ME450 W10 – Team 4

Layer-by-layer (LBL) Assembly of Nanocomposites on a Rotating Drum Substrate

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Layer-by-layer (LBL) self-assembly of nanocomposite materials is a process used to create films with exceptional properties for application within the fields of mechanical, materials science, chemical and biomedical engineering, among others. This project expands the concept of using a rotating drum substrate onto which nanocomponents are applied, as demonstrated successfully in previous work by the MRoller [ME450 Fall 2008].

The purpose of the present work is to create a robust and extensible system for applying bilayers of up to four separate nanocomponents. The new system improves the existing MRoller design by expanding the dimensions of the finished product, using spray nozzles to achieve uniform film thickness, and providing compatibility with a computerized user interface to control the process. The new machine achieves a more compact footprint, with reservoir storage and pumping systems on the unit. These objectives have been accomplished by constructing an entirely new device that applies some underlying concepts from the MRoller design.

The present concept has been based on engineering specifications developed through interviews with the sponsor, users of the current MRoller machine, vendors, and technical experts. These specifications are summarized in the full report. The customer has requested a robust, versatile design that will become a fixture in the lab for fabricating LBL films for research. The machine uses high-quality mechanical components, delivering a final design product which is fully functional and ready for use in the laboratory.

The final design consists of a large rotating drum within a square chamber that is separated into four quadrants, for a maximum of four different nanocomponent solution spray modules. Air-atomizing sprayers provide a predictable, even pattern of spray coverage, while rinse-water removes excess particles and air knives ensure uniformity of layer thickness. A drip-pan channels excess waste-water and solution from the spray chamber, while through-wall connections ensure isolation of fluid from electrical components beneath. Solenoid valves can be installed to control system operation.

Challenges in the design and fabrication process involved the many subsystems and their integration. To interface with purchased components, some unique components were machined in-house or sent to custom fabricators. Other challenges include accurate and repeatable positioning of the sprayers, requiring fine-tuning by someone familiar with spray patterns and their affects on the LBL process. Due to concern over strong currents caused by the air knives, an optional diffusing barrier was implemented to avoid disturbing the spray patterns of either the nanocomponents or the rinse-water.

Each subsystem was analyzed logically and quantitatively, where appropriate, to select the optimum components, manufacturing methods and external vendors. After thorough engineering parameter analysis, the final design was proposed and executed. Testing suggests that the machine can meet engineering specifications and exceed customer expectations.