March 2019
VOL. XXXV, NO. 3

Daniel Burrus'

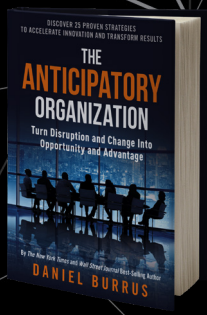
Celebrating 30+ Years of Publication

TECHNOTRENDS® NEWSLETTER

The biggest ideas that are changing everything

IN THIS ISSUE

MY NEW BOOK



Agility Levels the Playing Field.
Anticipation Changes the Game.

Learn more with my new book,
The Anticipatory Organization

"I'll pay for the book, you cover the shipping."

www.TheAOBook.com

www.DanielBurrus.com

The Industry 4.0 Advantage

By Daniel Burrus, CEO of Burrus Research

When the word "industry" is used in conversation, the picture painted in most minds is a gritty shop floor and blue-collar individuals on an assembly line.

While this visceral image is still true to some degree, when you add the term "4.0" after the word "industry," newfound interest perks in the minds of both white-collar and digital technology professionals. Simultaneously, fear looms in the hearts of those blue-collar workers accustomed to that initial visual of what industry means. They think instantly of job loss, robots, and artificial intelligence (A.I.) deleting them from the equation.

> *Industry 4.0 transformations are here to help us and allow us to work alongside machines.*

This fear may be common; however, it is unwarranted. Despite the now-proven Hard Trend that A.I., advanced automation and robotics, 3D printing, and other industrial Internet of Things (IoT) advancements often replace mundane tasks in manufacturing, Industry 4.0 transformations are here to help us and allow us to work alongside machines in new and highly productive ways.

Industry 1.0 to 4.0

Manufacturing in every industry has evolved in four major stages since the 1800s, and these four distinct industrial revolutions that took place are as follows.

The first industrial revolution took place between the late 1700s and early 1800s. Manufacturing evolved from manual labor performed by people and work animals to optimized labor performed by the use of water- and steam-powered engines, with human beings alongside them performing new, more efficient tasks.

In the early part of the 20th century, work efficiency continued to rise as the world entered a second industrial revolution. This brought along the introduction of steel and use of electricity in factories. Developments in electricity production and distribution enabled manufacturers to mobilize factory machinery and freed up the ability to increase productivity by capitalizing on manpower in mass production concepts, such as the assembly line.

A third industrial revolution began in the late 1950s, which brought with it more automation technology. This, and increasingly computers and robotics, became integrated into factories, yet again increasing efficiency and repositioning where the human workforce would put forth its energy. In recent years, near the end of this period, manufacturers began experiencing a shift from legacy technology to an increase in attention to digital technology and automation software and services.

That brings us to our fourth and most current industrial revolution: Industry 4.0. Industry 4.0 essentially brings increased interconnectivity and networked intelligence through the Internet of Things (IoT), 3D printing, and A.I. and introduces

continued on page 8

TECHNOLOGY NEWS HIGHLIGHTS

Fuel Cell Breakthrough

One of the biggest barriers to the widespread adoption of fuel cells is the high cost of producing hydrogen fuel itself. Most commercial methods still use fossil fuels, which, in addition to being expensive, are somewhat counterproductive to the goal of reducing carbon emissions.

More recently, techniques have been developed that split water into hydrogen and oxygen by means of electrolysis, but they require expensive precious metal catalysts, such as platinum and palladium, that are rare and in limited supply.

A new approach is now under development that utilizes inexpensive polymers to generate hydrogen from water electrochemically. Built using more common base metals like nickel and aluminum, the catalyst membranes would be more cost-effective to produce while retaining important characteristics of high conductivity, chemical stability and good mechanical strength.

The company is working with numerous multinational organizations to evaluate the product's potential. While not yet as efficient as platinum- or palladium-based methods, the technology will be adaptable for fuel cells as well as hydrogen production facilities, and chemical and water applications.

For information: Gabriel Rodriguez-Calero; Ecolectro, Inc., Weill Hall, Suite 41, 26 Campus Road, Ithaca, NY 14853; phone 607-592-5683; website https://www.ecolectro.com/about

Metallic Wood

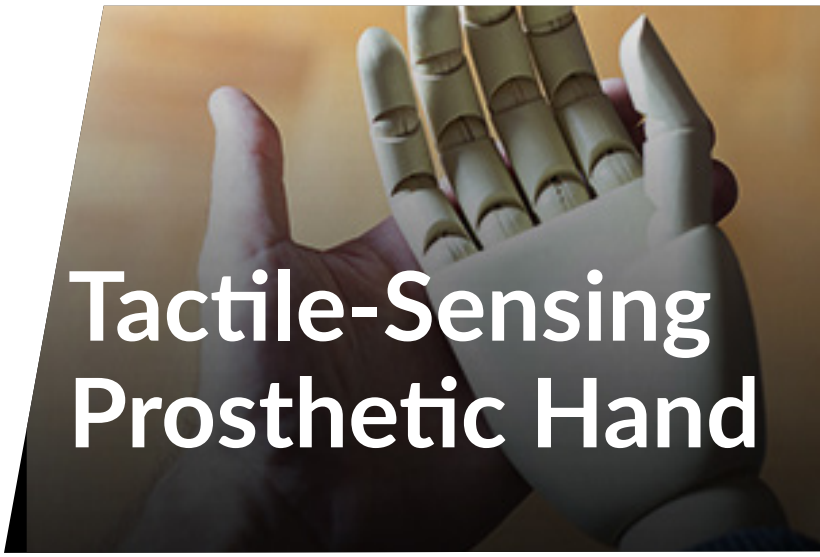
A team of researchers has once again used nanotechnology to develop a new material that is as stronger, but lighter, than any natural material known to man. Its porous nature also means that it can be infused with other materials that make it useful for a variety of applications.

The first step in fabrication is to suspend tiny plastic spheres in water. As the water evaporates, the spheres self-assemble into a crystalline framework which is then electroplated with nickel. When the spheres are ultimately dissolved with a solvent, what is left is an open metallic network with struts that are about 10 nanometers (about 100 nickel atoms) wide.

Other methods that utilize 3D printing have proven to be difficult to scale up, and the structures are too small to be of practical use. In comparison to previous strong material samples, which are typically about the size of a flea, the new approach can produce specimens that are 400 times larger.

Materials like metallic wood could someday be used to build structures such as airplane wings that are lighter and stronger than those available today. When infused with anode and cathode materials, they might even serve as batteries to store solar energy during flight.

For information: James Pikul, University of Pennsylvania, Department of Mechanical Engineering and Applied Mechanics, 220 South 33rd Street, 229 Towne Building, Philadelphia, PA 19104; phone: 215-573-2786; email: pikul@seas.upenn.edu; website: https://pikul-lab.seas.upenn.edu/ or https://www.upenn.edu/



Tactile-Sensing Prosthetic Hand

In a first-of-its-kind surgical procedure, doctors have successfully implanted the first clinically viable prosthetic hand that provides not only dexterity but also gives the user sensory feedback. The revolutionary development represents several breakthroughs in implant technology.

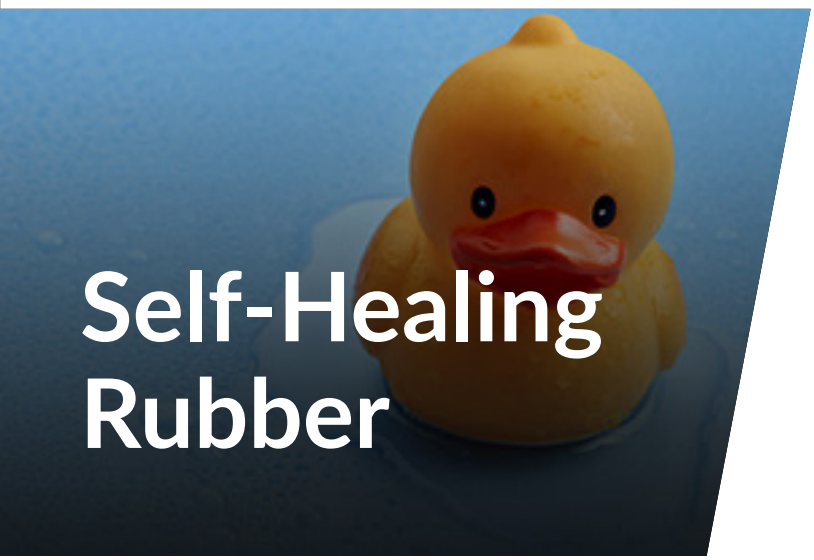
While it is not the first controllable prosthetic hand, earlier versions have relied on skin electrodes to pick up signals from underlying muscles, resulting in control of only a few gross movements such as opening and closing the hand. The new technology uses 16 electrodes implanted into the forearm to extract the signals directly from the nerves that used to be connected to the lost hand. This provides more detailed and reliable information for finer motor control and also enables kinesthetic feedback to the wearer regarding things like contact pressure.

It was also the first demonstration of a sentient prosthesis in a below-elbow amputee. While earlier experiments in above-elbow amputees using similar methods had indicated that the concept was viable, the smaller bones of the

forearm posed some challenges in the design of the prosthetic. And since bones weaken from lack of use, patients will need to follow a rehab program to build bone strength before being able to fully load the new prosthetic. One benefit of below-elbow implants, however, is the availability of more muscles in the forearm, which helps to achieve greater dexterity.

Two additional patients are already scheduled to receive the new implants in coming months.

For information: Dr. Max Ortiz Catalan, Integrum AB Krokslatts Fabriker 50, SE-43137, Molndal, Sweden; phone: +46-31-760-1060; fax: +46-31-155260; email: info@integrum.se; website: http://integrum.se/



Self-Healing Rubber

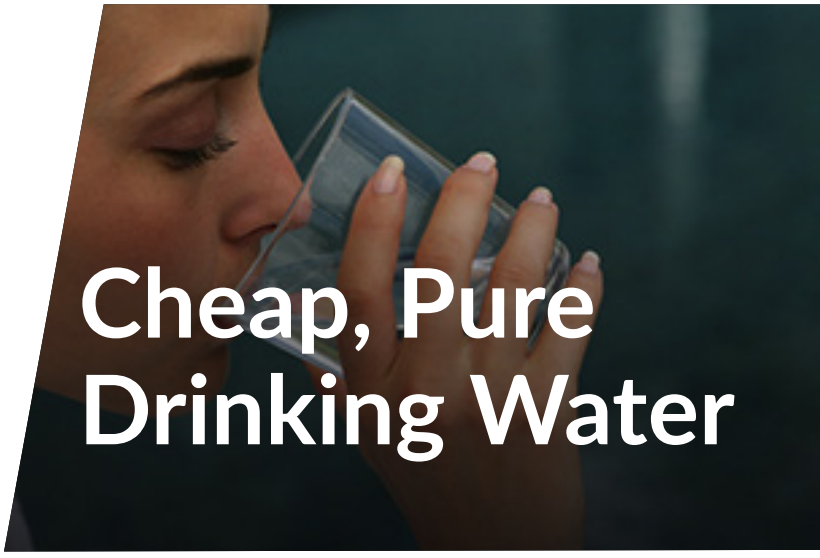
A new rubber material has been developed that repairs itself when torn or punctured – a discovery that could someday lead to self-repairing shoes, toys and even electronics. The material can be quickly manufactured using 3D printing methods and a process known as photopolymerization, which utilizes light to solidify a liquid resin to form a desired shape.

Photopolymerization relies on chemicals called thiols to form the cross-linked bonds that cause the resin to harden. Another group of chemicals called disulfides enable these bonds to reform when broken, and can be formed from thiols by adding an oxidizer to the polymer. But the two chemicals compete with each other, i.e., when photopolymerization factors are strong, self-healing behaviors are weak, and vice versa. The key was to find the optimum ratio between thiols and disulfides that would deliver both.

The material was tested in several forms – as a shoe pad, soft robot, multiphase composite and electronic sensor. The 3D printed samples were cut in half, and after just two hours at 60 degrees Celsius had repaired completely to regain their original strength and function. Changing the temperature (over a range of 40 to 60 degrees Celsius) impacts the speed of the reaction, but the material will heal even at room temperature.

The next step will be to apply these methods to create materials of varying stiffness, from soft rubbers to harder plastics. Applications could include everything from vehicle parts to body armor.

For information: Qiming Wang, University of Southern California, Viterbi School of Engineering, 3650 McClintock Avenue, Los Angeles, CA 90089; phone: 213-740-4530; website: https://www.usc.edu/ or https://viterbischool.usc.edu/



Cheap, Pure Drinking Water

Worldwide, it's been estimated that one in nine people lack access to clean drinking water on a day-to-day basis. Floods and other water-related disasters can cause periodic increases in these statistics, threatening the health, welfare and productivity of people

all over the world. So it's no wonder that finding solutions to the world's drinking water crisis is a top priority in the minds of many researchers.

Recently, Chinese scientists announced the development of a water system that combines a two-dimensional material with sunlight to remove 99.999 percent of bacteria from a 10-liter sample (enough for a family of four for a day) in less than 30 minutes. Inexpensive sheets of graphitic carbon nitride are placed inside of a container of water. When exposed to sunlight, the sheets release electrons that bond with oxygen, creating compounds that kill bacteria.

Compared to previous metal-free photocatalysts, the new system demonstrated five times the disinfection rate with only one-tenth of the catalyst being consumed. The next step will be to apply the method to portable drinking containers that can be shipped to a variety of high-risk areas throughout the world.

For information: Wang Chengyin, Yangzhou University, 88 Daxue South Road, Yangzhou City, Jiangsu Province, China; phone: +86-514-8797158; fax: +86-514-87311374; website: http://en.yzu.edu.cn/

Anti-Reflective Coating

Researchers have developed an antireflective (AR) coating that works better than anything currently available, over the entire solar spectrum and at multiple angles. Although it was initially conceived as a coating to maximize the efficiency of solar cells, the technology will have application as a coating for eyeglasses, computer monitors and smartphone displays as well.

Refractive index refers to the speed at which light travels through a specific medium. Reflections occur when light travels between materials with different refractive indices – in this case, air (with a refractive index of 1) and plastic (with a refractive index of 1.5). Teflon has the lowest index of any natural coating material at 1.3 and can be blended with other materials to cover a range of 1.3 to 1.5. So the challenge was to create a process that would bridge the gap between air and Teflon.

To do this, the researchers heated the Teflon to the point where it sent up a vapor flux. Sacrificial molecules were then added to the flux, and Teflon reformed around the molecules. The sacrificial molecules were then dissolved to form nanoscale pores, creating a graded-index Teflon film that transitions seamlessly from 1 to 1.5.

The technique is compatible with current manufacturing methods and could be scaled up relatively easily for a variety of applications.

For information: Chris Giebink, Penn State University, Electrical Engineering Department, 0121 Electrical Engineering East, University Park, PA 16802; phone: 814-865-2229; email: ncg2@psu.edu; website: https://www.psu.edu/

Autonomous Bus

The world's first autonomous bus was recently unveiled in Singapore. The introduction of the Volvo AB7900 represents a key milestone for the industry in general as well as an important step forward in creating cleaner, safer, smarter cities.

The newly designed vehicle is 12 meters long and has a capacity of 93 passengers. The fully electric vehicle produces zero emissions and will use 80 percent less energy than an equivalent-sized diesel bus. It also includes light detection and ranging sensors (LIDAR), 3D stereo-vision cameras, a global navigation satellite system and an operating system with artificial intelligence (AI) that is backed up by cybersecurity measures to ensure accurate navigation and safety.

Singapore is rated second only to the Netherlands as one of the best-prepared countries in the world for autonomous vehicles. With its high urban density, autonomous electric buses, which can transport much larger numbers of people than cars and taxis, will have a tremendous impact on overall mobility, accessibility and sustainable development within the city, while improving air quality.

The vehicle will undergo extensive testing before being placed into operation.

For information: Volvo Buses; website: https://www.volvobuses.com/en-en/home.html

Influenza Cure?

The reason current vaccines are only effective for a short period of time is that the antibodies tend to break down, making additional injections necessary. But a new approach, using the gene-editing tool known as CRISPR, could someday make people immune to the flu, requiring antibodies to be injected only once.

The technique involves editing the DNA of B cells – the white blood cells in the human immune system that are responsible for creating antibodies. In an initial study on 15 mice, the method provided a full 82 days of protection against a virus known as RSV (Respiratory Syncytial Virus) – the most common cause of bronchiolitis and pneumonia in children.

In addition to RSV and influenza, the researchers believe that the modified B cells could be programmed to fight other diseases as well, including human immunodeficiency virus (HIV) and Epstein-Barr virus (EBV). Although much research remains to be done, such a breakthrough could prevent thousands of hospital visits, deaths and disabilities each year.

For information: Howell Moffett, Fred Hutchinson Cancer Research Center, 1100 Fairview Avenue, N. Seattle, WA 98109; email: hmoffett@fredhutch.org; website: http://www.fredhutch.org/en.html or https://www.biorxiv.org/content/biorxiv/early/2019/02/06/541979.full.pdf

The Industry 4.0 Advantage

continued from page 1

new types of cyber-physical systems. Industry 4.0 is far more comprehensive, interlinked, and holistic than revolutions before, continuing the connection of the physical with digital, and allowing for improved company communication and collaboration, boosting productivity and greatly improving processes.

The definition of Industry 4.0 is, in general terms, the rise of digital industrial technology. To expand upon that, let's take a look at the nine building blocks that make up Industry 4.0 and simultaneously transform industrial production.

Big Data and Analytics

An issue that is common in industry is constructive and quick decision making among managers and employees. In Industry 4.0, collecting and comprehending ever-increasing amounts of data from many different sources including networked sensors, production equipment, and customer-management systems will become more streamlined and useful in support of real-time decision making.

Autonomous Robots

Robots replacing people is always the evident fear when discussing the future of technology in manufacturing jobs. However, the ability for robots to interact with one another while accomplishing rhetorical tasks not only increases productivity for the company, it too will open new job opportunities for employees who are willing to learn new things that once worked those repetitive tasks. Physical work aside, these future autonomous robots will cost less while having greater range of capabilities, freeing up money to afford to pay employees repositioned in new roles supporting the use and impact of all the machines.

Advanced Simulation

In conjunction with analytics, advanced simulations will be used more extensively in plant operations to leverage real-time data and mirror the physical world in a virtual model. This will include machines, products, and humans, allowing operators to test and optimize the machine settings for a product in the virtual world before the physical one. This will accelerate a predict-and-prevent operational strategy that will greatly combat the issues involved in downtime on machines and reduce error.

Horizontal and Vertical System Integration

Universal data-integration networks are a major impact stemming from Industry 4.0 that will increase connectivity among departments, suppliers, and partners. In manufacturing, too often there is a lack of communication or, worse, miscommunication that winds up being devastating for a project that crosses departmental boundaries. This is an improvement meant to positively impact human employees, and it leverages digital technology and interconnectedness of this industrial revolution to do so.

Industrial Internet of Things (IIoT)

Decentralizing analytics and decision making while enabling real-time feedback is key in today's age. IIoT is more than connected sensors and machines all communicating with each other; it also means that more devices will have embedded computing enabling what is called Edge Computing, computing at the edge of a network were networked sensors are instantly getting the new data and automated decisions can happen much faster than back at the "mothership."

Agile and Anticipatory Cybersecurity

It's absolutely no mystery that being so interconnected with sensors, devices, and software opens up a huge risk for hacking and security issues. Secure, reliable means

of communication is quite important to cybersecurity in Industry 4.0, but more importantly, access and identity management in that process as well. Similar to other industries handling highly secure consumer information, manufacturing companies must consider pre-solving problems in cybersecurity the more digital industrial functions become. Reacting quickly after a problem is a key to agile systems, and with A.I.-based behavior analytics and other new tools we can also implement anticipatory systems by adding a predict-and-prevent layer.

Advanced Hybrid Cloud and Virtualization
With Industry 4.0, data and the need for data storage is growing at an exponential rate. Increasingly, on-premise hard drives and servers used by IT departments at companies will not suffice, which brings us to Cloud Services and Virtualization. Advanced cloud services go way beyond data storage, to add elements of high-speed data analytics coupled with A.I. and machine learning enabling real-time knowledge sharing. This technology will reduce reaction times involving real-time data sharing to milliseconds, and once again enable anticipatory capabilities such as predict-and-prevent strategies.

Additive Manufacturing (3D Printing)
Additive manufacturing is not new, but what you can do with it and how you can apply it is! With Industry 4.0, advanced additive-manufacturing methods will be integrated into mass production systems, providing a new level of speed and customization, not to mention the ability to solve previously impossible manufacturing problems. It will also be used as a standalone system for custom and/or complex manufacturing.

Augmented Reality
This is a relatively new technology that has been gradually increasing in popularity among consumers outside of industry and, according to my Hard Trend Methodology, will quickly gain more traction as augmented reality (A.R.) apps for business and industry are developed and move beyond the overlaying of information and graphics on a smartphone, tablet, or handheld device screen, to AR glasses that look similar to normal glasses and allow for hands-free information access and use. In Industry 4.0, AR has endless possibilities, including quickly finding parts in a warehouse by looking around from one location, or seeing a video of repair instructions on a screen that is pointed at the object you are repairing as you perform the repair. The uses are only limited to our imaginations.

As with anything new, the adaptation of any of the new technologies in Industry 4.0 will face an uphill battle to some degree. As stated before, blue-collar manufacturing industries are not often known for their open mindedness about embracing new technology, let alone digital tools that are transformational, as it is often seen as a job eliminator. Companies in all industrial sectors must broaden their horizons and their speed of embracing the ever-changing spectrum of Industry 4.0 technologies and likewise deepen their practical knowledge about the revolution these technologies are already creating.

They can be used to accelerate innovation and growth, to pre-solve seemingly impossible problems, develop and implement tailored digital manufacturing solutions, and transform every process. This goes beyond the CEOs, presidents, and leadership of manufacturing companies, and involves middle managers and employees, as the concern is how their jobs may be impacted by all of this new transformational technology and how it will shape employment for all generations. Companies should help their managers and employees alike anticipate disruption and change and get excited about learning new skills that will not only keep them employed, but help to ensure the positive development of their careers as they help build a sustainable future for their companies.

Burrus Research®

Technotrends is published 12 times a year by Burrus Research, Inc., a research and consulting firm that monitors global advancements in science and technology and their direct impact on business and consumers. Mary Norby, Editor, 1860 Executive Drive, Suite E2, Oconomowoc, WI 53066. To subscribe, call 262-367-0949 or email office@burrus.com.