From superconducting CVD layers on carbon fibers to anti-adhesive scratch resistant surfaces for cooking devices

20 years collaboration with Georg Wahl

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In 1981 in the Institute fuer Chemische Technik of Universitaet Karlsruhe (T.H.) nowadays KIT, Prof. Erich Fitzer, managing director, introduced an industrial research partner and incoming new visiting lecturer from BBC Corp. Heidelberg Germany to me, who was famous for his firm squeezing handshake. His name was Dr. Georg Wahl.

We became colleagues for 20 years and friends until he passed away. With his personal background in physics and the unique research facilities at Brown Boveri Co. laboratories he was a pioneer in materials research on non-metallic superconductor materials and structures. The famous research team with Prof. Heinz from Karlsruhe Nuclear Research Center and Dr. K. Brennfleck from ICT Karlsruhe, were the first ones using flexible carbon fiber ribbons as substrates for CVD and PVD based ceramic superconductive coatings. Oxide ceramic high T_c superconductors based on $YBa_2Cu_3O_{7-d}$ were employed for PVD processing based on solid targets with the same corresponding phase composition and crystal structure. Karl Brennfleck and Franz Schmaderer, both in close collaboration with Georg Wahl, developed the alternative CVD deposition technique in hot and cold wall tubular reactors at ICT Karlsruhe in the 1980's based on volatile metalorganic precursors and subsequent optimized heterogenous reaction kinetics to obtain the desired solid film. With a Tc of 90 K and a current density above 10^6 A/cm^2 these coated fiber tapes were the most promising and best performing superconductors at that time.

Georg Wahl had always in mind, that the experimental results needed a deeper theoretical understanding with respect to the thermodynamics and deposition kinetics of the complex crystal structure of these ceramic phases. Erich Fitzer developed the concept and theory of chemical reaction kinetics for non-catalyzed heterogeneous reactions, especially on carbon and graphite as substrate materials. Heat and mass transfer and the fluid dynamics in various CVD reactor types were in the center of Georg Wahl's research including temperature gradient and pressure gradient reactor types. So as a consequence of that he accepted the appointment to become full professor and chair for surface technologies at Technische Universitaet Braunschweig in the 1990's.

His new responsibilities did not only include his beloved research but also the teaching obligations in a broader field of surface technologies. This became a common approach, just as when I was appointed full professor in Stuttgart 1995 with the teaching of all advanced surface technologies with a focus on high energetic technologies, such as plasma spray coatings and supersonic flame spray coatings. Structural and functional coatings with high added value in technical physics and advanced mechanical and energy engineering was a common research field, where, in various cases, market ready solutions had to be elaborated in our institutes and offered to the industrial partners.

With his background in physics and our focus on process and manufacturing engineering, we combined our expertise to create valid technical solutions. In the case of our Ph.D. students that meant also the collaboration as examiners for both our faculties. A remarkable solution was elaborated for a Braunschweig company, which was a market leader for industrial cooking devices; i. e. the griddle plate as they were used in thousands of McDonald restaurants. Scratch resistance and anti-adhesive functionality were crucial requirements in a very harsh environment. A few years later combined ceramic and metallurgical coatings were developed for the latest generation of low energy consumption glass ceramic surface heaters. Overcoming the physical and chemical incompatibilities of glass ceramics, insulators and metal conductors was not only a technical challenge but a further motivation to study nano- and microscale materials mechanics to understand the critical role of residual stresses in such multilayer coating structures.

While we had the focus on the product's performance and reliability, Georg wanted to understand the fundamental physical effects during the PVD and CVD processes in the various types of reactors. Summarizing to some extent, we both worked on the path given by the legacy of the late Prof. Erich Fitzer, the father of isothermal CVD in chemical and mechanical engineering applications in the German speaking countries, with so many innovations in nuclear energy applications. Twenty years later M. Floristan from IFKB Stuttgart developed the ceramic functional coatings for the cryo- pump absorbers for the nuclear fusion reactor of the EU in Greifswald. Research is mainly driven by intelligent, hard-working and creative individuals, but there are add-ons if loyal friends in a community and a scientific family collaborate. That is why Georg Wahl will not be forgotten.