

Improving Sustainability of Atomic Layer Deposition: A Hierarchical Systems Approach

**Tien-Chien Jen, Professor, ASME Fellow
Head, Department of Mechanical Engineering Science
Director, UJ-Nanjing Tech Joint Research Center
Director, UJ Manufacturing Research Center
University of Johannesburg, South Africa**

Outlines of the Seminar

This presentation will focus on the development of mathematical models and tools for reducing the environmental impact and economic costs of ALD nano-manufacturing processes. A systematic investigation has been performed and there are three major research objectives as stated follows:

Objective 1: Mathematical modeling and experimental investigations of ALD process emissions

- 1.1. Modeling and validating the ALD precursor use and emission generations
- 1.2. Experimental investigations of ALD nano-particle emissions

Objective 2: Thermodynamic flows and energy modeling of ALD nano-manufacturing system

- 2.1 Modeling thermodynamic energy flows in ALD system
- 2.2. Development of a mathematical energy model for ALD system

Objective 3: Sustainable scale-up of ALD nanotechnology for industrial productions

- 3.1. Sustainability of batch-size ALD production system
- 3.2. Sustainable development of roll-to-roll fast ALD nano-manufacturing technology

This research work was supported by National Science Foundation (NSF) of USA with the funding amount of \$475,902.

Short Bio for Tien-Chien Jen

Prof Jen joined University of Johannesburg on August 2015, before that Prof Jen was a faculty member at University of Wisconsin, Milwaukee. Prof Jen received his Ph.D. in Mechanical and Aerospace Engineering from UCLA, specializing in thermal aspects of grinding. He has received several competitive grants for his research, including those from the US National Science Foundation, the US Department of Energy and the EPA. Dr. Jen has brought in \$3.0 million of funding for his research, and has received various awards for his research including the NSF GOALI Award. Prof Jen has recently established a Joint Research Centre with Nanjing Tech University of China on the "Sustainable Materials and Manufacturing." Prof Jen is also the Director of Manufacturing Research Centre of the University of Johannesburg. Meanwhile, SA National Research Foundation has awarded Prof Jen a NNEP grant (National Nano Equipment Program) worth of USD 1 million to acquire two state-of-the-art Atomic Layer Deposition (ALD) Tools for ultra-thin film coating. These two ALD tools will be the first in South Africa and possibly the first in Africa continent.

In 2011, Prof Jen was elected as a Fellow to the American Society of Mechanical Engineers (ASME), which recognized his contributions to the field of thermal science and manufacturing. As stated in the announcement of Prof Jen Fellow status in the 2011 International Mechanical Engineering and Congress Exposition, it states "Tien-Chien Jen has made extensive contributions to the field of mechanical engineering, specifically in the area of machining processes. Examples include, but not limited to, environmentally benign machining, atomic layer deposition, cold gas dynamics spraying, fuel cells and hydrogen technology, batteries, and material processing." Prof Jen has written a total of 210 peer-reviewed articles, including 84 peer-reviewed journal papers, published in many prestigious journals including International Journal of Heat and Mass Transfer, ASME Journal of Heat Transfer, ASME Journal of Mechanical Design and ASME Journal of Manufacturing Science and Engineering. He also has written many chapters in special topics book. For example, Prof Jen has a chapter in Numerical Simulation Proton Exchange Membrane Fuel Cell, published by WIT Press, and another chapter in Application of Lattice Boltzmann Method in Fluid Flow and Heat Transfer in Computational Fluid Dynamics – Technology and Application.