Brief Vitae of C. Richard Liu, Purdue University

Dr. Liu is interested in research for understanding the inter-relationships among structure, property, performance and processes of materials at macro, micro and nano scales. He has applied this understanding from his past research for creating large scale benefit for industrial competitiveness. (See next section on **Research Accomplishment)**

Current Research: Dr. Liu's current research covers the development of high-rate nanomanufacturing methods and the study of the relationships among structure, property, performance and the manufacturing processes for engineering cost-effective nano-structured materials and energy devices. Current research projects include high rate methods of making heterogeneous nanomaterials and the study of the effect of processing methods and parameters on the structure, morphology and performances of nanomaterials and nanocomposites. (Figure 1: Porous nanotube arrays produced by a new high-rate method; Figure 2: Surface enhancement by sintering with nanomaterials)

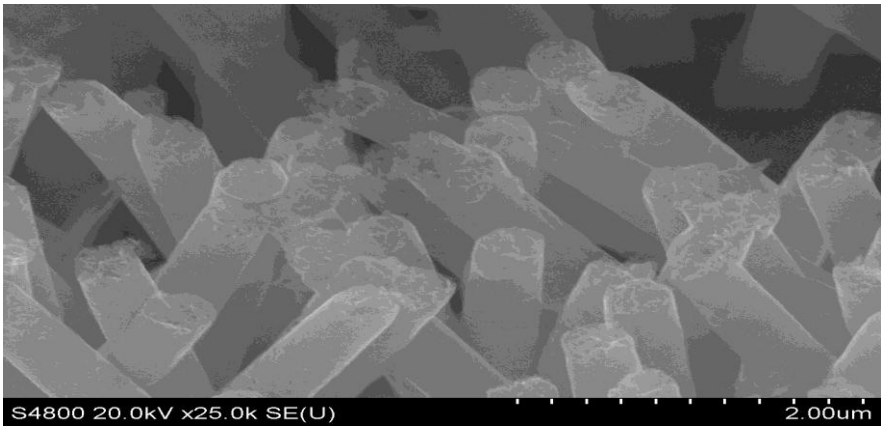


Figure 1: Nanotubes produced by a new process for energy storage [Liu, 2012]

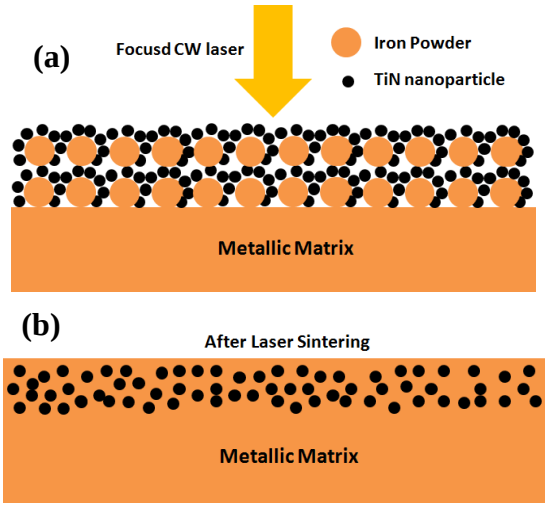


Figure 2 Surface Enhancement: Laser sintering of mixed iron and TiN nanoparticles on AISI 4140 surface. Illustrative cross-section of a sample (a) after surface coating, and (b) after laser sintering [Lin, Cheng, Liu, 2013].

Another area of interest is to develop cost-effective solar cells. He has supervised a project having developed a novel manufacturing method reducing the cost from region I to II and doing research to move it to region III, as shown in Figure 3.

$$\$/W = \frac{Cost\ (\$/m^2)}{Efficiency \times 1000\ W/m^2}$$

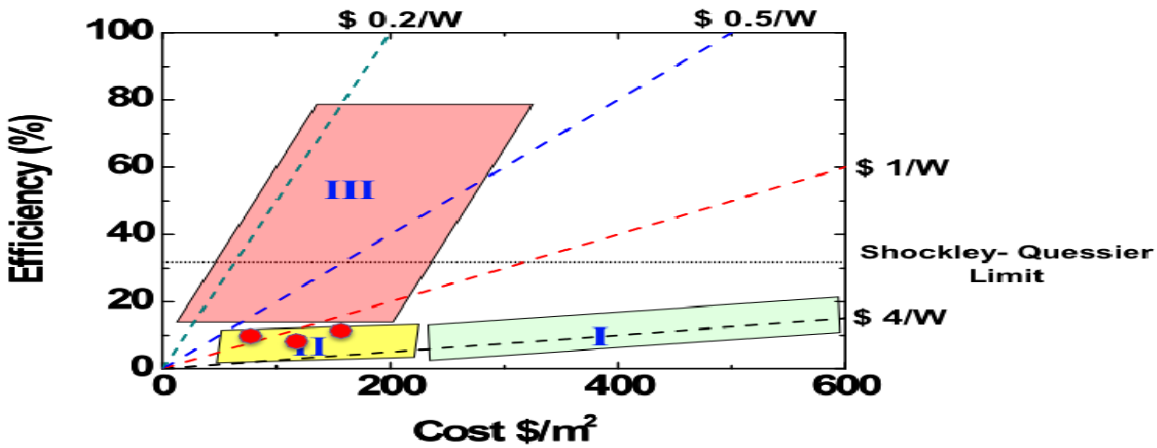


Figure 3 Cost Effective Manufacturing of Solar Cells: Improving Region II.

A third area is to study the fatigue performance of materials manufactured by real industrial processes. Our current effort is on the modeling of crack behavior at the lattice level of engineered materials including micro and nano structures in solid. (See Figure 4 below; Voothaluru and Liu, accepted for publication.)

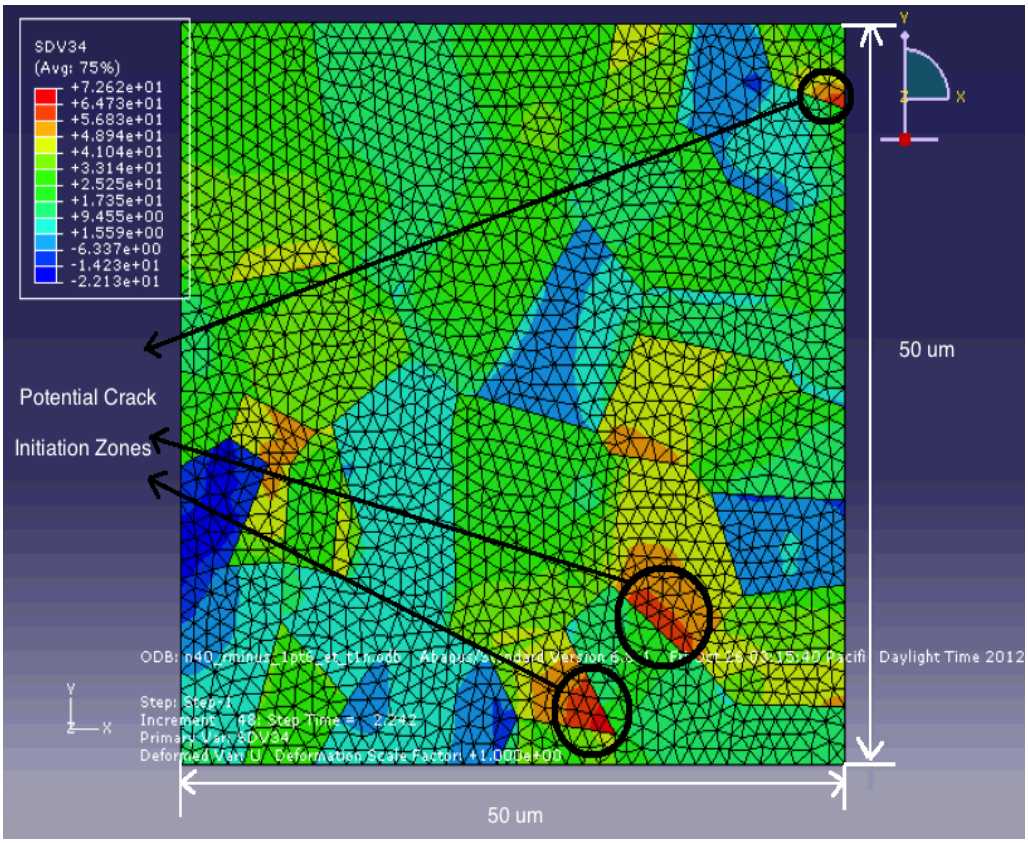


Figure 4: Sample FEM Computing for Crack Initiation

Research Accomplishment: Dr. Liu is considered a pioneer of and a leader in the field of manufactured surface integrity. Among professional society-level research awards, he received the 2008 ASME Ennor Manufacturing Technology Award, "***for his seminal research on the integrity and fatigue performance of finish machined surfaces leading to significant impact on cost, reliability and safety for load-carrying components made of hardened steels."*** An important impact of this research was the rolling contact fatigue theory and experiments showing the tremendous influence of selecting manufacturing conditions on improving the material microstructure and fatigue performance. [Figure 4] This is revolutionizing the manufacturing industry making load-carrying components, such as bearings, with significant performance improvement at reduced cost.

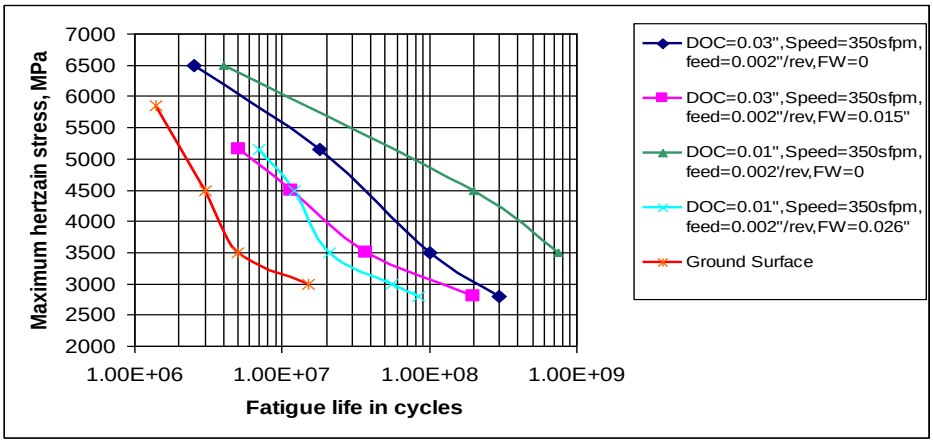
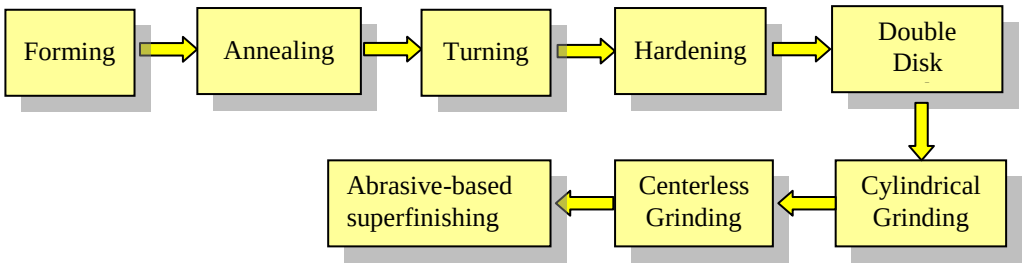
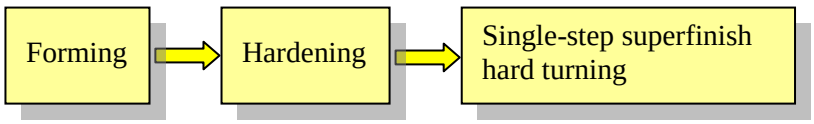


Figure 4. Fatigue life as affected by manufacturing conditions [Agha and Liu 2000]



(a) Conventional method in production



(b) Developed innovative single-step hard machining (Liu and Mittal,1995)

Figure 5. Process simplification for manufacturing bearing races.

He also received 2011 Society of Manufacturing Engineers NAMRI S. M. Wu Research Award, ***"for having created finish/superfinish hard machining, leading to a new market***

and a science base for engineering a new generation of processes, machine tools, cutting tools and manufacturing systems." [Figure 5]

He has modeled rolling contact fatigue life (crack initiation and propagation) including the effect of manufacturing processes. Four of his journal papers were selected as "top 25 of the hottest (most downloaded) papers" in a specific quarter by ScienceDirect, which publishes a large number of research journals. [Choi and Liu 2006, Liu and Choi 2008a and 2008b, Choi and Liu 2009]

In 1980, he proposed the concept of a new industrial structure of separating the design and manufacturing businesses in vertically integrated companies. This concept has evolved into the current structure of global supply-chain based manufacturing. While on leave from Purdue, he served as a Vice President of Industrial Technology Research Institute of Taiwan which employed 5000 researchers. His effort has helped the creation of an auto engine design and manufacturing infrastructure and a competitive CNC machine tool industry in Taiwan.

Early in his career with Whirlpool, he developed an innovative automatic washer based on scientific understanding of the complex interactions of mechanical energy, detergency and dynamics of clothes motion in fluid. This new design has dominated American market for over 30 years. Through a large project funded by Office of Naval Research, he developed the fundamentals and applications of machine error modeling and compensation, resulting in one order of magnitude improvement on both precision and accuracy of metal cutting machine tools, enabling the single-step finish machining mentioned above. Now this technology is widely applied in CNC controllers and CNC machine tools.

RESEARCH INTEREST AND EXPERTISE

Structure, morphology, integrity and performance for functional materials and components at nano, micro and macro scales, high throughput nanomanufacturing, finish/superfinsih hard machining, advanced manufacturing processes and manufacturing equipment, competitive manufacturing, modeling and prediction of fatigue crack initiation and propagation, technology innovation.

PROFESSIONAL EXPERIENCES

-Professor of Industrial Eng., Purdue University, 1985 to present,
-Associate Head-Graduate Program, Industrial Engineering, 2007-2011.
-Vice President of Industrial Technology Research Institute and General Director of Mechanical Industry Research Laboratories, Taiwan. 1/1991 to 1/1994 (on leave from Purdue University),
-Program Chairman, Int. Conf. on Manufacturing Technology, 1991-1999, (designed and implemented a new program structure for providing visions of emerging technologies)
-Associate Professor of Industrial Engineering, Purdue University, 1978-81, 1982-85,
-Assistant Professor of Mechanical Engineering (Design), Stanford University, 1975 to 1978,
-Research Engineer, Whirlpool Corporation, Sept. 1972 to August 1975, (developed the dominant design of automatic washers for the US market)

HONORS AND AWARDS

- Society of Manufacturing Engineers/NAMRI S. M. Wu Research Award, 2011.
-ASME Ennor Manufacturing Technology Award, 2008.
-Fellow, American Society of Mechanical Engineers, since 1992.
-Fluke Distinguished Professor, University of Washington. (elected in open search, 1989)
-Reviewer for National Chair in Eng. and MoEd Research Awards, Ministry of Ed, ROC. Since 2000.
-General Co-chairman, North American Manufacturing Research Conference, 2002.
-Distinguished Performance Citation, ITRI, ROC, 1994. (see above for details)
-IR 100 Award, 1985. (with a NIST team)
-ASME Blackall Award, 1984. (Best Paper in Manufacturing Engineering, ASME)
-SME Outstanding Young Manufacturing Engineer Award, 1981. (One of five selected)
-Invited speaker (5 times), Int. Conf. Mfg Technology (1991, 1993, 1995, 1997, 1999)
-Advisor and site reviewer for US Department of Commerce for a large grant to Singapore on developing CAD/CAM Programs, 1988.
-Invited speaker, CIRP Int. Conference on Intelligent Manufacturing, 1985.
-Invited Speaker, ASME Symposium on Hard Turning, 2000.
-Keynote Speaker, International Conference on Automation Technology, 1991.
-Keynote Speaker, International Conference on Precision Engineering, 1997.
-Keynote Speaker, International Conference on Automation Technology, 2000.
-Keynote Speaker, International Conference on Mechanical Engineering, 2001.
-Keynote Speaker, International Conference on Industrial Eng. and Eng. Mgt, April, 2004.
-Keynote Speaker, International Conference on Advanced Manufacturing, December, 2005.
-Keynote Speaker, International Conference on Advanced Manufacturing, March, 2012.
-US Patent (Liu and Mittal), "Method of Manufacturing a Component," 1999. (For a new process design methodology enabling finish/superfinsih hard machining.
-Published over 160 refereed research papers.
-Initiated and developed curriculum at Purdue University in teaching Innovation, Leadership and Effectiveness to engineering students.
-Listed in “Who Is Who in America: Science and Engineering”.

Current Research Projects

High-rate manufacturing of discrete nanostrucutures with battery applications
Competitive manufacturing of solar cells
Laser sintering of 1 and 2 D nanostructures
Modeling of fatigue initiation at lattice level

New Course Development

Competitive Strategy
Product and Process Innovation

Recent Refereed Publications

Choi, Y. and Liu, C. R., 2006, “Rolling Contact Fatigue Life of Finish Hard Machined Surfaces: Part 1. Model Development,” Wear, **261**, pp. 485-491. (ScienceDirect Top 25 Hottest Articles).

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Huang, R., Xi, L., Liu, C. R. and Lee, J., “Prognostics for Ball Bearing based on Neural Networks and Morlet Wavelet,” *Materials Science Forum*, Vols. 505-507, 2006.

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Byun, J., Liu, C.R., 2008, “Improving chucking Accuracy and Repeatability by Reducing Kinematic Redundancy”, Proceedings of the 2008 International Manufacturing Science and Engineering Conference, MSEC_ICMP2008-72147

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Youngsik Choi and C. Richard Liu, 2009, "Performance of Nano/micro CBN Particle Coated Tools in Superfinish Hard Machining," International Journal of Machine Tools and Manufacture, Vol. 49, pp. 683-689. (ScienceDirect Top 25 HottestArticles).

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Wasawat Nakkiew, C. Richard Liu, 2009, “Finite Element Analysis for Orthogonal Cuttings of Hardened AISI52100 by Advanced cBN-TiN Composite Coated Tools of Two Depositing cBN Particle Sizes”, ASME International Manufacturing Science and Engineering Conference 2009 October 4-7, 2009.

Zhang, Xueping; Guo, Erwei; C. Richard Liu, 2009, “Optimization of process parameter of residual stresses for hard turned surfaces,” J. Material Processing Technology, volume 209, Issue 9, May 2009, pp. 4286-4291.

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