IMPORTANCE OF STATISTICAL DESIGN OF EXPERIMENTS FOR PVD DEPOSITION

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Physical Vapor Deposition (PVD) is a primary method for depositing various types of protective coatings, which has undergone significant advancements in materials development, applications, design, and quality assurance. However, a major drawback of the PVD process is the high cost associated with machine time dedicated to part production. Hence, there is a pressing need to accelerate the process, making widespread application more economically feasible.

This study aims to enhance the sustainability of deposition processes. As a result, other process parameters will be adjusted to ensure complete densification of the part. Moreover, optimization efforts will consider additional aspects of product quality, including surface finish, hardness, and microstructure.

This study employed statistical Design of Experiments (DoE) and regression analysis to optimize crucial parameters in PVD deposition. Multiple experimental campaigns were conducted using a similar DOE matrix (central composite design) but with varying deposition modes. Consistent specimen geometry was maintained throughout the experiments. Regression analysis was used to identify a processing window with an optimized combination of applied power (U_i), duration of impulse, and working pressure in the chamber. Hardness measurements were used as the basis for these optimizations.

To develop a model for predicting optimal conditions that yield the highest hardness, a regression analysis was conducted. Furthermore, considering the number of experimental runs and the range of variables employed, the most significant terms influencing the outcome (hardness) can be identified.

The analysis underscored the importance of certain variables and their impact on the outcome, particularly in the deposition of TiN and ZrN coatings using the PVD method. Notably, the duration of pulsing (τ) and pressure (p_N), along with their interaction, emerged as the most influential factors in the model. These results validate that samples exhibiting higher hardness values were linked to optimal levels of these variables.

That is why it is important to run the DoE for PVD deposition, because it lies in its ability to systematically optimize process parameters to achieve desired outcomes efficiently and effectively. While cost considerations are certainly a factor, the primary benefits of DoE in PVD deposition are: efficient optimization; reduced experimental runs; increased understanding; robustness and reproducibility.

Overall, while cost efficiency is a consideration, the primary importance of statistical Design of Experiments for PVD deposition lies in its ability to optimize process parameters, increase understanding, and improve the reliability and reproducibility of results.