Two decades of HIPIMS technology: challenges and innovations enabling industrial success

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Since beginning of the millennium the HIPIMS technology is developing very fast. Within only 20 years the HIPIMS has become a mature technology with hardware and process knowhow optimized for industrialization. Yet, in many industries the great quality of HIPIMS-deposited coatings was not able to balance the expenses necessary to change previous plasma sources and mass production recipes for HIPIMS. Furthermore, the implementation of HIPIMS technology was slowed down due to the lower deposition rate compared to DC, pulsed-DC or MF technology. In the high precision coating industry such as ophthalmic or display, industrialization of HIPIMS suffered also from insufficient controllability of power supply working parameters, especially when scaling form laboratory to industry size was done and HIPIMS peak current and voltage must reach or exceed 1kA and 2kV, respectively. Operation with such high current and voltage sets rigorous performance and reliability requirements for the HIPIMS units. In addition, the ability to detect and suppress high-current arcing is crucial to avoid deterioration of coating's quality by macroparticles. Finally, the HIPIMS hardware must allow an easy integration in the production system, providing necessary interfaces as well as communication with other power supplies installed on the system i.e. for synchronization of arc suppression.

Very recently the industry has finally made next step and integrated HIPIMS into standard production processes. Since the application of HIPIMS shall bring indisputable advantages into different applications it seems to be necessary to review the two decades of HIPIMS technology development from the perspective of its transfer into industry and analyze challenges and solutions which made this transfer possible. Several technical advancements of HIPIMS plasma deposition will be highlighted as milestones of HIPIMS industrialization. Discussion will be opened with the development of the HIPIMS pulse shape and peak current increase control and their influence on the plasma composition. The flexibility in the HIPIMS peak shaping will be demonstrated to be the key success factor in operation on materials with poor electrical conductivity, prone to arcing such as Si in Ar+O2 and Ar+O2/N2 atmosphere. Furthermore, application of HIPIMS on rotatable dual magnetron arrangements will be demonstrated to increase the stability of reactive processes also on largest-available systems used for architectural glass coating. As next, the deposition rate issue will be analyzed separately for single- and multi-magnetron systems as it can be found in real industrial applications. The influence of synchronization of substrate bias with HIPIMS pulses will be discussed as an effective method for arc-related coating failure elimination and enhancement of coating's quality. Thus, the application of HIPIMS for deposition of high quality ITO and DLC thin films, which not long ago was not possible to achieve on industrial scale, will be presented. The discussion will be concluded with a summary of the Design of Experiment (DoE) application as a convenient method at the early stage of HIPIMS introduction into new industrial process.