對外合作組織與機構動態報導

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ARGONNE EFFORTS ACCELERATE 3-D PRINTING JOURNEY

阿岡推動 3D 列印的進展

By Dave Bukey • September 6, 2017

With the development of additive manufacturing — often referred to as 3-D printing — engineers are limited only by their imagination — and the quality of the part that they can produce. By heating plastic or metal powders with lasers, scientists have already built cars, pedestrian bridges and even artificial jawbones layer by layer. This technology has the potential to transform

報告摘要(KEY INFORMATION)

1. 3D 列印不斷發展，藉由雷射加熱塑料或金屬粉末，不論是汽車、人行步橋，甚至連人工下顎骨都可以層層堆積而成。為了更加瞭解粒子堆疊的過程、確定列印成品的質地與設計相吻合，阿岡實驗室的科學家以高速 X 光儀器拍攝幀率每秒 5 萬張的影片。藉由分析每一幀照片，可以看見孔洞與凹陷，瞭解其微結構。
2. G20 高峰會今年 7 月於德國漢堡舉行，會中美國與其他 G20 國家的意見不一致備受各界關注。法國正計畫於今年底舉辦一氣候高峰會，後續發展值得期待。
3. 伊拉克第二大城摩蘇爾光復是個好消息，但美國仍未找出應對沙烏地阿拉伯等國制裁卡達的方法；而在伊朗，總統羅哈尼正與強硬派陷入僵持。目前，耶路撒冷持續緊繃的張力仍是中東一大隱憂。
4. 約旦位列世界上最缺水的國家之一，而最新的研究分析上游敘利亞的區域性乾旱與土地利用變更，顯示情況還可能更加惡化。
5. 一旦核戰爆發，對全球環境將造成嚴重影響，這點無法否定。然而，雖有每日頭條提升我們對國安及人民安危的警醒，對於環境的影響卻鮮少被論及；如大火、飢荒、物種基因突變、癌症等後果，也不限只發生在參戰國。

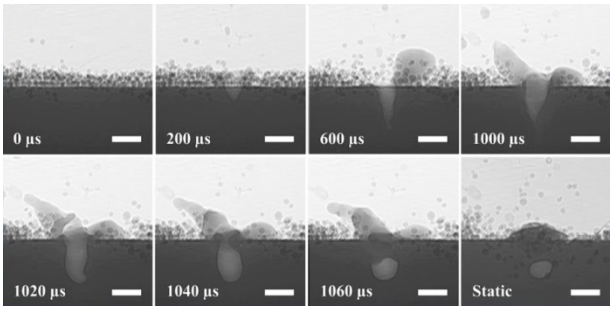
manufacturing as engineers use titanium and other metal alloys to tap raw materials more efficiently, which in turn will reduce product costs and weight and shorten supply chains.

Yet metal additive manufacturing faces roadblocks. Printed materials often contain structural defects and vary from their designs, forcing engineers to repair their finished pieces or start over from scratch. And not all physics behind the process are well understood. Much of the research in this area involves trial and error — a costly and time-consuming way to innovate.

To address these problems, scientists from the U.S. Department of Energy's (DOE) Argonne National Laboratory, Carnegie Mellon University, and Missouri University of Science and Technology are investigating the entire 3-D printing process, including the material properties of the metal powders and how the laser "melts" and shapes those powders into the desired components, to discover both how defects form and methods to avoid them.

For the first time, scientists recently peered inside materials formed by 3-D printing in real-time as the laser molded the metal powders into shapes. As the laser "prints" metal components, Argonne physicist Tao Sun and his collaborators have a front-row seat to its inner workings via the intense synchrotron X-rays at the Advanced Photon Source, a DOE Office of Science User Facility located at Argonne.

"The laser-metal interaction happens very quickly," said Sun. "Fortunately, we captured the process at 50,000 frames a second using the high-speed X-ray instrument at the Advanced Photon Source. We can study the resulting movie frame by frame to examine how the material's microstructure, especially defects and pores, form."



The team showed they can observe and quantify many metal 3-D printing characteristics — including melt pool size/shape, powder ejection, solidification, porosity formation and phase transformations.

Sun will share his conclusions with partners in academia and other national laboratories who are building models to reliably predict the characteristics of the printed materials. These models also predict the dynamics of the process — such as how the laser melts the powder, when the powder changes into gases and liquids, and so on.

Meanwhile, Aaron Greco, a principal materials scientist at Argonne and project co-leader for Argonne's additive manufacturing effort, enhances the models from a different angle. "After printing, we examine the product's resulting microstructure and defects," said Greco. "We use a variety of

techniques including optical and electron microscopy and even tomography at the Advanced Photon Source, to validate the models."

The result is a virtuous loop in which the experimental data feeds into models of additive manufacturing, and then the improved models are tested by more elaborate and insightful experiments. This interplay between modelers and experimentalists is essential to clearly and accurately understanding the underlying materials physics required to make 3D-printing truly reliable.

Although this loop is vital to their fundamental understanding of additive manufacturing, the researchers' ambitions extend further. "Our goal is to explore new possibilities," said Greco. "Industries are currently limited to a certain set of metal alloys. But what about new ones? If you understand the physical properties related to how to print new alloys, you can adopt these into the process and speed up the reliability of printing." Industries are also limited by the extremely detailed models currently required to define the printing process for complex parts. By reducing these models to just the handful of elements that affect quality and reliability, the team hopes to make the models faster and more suitable for industry.

Ultimately, Argonne's efforts will achieve the best of both worlds: Scientists will uncover the dynamic mysteries of metal additive manufacturing, while industries will thrive with blueprints to rapidly print cost-effective and reliable products.

"Our work will not only help industries improve efficiency and performance, but increase the likelihood that metal additive manufacturing will be more widely adopted in other applications," Greco said.

Sun's research was reported in the *Scientific Reports* article, "Real-time monitoring of laser powder bed fusion process using high-speed x-ray imaging and diffraction." The experiments were performed at the Advanced Photon Source's 32-ID-B beamline.

EU: ENERGY-RELATED DISCUSSIONS AT G20

歐盟觀察：G20 之能源相關討論

As reported in this Newsletter under "Update on Policies Related to Climate Change," the G20 Summit was held in Hamburg, Germany on July 7 and 8. The Summit was the first global conference after the US had announced its withdrawal from the Paris Agreement. In the Leaders' Declaration, the leaders collectively pledged a commitment to

mitigate greenhouse gas (GHG) emissions through increased innovation on sustainable and clean energies and energy efficiency, and to work on low-GHG energy systems. Further, the G20 leaders except the US stated that the Paris Agreement is irreversible, and agreed to the G20 Hamburg Climate and Energy Action Plan for Growth ("the Hamburg Action Plan").

The Hamburg Action Plan largely reconfirms the initiatives mentioned in previous G20 Leaders' Declarations and Energy Ministerial Meeting communiqués. Looking back, energy has been mentioned at the G20 Summit since the first event in Washington DC. At the 2014 Brisbane Summit, the G20 Principles on Energy Collaboration was approved as an energy-related document. Further, ahead of the 2015 Antalya Summit, the first G20 Energy Ministerial Meeting was held in Istanbul. The communique from the Summit noted, as measures to address the G20 Principles, “consideration of energy access, energy efficiency, renewable energy, market transparency, and the rationalization and phase-out of inefficient fossil fuel subsidies that encourage wasteful consumption, recognizing the need to support the poor.”

The Antalya Summit also approved the G20 Energy Access Action Plan and the G20 Toolkit of Voluntary Options for Renewable Energy Deployment. The Second G20 Energy Ministers Meeting ahead of the 2016 Hangzhou Summit confirmed the initiatives agreed at the First Meeting, and the Hangzhou Summit adopted the Enhancing Energy Access in Asia and the Pacific: Key Challenges and G20 Voluntary Collaboration Action Plan, G20 Voluntary Action Plan on Renewable Energy and G20 Energy Efficiency Leading Program.

The characteristic of the Hamburg Action Plan is that it mentions, in addition to the ongoing initiatives noted above, efforts to facilitate the implementation of the Paris Agreement at the top. It refers to moving toward implementing the current and future Intended Nationally Determined Contributions (INDCs) in line with the Paris Agreement and increasing cooperation in doing so, and to welcoming the submission of long-term strategies by G20 countries while engaging in good-practice sharing and cooperation.

The Preamble of the Action Plan states that the actions of the G20 will be guided by the Sustainable Development Goals (SDGs) of the United Nations and the Paris Agreement. Regarding the SDGs, a ministerial meeting was held on July 19 for achieving the SDGs, and a declaration centered on the full implementation of the Paris Agreement was adopted, but the US emphasized again its non-involvement in the declaration. While some European countries including Britain and France hope that the US may

return to the Paris Agreement, Germany, which is the chair of the Hamburg Summit, is skeptical. French President Macron has announced that a climate summit conference will be held at the end of 2017; the developments must be closely monitored.

MIDDLE EAST: LIBERATION OF MOSUL AND THE PROLONGED BOYCOTT OF QATAR

中東觀察：伊拉克第二大城摩蘇爾光復、各國對卡達制裁延續中

Koichiro Tanaka

On July 10, Iraqi Prime Minister Haider al-Abadi declared the liberation of Mosul, Iraq's second largest city, some three years after being occupied by ISIS/ISIL in June 2014. The focus of the mopping-up operation against ISIS has now shifted to Tal Afar, west of Mosul and within the borders of Syria. However, behind the advance of the Iraqi forces, Peshmerga, the militia of the Kurdish Regional Government (KRG), and the mainly Shiite Popular Mobilization Units (PMU), there is growing concern over new political and social problems caused by disregard for the rights of minorities in various regions of the country.

There is no end in sight for the boycott of Qatar by Saudi Arabia and others. On July 5, foreign ministers of Saudi Arabia, UAE, Bahrain and Egypt dismissed Qatar's response to their 13 demands delivered by Kuwait as an intermediary, and questioned whether Qatar understood the seriousness of the situation. They demanded that Qatar stop meddling in their internal affairs and supporting terrorist groups, and implied their intention to take "additional measures" if Qatar does not comply with them. Qatar's Emir Sheikh Tamim bin Hamad Al Thani broke his long silence and clarified the position that the country will not bow to unjust demands that infringe its sovereignty, while also calling for a solution through dialogue.

The growing disagreement among its Middle East allies is causing problems for the US. After King Salman of Saudi Arabia missed the G20 Summit in Hamburg, US State Secretary Tillerson diverted from his mediating efforts via phone to take up shuttle diplomacy. However, after visiting Kuwait, Qatar and Saudi Arabia, he expressed pessimism for an early settlement. There is no prospect for the embargo to be lifted soon. Turkish President Recep Tayyip Erdogan has also visited the three countries as mediator,

but Saudi Arabia and others are cool toward Turkey, which deploys troops in Qatar.

Sworn in for his second term, Iran's President Hassan Rouhani has drawn fire by criticizing the suppression of speech and the press by the judiciary, which is dominated by rightwing hardliners. The President's brother was detained temporarily for corruption charges, and the conflict with hardliners since the recent presidential election is intensifying. Meanwhile, both houses of US Congress agreed to add sanctions against Russia and North Korea to the original sanction bill against Iran, enraging the country which believes that the legislation itself breaches the nuclear agreement of 2015. President Trump has abruptly demanded the release of American prisoners in Iran, threatening "serious consequences" if the country does not comply with the demand. Iran responded by counter demanding the release of prisoners with Iranian background in the US.

The stand-off between Israel and Palestine has intensified after two Israeli police officers were shot dead in the Temple Mount/Haram al-Sharif complex in Jerusalem. Even after Israel stopped installing metal detectors, which further complicated the situation, President Mahmoud Abbas of the Palestinian National Authority has expressed anger that the "new security measures" mentioned by Israel would change the status quo. The situation remains volatile.

JORDAN FACES LIKELIHOOD OF MUCH MORE FREQUENT LONG AND SEVERE DROUGHTS, STANFORD RESEARCHERS FIND

史丹佛研究發現，約旦的長期嚴重乾旱可能更常發生

By Rob Jordan

A new analysis of drought in Jordan – one of the world's most water-poor countries – suggests that without alternate water sources, better land use and improved water-sharing agreements, the country could face a future of potentially disastrous droughts. The research, which was the first to analyze several types of drought and to take into account land use changes in upstream Syria, could inform water policies in other arid countries with shared rivers.

This satellite image shows the Wadi Rum desert and irrigated farmland in Jordan. *(Image credit: NASA)*

"Jordan's ability to satisfy future urban and agricultural water demands will be stressed by cascading effects on its freshwater supply," said study co-author Steven Gorelick, the Cyrus

Fisher Tolman Professor in Stanford's School of Earth, Energy & Environmental Sciences. "These impacts are from increasingly severe droughts and eventual agricultural land-use recovery in the aftermath of the Syrian civil war."

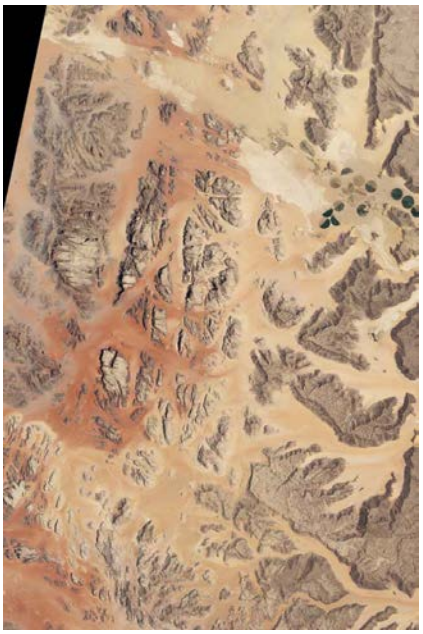
Gorelick leads the Jordan Water Project, which is exploring water management and policy in Jordan with the hope of both improving water security in the water-poor nation and developing tools to improve water availability in other drought-prone regions. The recent paper, published August 30 in *Science Advances*, found that without significant changes, Jordan could face lower rainfall, much higher temperatures and as much as a 75 percent decline in water flowing into the country from Syria.

The situation would be exacerbated by increasing Syrian agricultural water use in the aftermath of the country's prolonged civil war, which could further diminish flow to the Yarmouk River, the largest tributary to the Jordan River.

Management-focused analysis

Rather than focusing just on lower rainfall, the team measured three types of drought as they affect Jordan: rainfall decrease, agricultural soil moisture loss and declines in freshwater streams. They looked at each of those conditions through, first, a business-as-usual lens that assumes a lack of international climate-policy action with continued high rates of greenhouse gas emissions and, second, an optimistic scenario of reduced emissions with climate change policy interventions. They used the period 1981–2010 as a historical baseline against simulations for the years leading up to the end of the century.

The authors said this approach could better inform drought management by considering all vulnerabilities for people, agriculture and the environment. That's because declines in streamflow and soil moisture, which are critical to freshwater supply and agriculture, are driven not only by lower rainfall but also by higher temperatures, evaporation and land-use change. Importantly, countries such as Jordan that are dependent on waterways flowing downstream to them are vulnerable to the consequences of drought and land-use change in upstream regions.



A tanker truck illegally takes water from a river in Jordan. *(Image credit: Steven Gorelick)*

Sobering findings

The team's results suggest that by the end of the century under a business-as-usual scenario, rainfall in Jordan will decrease by 30 percent, temperatures will increase by 6 degrees Celsius, and the number and duration of droughts will double. Increasingly severe drought events will occur almost every year. Flow from the

Yarmouk River, an important source of water that flows from Syria, would decline by up to 75 percent.

"Most importantly, our findings also showed a steep rise in the simultaneous occurrence of multiple drought types," said lead author Deepthi Rajsekhar, a former postdoctoral scholar in Gorelick's lab now working at the California Department of Water Resources. "This brings on a compound effect and increases the overall drought impact significantly. The need for an integrated drought analysis has never been more important for water management."

In a sad twist, an end to the Syrian civil war could add to Jordan's water misery. That's because resurgent Syrian agricultural operations now stalled by the conflict would draw heavily on the Yarmouk.

Toward solutions

Jordan's experience holds lessons for not only countries in arid regions but also those that obtain supplies from one or more of the 278 trans-boundary waterways that feed into shared watersheds occupying nearly half of the world's land.

Despite the challenges, countries such as Jordan have already gone a long way toward water security through sound water management such as efficient irrigation and extensive use of treated wastewater for agriculture. But regional cooperation on water is paramount. A shining example: Jordan, Israel and the Palestinian Authority signed an agreement to desalinate and share water from the Red Sea.

The Jordan Water Project is a program of the Stanford Woods Institute for the Environment's Global Freshwater Initiative.

Gorelick is also a senior fellow at the Stanford Woods Institute for the Environment, director of the Global Freshwater Initiative at Stanford and director of the Hydrogeology and Water Resources Program at Stanford's School of Earth, Energy & Environmental Sciences.

Funding was provided by the National Science Foundation and the Stanford Woods Institute for the Environment.

HOW NUCLEAR WAR WOULD AFFECT THE WORLD CLIMATE AND HUMAN HEALTH

如核戰爆發，將對全球氣候與人類健康造成什麼影響

Q&A with Paul N. Edwards, CISAC's William J. Perry Fellow in International Security at the Freeman Spogli Institute for International Studies.

There is no denying that nuclear war would have a huge impact on the environment. Though daily headlines worry about the safety of nations and citizens, little has been said about the impact on climate change. In Part Two of our series on the consequences of nuclear war, science and technology historian Paul N. Edwards tells us about the effects of nuclear war on Earth itself — and how they would affect humans.

In the nuclear conversation, what are we not talking about that we should be?

We are not talking enough about the climatic effects of nuclear war.

The "nuclear winter" theory of the mid-1980s played a significant role in the arms reductions of that period. But with the collapse of the Soviet Union and the reduction of U.S. and Russian nuclear arsenals, this aspect of nuclear war has faded from view. That's not good. In the mid-2000s, climate scientists such as Alan Robock (Rutgers) took another look at nuclear winter theory. This time around, they used much-improved and much more detailed climate models than those available 20 years earlier. They also tested the potential effects of smaller nuclear exchanges.

The result: an exchange involving just 50 nuclear weapons — the kind of thing we might see in an India-Pakistan war, for example — could loft 5 billion kilograms of smoke, soot and dust high into the stratosphere. That's enough to cool the entire planet by about 2 degrees Fahrenheit (1.25 degrees Celsius) — about where we were during the Little Ice Age of the 17th century. Growing seasons could be shortened enough to create really significant food shortages.

So the climatic effects of even a relatively small nuclear war would be planet-wide.

What about a larger-scale conflict?

A U.S.-Russia war currently seems unlikely, but if it were to occur, hundreds or even thousands of nuclear weapons might be launched. The climatic consequences would be catastrophic: global average temperatures would drop as much as 12 degrees Fahrenheit (7 degrees Celsius) for up to several years — temperatures last seen during the great ice ages. Meanwhile, smoke and dust circulating in the stratosphere would darken the atmosphere enough to inhibit

photosynthesis, causing disastrous crop failures, widespread famine and massive ecological disruption.

The effect would be similar to that of the giant meteor believed to be responsible for the extinction of the dinosaurs. This time, we would be the dinosaurs.

Many people are concerned about North Korea's advancing missile capabilities. Is nuclear war likely in your opinion?

At this writing, I think we are closer to a nuclear war than we have been since the early 1960s. In the North Korea case, both Kim Jong-un and President Trump are bullies inclined to escalate confrontations. President Trump lacks impulse control, and there are precious few checks on his ability to initiate a nuclear strike. We have to hope that our generals, both inside and outside the White House, can rein him in.

North Korea would most certainly "lose" a nuclear war with the United States. But many millions would die, including hundreds of thousands of Americans currently living in South Korea and Japan (probable North Korean targets). Such vast damage would be wrought in Korea, Japan and Pacific island territories (such as Guam) that any "victory" wouldn't deserve the name. Not only would that region be left with horrible suffering amongst the survivors; it would also immediately face famine and rampant disease. Radioactive fallout from such a war would spread around the world, including to the U.S.

It has been more than 70 years since the last time a nuclear bomb was used in warfare. What would be the effects on the environment and on human health today?

To my knowledge, most of the changes in nuclear weapons technology since the 1950s have focused on making them smaller and lighter, and making delivery systems more accurate, rather than on changing their effects on the environment or on human health. So-called "battlefield" weapons with lower explosive yields are part of some arsenals now — but it's quite unlikely that any exchange between two nuclear powers would stay limited to these smaller, less destructive bombs.

Larger bombs can flatten cities. Many if not most people within the blast radius — which can be up to 10 miles — would die instantly. Those who survived would wish they hadn't, since most would die later of severe burns or awful cancers. Radioactive fallout from these weapons' debris clouds would reach the stratosphere, where it would travel worldwide, potentially contaminating crops and livestock as well as causing radiation sickness and cancer directly. Later, this fallout would cause genetic mutations in plants, animals and human beings, as it has in the vicinity of the Chernobyl nuclear accident.

Nuclear explosions would also cause immense fires. The smoke from burning buildings, oil and gas fields, refineries, chemical factories, and industrial facilities would be highly toxic. Forest fires would engulf large areas. These effects would destroy more property and kill more people.

You have asked whether it is legal to start a nuclear war, given its environmental effects.

Tell us about the impacts of such a war on climate change.

So far, nuclear weapons have been treated as a last resort. If leaders are rational, political scientists have always argued, they will never launch first because they know they'll be destroyed, or at least badly damaged, by the retaliatory attack.

As I noted, the climatic consequences of nuclear war are potentially catastrophic. This fact, were it widely known and accepted, ought to act as an even further deterrent to nuclear conflict.

The laws of war require belligerent nations to avoid damage and casualties to neutral nations and non-combatants. But medium- and large-scale nuclear conflicts would have severe, *and global,* climatic effects. Most or all neutral nations and non-combatants would be damaged and would suffer casualties. So a strong argument can be made that any such war would be illegal (a point I owe to discussions with Scott Sagan and Bill Perry).

My hope is that as the much slower catastrophe of global climate change continues to grow, the full scale of the climatic damage that could be done by nuclear war will also become a serious issue for international negotiation.