**Software for Simulation, Planning, and Control of Physical Vapor Deposition Processes**

**Disclosure Number**

* S107

**For Licensing Information  
and Patent Status**

Bradley Swope  
Sr. Technology Licensing Officer  
Office of Technology Management  
[bradswope@psu.edu](mailto:bradswope@psu.edu)  
Phone: 814-863-5987  
Fax: 814-865-3591

Electron beam physical vapor deposition (EB-PVD) is a versatile coating process that enables the design and production of tailored microstructures such as, functionally graded coatings, nanostructured coatings, and new materials that can not be produced economically by conventional methods. This patentable software-based technology provides for a model that can acquire key dynamics of the EB-PVD system, including proper modeling of substrate shape, motion and microstructure.

**Background**

Electron beam physical vapor deposition (EB-PVD) is a versatile coating process that enables the design and production of tailored microstructures such as, functionally graded coatings, nanostructured coatings, and new materials that can not be produced economically by conventional methods. EB-PVD can lay down a variety of metallic and ceramic coatings (oxides, carbides, nitrides) at relatively low temperatures and these coatings usually have a good surface finish and a uniform microstructure. Developing detailed process models of an EB-PVD system requires a complete understanding of mechanisms such as melting, evaporation, and deposition. The complexity of the process is exacerbated by the inability to correctly predict a particle's properties in a vapor plume and by the ability to manipulate the substrate which changes the vapor incidence angle significantly. As a result, the accuracy of existing process models is poor and it has become impractical to apply modern control methods such as adaptive control, predictive control, multivariable control and robust control. A unified process model combining all aspects of the EB-PVD deposition process and providing an efficient model for predicting and optimizing EB-PVD deposition is needed.

**Invention Description**

This patentable software-based technology provides for a model that can acquire key dynamics of the EB-PVD system, including proper modeling of substrate shape, motion and microstructure. This is accomplished by dividing the EB-PVD process into a combination of simplified systems and developing a unified model that is more easily simulated. The invention allows for the combination of the simplified processes to be divided into at least three basic models. These models can then be cascaded where the output of one model can be used as an input of a next model. For EB-PVD control, an EB-PVD system can receive optimum conditions generated by the model, provide dynamic readings and process optimization data, and allow for consideration of process constraints such as process cost, coating uniformity, collection efficient and coating lifetime.

**Advantages**

Unified, accurate process model useful for process planning EB-PVD systemsSimulation and feedback control of EB-PVD processesWill lead to systematically engineered EB-PVD processes with high repeatability and low variance instead of the "trial and error/ recipe-based methods" used in industry