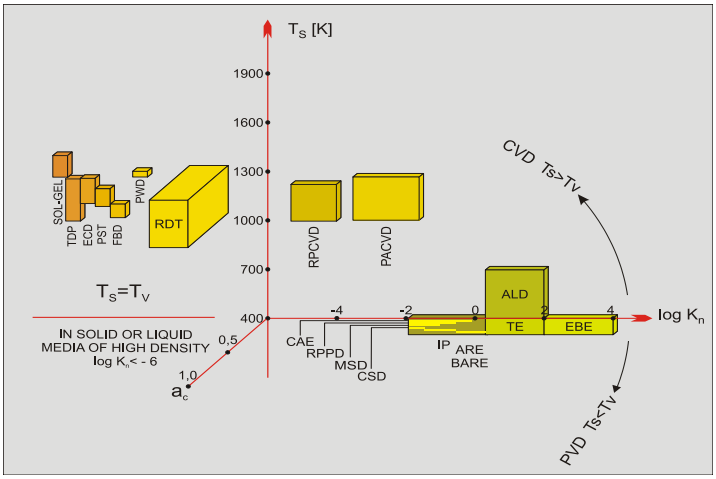
A heuristic system of classification of numerous coating deposition techniques

Prof. Bogdan G. Wendler, Lodz University of Technology, Lodz, Poland

Abstract

Statement of the Problem: Useful product properties demanded from surface of machin elements or of static constructions are different from those demanded from the core of the elements. This inconvenience can be eliminated in a limited number of cases or situations by thermal, mechanical, chemical, or thermomechanical treatments, however in most cases such problems can be surmounted by deposition of so called functional coatings, which are being deposited on the surface of the elements under consideration with use of a very great number of specific methods and techniques as, among others, CVD and PVD ones. In fact that number is steadily increasing and it looks like it is unlimited, taking into account an unlimited growth in science, techniques and technologies. In this situation it is obvious that any systematic would help to compare different deposition techniques with each other in order to choose the more convenient one. In the past there were undertaken some attempts (as, e.g., Ohring, 1992; Bunshah, 1994; Mattox, 1998; Burakowski & Wierzchoń, 1999). Unfortunately, only a limited number of different methods and techniques could be taken into consideration within any of the above mentioned systems. A reasonable solution of the problem could be a classification of a very great number deposition methods and techniques given by B.G. Wendler in 2001 [1] (see Fig. 1) which can be easily extended to any existing method or, eventually, to new ones in the future. One can see from the Figure that the following parameters are relevant to the systematic, independently of neither an aggregation of the medium, in which the deposition process is carrying on, nor of a particular pressure during deposition, nor of the dimensions of a particular reactor for coatings deposition: 1) Knudsen number Kn=λf/Dr where λf is a mean free path of atoms or ions used for constitution of the planned coating and Dr is a characteristic dimension of the reactor used for deposition; 2) Substrate temperature Ts; 3) Kinetic temperature Tv of atoms or ions in the medium used in the deposition process; 4) ac – is an activity of carbon atoms in the substrate, which is of concern only when carbon or carbonitride coatings are being deposited onto a steel substrate, or, in a case of other substrates, which react with the surrounding media and constitute the growing coating together with other elements. Other abbreviations used in the Fig.1 are explained below: ALD-Atomic
Layer Deposition; ARE - Activated Reactive Evaporation; APCVD

Image



Atmospheric Pressure CVD; BARE - Biased ARE; CAE - Magnetron Sputtering; MOCVD – Metal - Organic CVD; PACVD- - Plasma Assisted CVD; PST – deposition from pastes; PVD - Physical Vapour Deposition; PWD - Deposition by diffusion in powders; RDT - Revers Duplex Technology; athodic Arc Evaporatyion; CS – Cathode Sputtering; LTCVD - Low Temperature CVD; MS- RPCVD - Reactive Plasma CVD; RPPD - Reactive Pulse Plasma Dposition; S–G means a Sol-Gel deposition technique; TDP - Toyota Diffusion Process; TE - Thermal Evaporation. The above mentioned methods and techniques were chosen by the author for the sake of an example and at typical values of process parameters for particular processes. It is worth to mention that the values of the Knudsen number K_n of several processes shown in the Figure can differ even more than by 10 orders of magnitude.

Conclusions & Significance:

In the approach a new heuristic classification system of functional coatings deposition methods and techniques is proposed. It is based on four basic parameters and allows comparison of much greater number of known methods and techniques than the former systems proposed in the past.

Ref. [1]. Wendler B.G.: Making use of a reactive up-hill diffusion for surface betterment of steel substrates. Scientific Dissertation No. 290, 1st ed., Editing House of the Lodz University of Technology in Lodz, Poland, 2001.

Photograph

Biography

Prof. emeritus Bogdan G. Wendler, graduated of the University of Lodz in 1963, s tarted to work in the Lodz University of Technology (LUT) in 1967, where created a research facility for metallic, ceramic and composite coatings. He has been giving lectures and exercises in seven subjects of study in Polish, English and French and organized laboratories in three high technical schools in Poland and abroad. He is an author of two monographs, of 177 papers published in Poland and abroad, cited 978 times, Hirsch Index 20, author and co-author of 12 patents, promoter of 12 Ph.D. students from Poland and abroad, manager or contractor of 13 National and of 3 European grants, completed 8 internships, secretary or member of Scientific Committees of 16 National and International Conferences and delivered 70 oral presentations during National and International Conferences. Awarded the Golden Cross of Merit, Knight's Cross of the Order of Polonia Restituta, Knight's and Officer's Cross of the Belgian Order „Mérité de l' Invention", Medal of Merit from LUT, Medal of the 10th Anniversary of the International Training Center at LUT, Tadeusz Sendzimir's Medal, 5 Awards granted by the Minister of Higher Education in Poland as well as 15 Gold Medal Prizes granted by Presidia of International Salons and Exhibitions of Inventions and Innovations. Reviewed 8 doctoral and habilitation theses, 40 grant applications as well as 95 manuscripts for Editorial Boards of national and international scientific magazines devoted to coatings deposition. Professor Senior of the LUT from 2021. Speakes English, French, German, Russian, Spanish and Ukraine.

Email: bogdan.wendler@p.lodz.pl