic Layer Deposition of Metal Oxides and Nitrides;English
2008;Kai Kolari;Fabrication of silicon and glass devices for microfluidic bioanalytical applications;English
2008;Satu Korhonen;Effect of Support Material on the Performance of Chromia Dehydrogenation Catalysts;English
2008;Erik Langereis;Plasma-assisted atomic layer deposition: an in situ diagnostic study;English
2008;Ville Miikkulainen;Molybdenum nitride thin films on micro- and nanopatterned substrates: atomic layer deposition and applications;English
2008;Sang Jeong Oh;Spectroscopic Investigation of Hf-Si Oxynitride Alloys and Low Temperature Cobalt Metal ALD;English
2008;Tae Joo Park;New materials in advanced gate stacks for next generation complementary metal oxide semiconductor field effect transistors(CMOSFETs) technology;English
2008;Tero Pilvi;Atomic Layer Deposition for optical applications: metal fluoride thin films and novel devices;English
2008;Mårten Rooth;Metal Oxide Thin Films and Nanostructures Made by ALD;English
2008;Jouni Tiilikainen;Novel genetic fitting algorithms and statistical error analysis methods for X-ray reflectivity analysis;English
2008;Perrine Violet;Thermodynamic and experimental studies of ALD (Atomic Layer Deposition) of TaN and of its organometallic precursor PDMAT, Ta[N(CH3)2]5, used in microelectronics;French
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