Advanced Materials and Manufacturing

From nanomaterials to heat-resistant materials on spacecraft, the discoveries made in this signature area will run the gamut of all things manufactured—small to large.

The machine shop chips swept into bins as debris from drills, lathes, and milling machines are moving from scrap heap to center stage in the Schools of Engineering. Professors of industrial engineering, Dale Compton and Srinivasan Chandrasekar, collaborating with colleagues in materials engineering, uncovered the coveted nanostructure in chips produced by industry’s material removal processes.

Purdue researchers observed chips produced in typical machining processes undergoing very large shear strains that stretch the metal’s internal structure and shrink crystal grains into a nanocrystalline structure. “These nanostructured or nanocrystalline materials have extremely small crystal sizes of under a few hundred nanometers and exhibit superior strength and hardness compared to conventional materials,” says Chandrasekar. “You can think of machining as a way to make materials. You change certain parameters of the machining process to control the characteristics of the resulting material.”

Whereas traditional efforts to make nanomaterials cost more than $100 per pound and are limited in the kinds of material produced, Purdue researchers demonstrated nanomaterials can be made in a wide variety of metals and alloys for about $1 a pound over the cost of the incoming material. With the extremely high strength-to-weight ratio and wear resistance, nanostructured materials can be important, cost-efficient strengthening constituents in monolithic solids or composites.
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Shin’s Students: Yung Shin, a professor of mechanical engineering, confers with Ph.D. students, Chengying Xu (in red) and Taejun Choi, about manufacturing systems. This research intelligently optimizes and controls complex manufacturing processes.

Right: Master’s student Mark Anderson (foreground) and Ph.D. student Yinggan Tian are looking at laser-assisted machining.

The new hires in AMM provide a core expertise and focus that link manufacturing and materials research. Clustering opens exciting, new areas of study and promotes further

As research in nanostructured materials demonstrates, the Advanced Materials and Manufacturing (AMM) signature area brings the decidedly distinct approach of researching manufacturing from a materials perspective. “With the large, comprehensive engineering program at Purdue, we are unique in joining the study of advanced materials to the manufacturing process itself,” says Alex King, head of materials engineering and AMM co-chair. “Often labs can easily develop advanced materials, such as in high-temperature superconductivity, but without the material being manufactured into any useful form.”

for automotives, aerospace, and even steel wire and concrete applications.
collaboration where Purdue researchers are already making rapid advances.

In Purdue’s Center for Laser-Based Micro-Fabrication and Center for Laser-Based Manufacturing, laser processing research develops fabrication and materials processing techniques that cannot be produced, or are too expensive to produce by other means, yielding higher quality parts in less time and at less cost. Laser micromachining processes precise, small, and clean parts below the micrometer scale. Mechanical engineering researchers develop nano-optical antennas to concentrate light to the subwavelength size for direct machining.

Researchers in cross-disciplinary Intelligent Manufacturing Systems apply intelligent control to optimize and control complex manufacturing processes. A hybrid technique combines conventional control, information technology, and emerging areas of soft computing to solve complex problems such as grinding, where multiple issues such as roughness, power, wear of wheel, and temperature must be addressed.

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Locating the Advanced Manufacturing Institute

Exploration has begun into an innovative Advanced Manufacturing Institute that could possibly join the ranks of applied research organizations at the Purdue Research Park north of the West Lafayette campus. With an eventual employee base of 130 scientists and engineers and 25 staff personnel, the institute would significantly impact the Purdue University community and Indiana’s manufacturing industry.

“The institute would most likely be an organization outside the university. Research professionals with bachelor degrees, master’s, and Ph.D.s from a cross section of disciplines would work on more applied and often confidential projects submitted by companies,” says John Schneider, assistant vice president for industry research and outreach. “The institute would maintain deep collaborations with Purdue and could contract the expertise of engineering faculty.”

As perhaps the only institute in the country to focus on manufacturing issues, the organization’s chief aim would be to support Indiana manufacturing companies. Schneider predicts an ultimate revenue level of about $30 million a year, which is the sustainable level for keeping overhead costs down and maintaining a group of researchers large enough to respond to any request.

The institute’s collaboration with Purdue University would include subcontracting professors and graduate students to solve industry needs, joining forces to compete for large federal grants, and writing joint grant proposals. The institute would also provide the framework needed to conduct classified research that cannot be done on campus.

In addition to the economic benefits to Indiana industries, the institute would be a source of possible internships, collaborative research for theses, and local career opportunities for Purdue graduates and their spouses.
In Sustainable Manufacturing Systems, researchers improve the efficiency of the manufacturing process, while reducing effluents and energy consumption. Three thrust areas include: nanomaterials; reducing friction in machining while improving efficiency by application of controlled vibrations; and improving efficiency of processes through better sensing and control of manufacturing machines and processes.

Research continues on the structure and properties of materials in thin films. Novel material structures will have designed-in conducting properties related to a polycrystalline structure characterized through x-rays in a unique application of an area detector diffractometer. The results of Purdue’s thin film research will remove several steps from the manufacturing process of computer chips.

High-speed machining research already uses predictive modeling for forces such as vibration and chatter. Implementing these modeling simulation tools, manufacturers can significantly affect process design at the product design stages. Next, research will provide a virtual manufacturing environment for simulating process design, thereby reducing the process design lead time.

**Powder Studies:** Under the direction of Elliott Slamovich, a professor in materials engineering, Huiwen Xu, a Ph.D. student measures the surface area of a hydrothermally derived ceramic powder. The results of her research will enable powders to be manufactured at lower temperatures.