# The Fourth Industrial Revolution (Industry 4.0): Intelligent Manufacturing

**by Dr. Jennie S. Hwang**
H-TECHNOLOGIES GROUP

As the world is pivoting away from the third industrial revolution, what will we face in terms of running business, producing products, offering services, and living our lives?

The last industrial revolution was driven by striking advances in electronics and information technology having achieved enormous economic prosperity and manufacturing automation. So what is the fourth industrial revolution and what does it encompass? Is it gravitational pull?

## The First to Third Industrial Revolutions

The first industrial revolution in the late 18th century used steam engines, which flourished the textile industry and other mechanization systems; the second industrial revolution in the final third of the 19th and beginning of the 20th centuries introduced electrically-powered mass production, creating steel industry, and telegraph and railroad systems. The invention of transistors in 1947 led the dawn of the digital age and information technology, thus the third industrial revolution has offered phenomenal applications of computers and electronic gadgets since the 1970s.

The third industrial revolution propelled the global economic development and the manufacturing advancement by utilizing information and automation technology, making the beginning and the continued progress of the vibrant and fast-paced digital era. As most of us have lived through (and are living in) this era, smart electronics has been proliferating and relentlessly moving toward a higher level of wearability, connectivity and mobility[1].

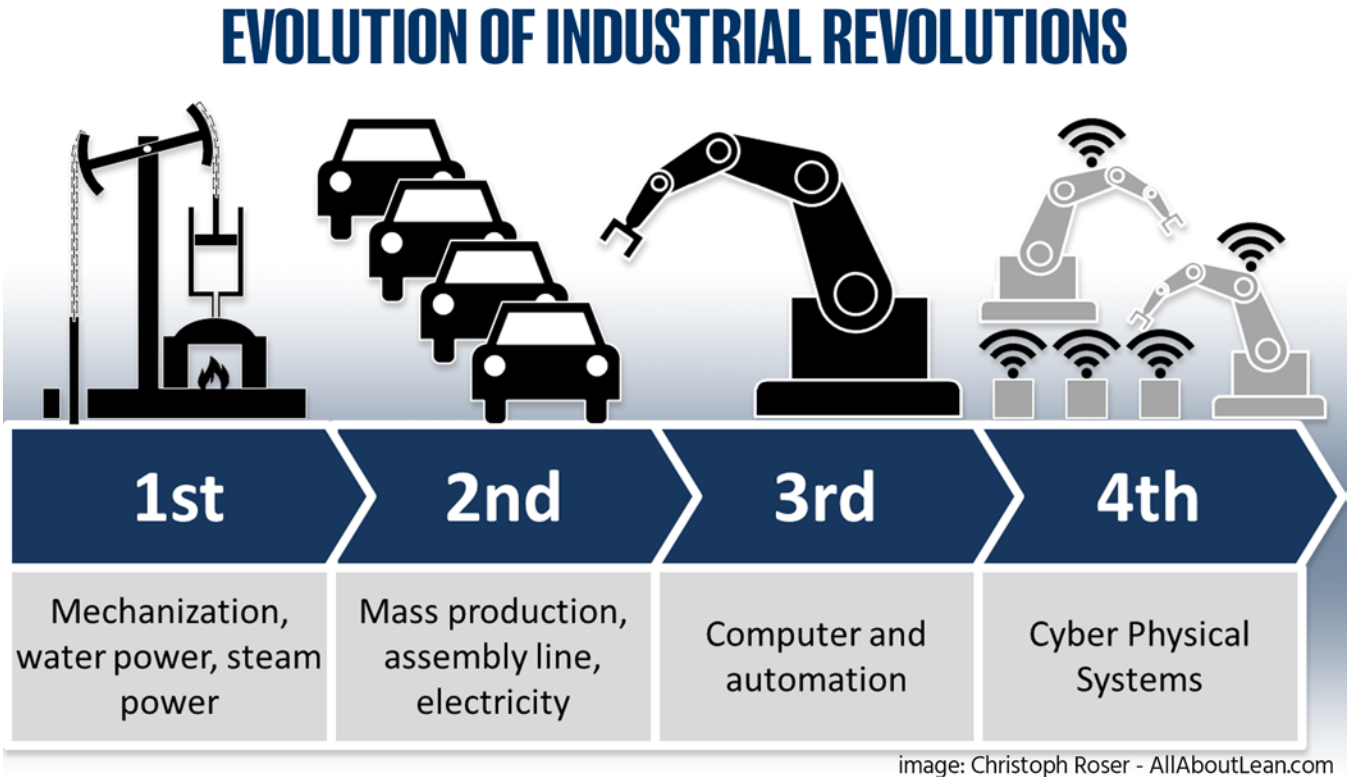

image: Christoph Roser - AllAboutLean.com

Five words speak for the essence of electronics: smart, mobility, connectivity, wearability, and innovation[2]. Innovation has been the name of the game. It spurs an unprecedented growth of exponential technology during the period of the third industrial revolution.

### The Fourth Industrial Revolution

The genesis of the term, fourth industrial revolution, also dubbed Industry 4.0, was rooted in the German federal government's high-tech strategy in 2011. Industry 4.0 will leverage the internet, digital technologies and quantum sciences to drive further into autonomous, intelligent cyber-physical systems.

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As Industry 4.0 is evolving, it is fitting to define it as the get-together assembly of cyber-physical systems, cloud technology, internet of things and internet of services, and its integration and interaction with humans in real-time to maximize value creation. Through the fusion of the physical and the virtual world, interoperability, advanced artificial intelligence and autonomy will be integral parts of the new industrial era. In this era, fascinating technological developments are underway or will be pursued in both military and commercial sectors in the U.S. and around the world.

### Commercial Sector—Intelligent Manufacturing

In the commercial sector, rigidity is out, flexibility is in; stiffness is out, agility is in. Sluggishness is out, and swiftness is in. Responding to the evolving new industrial era, delivering customized products with flexible, modular production flow at an optimal economics becomes necessary.

Manufacturing companies need to develop a deep understanding of the technologies, translating business objectives into technology roadmaps targeting at operational efficiency. This will be accomplished by leveraging the machine-to-machine communication, machine-to-human interaction, cloud computing and advanced analytics. For instance, intelligent machines can trigger maintenance processes autonomously and are capable of predicting failures; data analytics aids to detect process inefficiencies, thus reducing production cost.

I cannot emphasize enough that inventory management is imperative to the success of manufacturing operations, and its optimization is paramount to the healthy balance sheet and cash flow, especially for raw-material-intensive businesses. Companies must keep track and control of both days of inventory as well as the actual dollar value of inventory. Doing well in this area mitigates the mishap of production outpacing demand as well as eschews cash flow trap.

Using cyber-physical systems, supply chains will be fully integrated and automated. Cyber physical systems deployed throughout the value chain enable the linkage between data and material flows, creating the complete visibility of the supply chain, in stationary or in transit state. This also facilitates the formulation of reliable inventory forecasts, the avoidance of unscheduled downtimes, and the timely reaction to unexpected changes in production.

Visibility, traceability, predictability and sophisticated simulations, coupled with speed, agility and flexibility are the underlying characteristics of intelligent manufacturing.

### Military Sector

In preparation for the future, the U.S. Department of Defense recently unveiled technology areas that will translate into operational advantages. Deputy Defense Secretary Robert Work recently unveiled five technology areas that will guide future investments in new weapon capabilities as well as drive organizational and operational experimen-

tation as part of the "Third Offset Strategy." The Strategy reflects the Defense Department's new paradigm to strengthen conventional deterrence against potential global threats and adversary nations. The Pentagon will not try to match its adversaries "tank-for-tank, gun-for-gun, missile-for-missile, person-for-person, and instead will offset enemy strengths in other ways...We will reveal for deterrence, and we will conceal for war-fighting advantage," Work said (Inside Defense). It is a dynamic strategy aiming at the dynamic, complex and uncertain environment.

Among the technological "elixirs," the U.S. military will pursue its effort to harness artificial intelligence and autonomy as part of a competition among the world's greatest powers. Secretary Work said, "We have identified what we believe to be the five key technological components of the Third Offset Strategy." The five components are:

- Learning machines that will literally operate at the speed of light; they will change the way we pursue intelligence; they will be utilized for indications and warning; they will be used in cases where human reaction speed is simply not up to the task—specifically in cyber defense, electronic warfare and large-density missile raids.
- Human-machine collaboration, as teaming up human insight with the tactical acuity of human computers, to make the human more effective in the decision space.
- Assisted-human operations, coming online in the commercial sector, such as automotive technology that warns an operator about obstacles when backing up. Such capabilities would evolve to allow decisions to be delegated to a machine. The U.S. military will primarily be interested in wearable electronics—combat apps, new types of different things that the solider, sailor, airman and Marines will carry and help them fight.
- Advanced manned and unmanned combat teaming, which is happening now and will get more powerful in the future.
- Network-enabled autonomous weapons that are hardened for cyber-attack and electronic-warfare environments.

According to Work, implementing the Third Offset Strategy, which is set to be as part of the fiscal year 2017 budget request, will require "strong, top-down governance," revitalization of war-gaming with more demonstrations and experimentation, and a focus on agility and cost.

**Gravitational Pull**

The fourth industrial revolution epitomizes "gravitational pull" that is set by multiple and complex drivers as well as crosscurrents—expanded globalization, technological explosion, digital tools, Internet-centric data flow, global competitiveness, among others. As striding toward the fourth industrial revolution, regardless of a particular business strategy, be it a service provider or an agile niche product producer or a low-cost mass merchandise supplier, success in the era of Industry 4.0 hinges on a comprehensive vision coupled with a compelling business model embodied with a decisive strategy and defined core value drivers. To that end, focus areas for future investments can then be identified.

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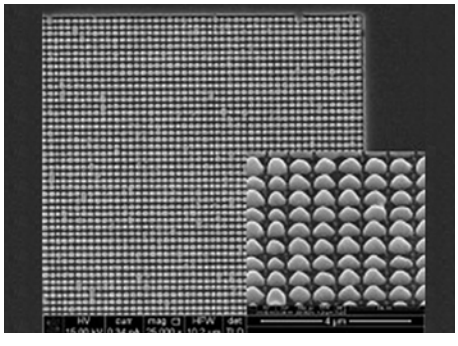
Key efforts are to be made on the collectivity and connectivity of technologies, seamless integration of data, effective use of digital tools, and the vision and continued deployment of new technologies to achieve operational optimization and business excellence. **SMT**

**References**

1. Hwang, Jennie. "2013 Year-in-Review," SMT Magazine, December 2013.
2. Hwang, Jennie. "2014 New Year Outlook," SMT Magazine, January 2014".
3. Further readings: "The Fourth Industrial Revolution" by Klaus Schwab, published by World Economic Forum January 11th, 2016.

**Dr. Hwang** is a forward thinker, an international businesswoman, international speaker, and a business and technology advisor. She is a pioneer of and long-standing contributor to SMT manufacturing since its inception, as well as to the lead-free electronics implementation. Among her many awards and honors are induction into the International Hall of Fame—Women in Technology, election to the National Academy of Engineering, YWCA Women Achievement Award, and being named an R&D-Stars-to-Watch (Industry Week). Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., Hanson, plc, IEM Corp., she is currently CEO of H-Technologies Group, providing business, technology and manufacturing solutions. She serves as Chairman of Assessment Board of DoD Army Research Laboratory, National Institute of Standards and Technology (NIST), National Materials and Manufacturing Board, Board of Army Science and Technology, Commerce Department's Export Council, various national panels/committees, international leadership positions, and the board of Fortune 500 NYSE companies and civic and university boards. She is the author of 450+ publications and several textbooks, and a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees (Ph.D., M.A., M.S., B.S.) as well as Harvard Business School Executive Program and Columbia University Corporate Governance Programs. For more information, click here.

# New Generation of High-efficiency Solar Thermal Absorbers Developed



Researchers from the Universities of Bristol and Exeter are one step closer to developing a new generation of low-cost, high-efficiency solar cells. The structure is one of the world's first examples of a tri-layer metasurface absorber using a carbon interlayer.

The system, developed by Chenglong Wang, a PhD student in Professor Martin Cryan's research group, uses amorphous carbon as an inter-layer between thin gold films with the upper film patterned with a 2D periodic array using focused ion beam etching. Professor Cryan is the professor of Applied Electromagnetics and Photonics in the Department of Electrical and Electronic Engineering.

The trilayer gold-carbon-gold metasurface strongly absorbs light across the solar spectrum but minimizes emission of thermal radiation from the structure. The use of gold in the research is a first step towards a high temperature metasurface where gold can be replaced by other refractory metals such as tungsten or chrome.

The cell will be used for solar thermal energy applications and has the potential to reach much higher temperatures than simple black surfaces because it can minimise the emission of thermal radiation.

The metasurface has been developed as part of a joint project, led by Dr. Neil Fox, between Bristol's Department of Electrical and Electronic Engineering and Schools of Physics and Chemistry.

The Bristol team have been working with Professor Tapas Mallick from the University of Exeter to develop the low-cost solar concentrator systems.