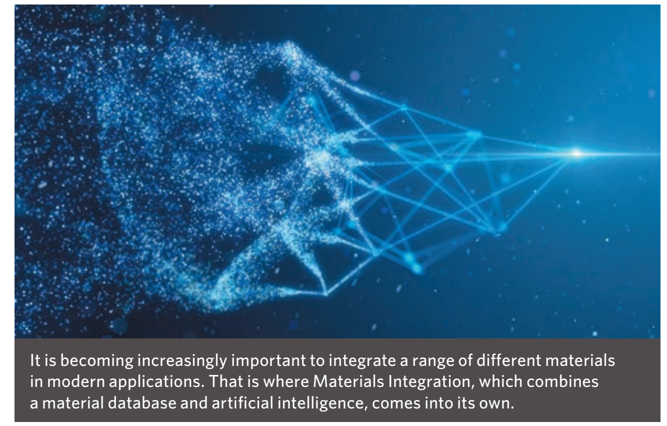
ADVERTISEMENT FEATURE

Connecting material designers through a digital language

A big-data platform developed by JAPAN'S NATIONAL INSTITUTE FOR MATERIALS SCIENCE is raising the competitiveness of stakeholders

Composite materials make up about half of the body of the Boeing 787 Dreamliner.

Masahiko Demura (centre) is using artificial intelligence to accelerate the optimization of material treatments.



It is becoming increasingly important to integrate a range of different materials in modern applications. That is where Materials Integration, which combines a material database and artificial intelligence, comes into its own.

From superalloys to lightweight carbon-fibre composites, materials designed to support and transfer force form the backbone of critical infrastructure. Innovation in this field has long been driven by experimental trial and error, but a new approach is emerging — tailoring materials from the atomic scale up to meet specific performance needs, with the computer as the primary design tool. The National Institute for Materials Science (NIMS) in Japan is playing a key role in this shift by developing a big-data platform called Materials Integration, which applies the latest advances in data science to materials.

"THE KEY ADVANTAGE OF MATERIALS INTEGRATION IS ITS FLEXIBILITY TO GROW"

The past few decades have seen enormous improvements in algorithms designed to model structural materials. Aerospace manufacturers, in particular, have adopted these techniques to simulate the overall system response of aircraft to expected real-world conditions. This is typically accomplished by combining models that operate at different scales, from molecular-level polymer orientation to aerodynamic analysis of wing structures.

But new problems are emerging as this field matures. When manufacturers of different aircraft components need to collaborate, for instance, who decides on the appropriate mix of models? Are the algorithms able to communicate with each other? And how do these simulations keep up to date with latest safety requirements and research results?

BRINGING IT ALL TOGETHER

Increasingly, organizations in the Asia–Pacific region are finding solutions to these issues through Materials Integration — a platform that combines data science and machine learning techniques to help users navigate the complex factors that determine how a material's properties and performance can be affected by processing steps and atomic structure.

Tasked in 2014 by the Japanese government to help manufacturers adapt to computer-driven product development, NIMS and the University of Tokyo created a system called Materials Integration by Network Technology (MInt) with the aim of providing a common system for interlinking many types of simulation tools. A key feature of MInt is that it digitizes different aspects of the material-production process into distinct modules.

"Let's say we're asked to give input on the heat treatment of a certain type of metal. We can have modules that simulate heat treatments, mechanical testing and even scanning electron microscopy," explains Masahiko Demura, director of Research and Services Division of Materials Data and Integrated System at NIMS. "We then use a workflow to combine the modules with some databases according to an input parameter, such as a heating schedule. These connections enable us to extract computational images of the precipitate and predict the temperatures that maximize the hardening by the precipitate."

"Because these treatments can be history dependent, we used to have trouble optimizing them — there was just too much to explore through experiments," Demura continues. "But we can now apply artificial-intelligence algorithms to narrow the conditions we have to search. The entire process takes only a few hours."

After initial trials demonstrated success in modelling the complex microstructure and performance of welded steel, the NIMS team began to seek industrial and academic partners to adopt the MInt platform. Now, 17 organizations are a part of the consortium, contributing research findings and experience to help all members improve the efficiency of their digitization efforts.

"The key advantage of Materials Integration is its flexibility to grow," says Demura. "It can treat new materials problems by adding modules and establishing workflows. We even have a web-based system that allows these modules to be searched and automatically connected."

REALIZING 'ATOMS TO AIRCRAFT' CONCEPTS

One place where the Materials Integration strategy is taking flight is the University of Washington in the United States. Tomonaga Okabe, a professor at Tohoku University in Japan and a specialist in carbon-fibre composites and multiscale modelling, has spent the past several years as an affiliate professor at the University of Washington, helping a network of academics, component producers, and one of the largest manufacturers in the world implement revolutionary changes in the way aircraft are built.

"We're focused on applying carbon-fibre-reinforced plastic (CFRP) composites to aircraft. Boeing really kickstarted this when they introduced their 787 Dreamliner — composites make up 50% of its body," says Okabe. "Many of those structural components are manufactured by Japanese heavy industries and CFRP used in the 787 Dreamliner is also made by the chemical company Toray. In the Cross-ministerial Strategic Innovation Promotion Program, those Japanese companies have united to develop the Comprehensive System for Materials Integration of CFRP (CoSMIC)."

"When material scientists make composite materials from the molecular scale, they might not appreciate how the products impact the final aircraft. CoSMIC can provide that sensitivity quantitatively," explains Okabe. "It makes it possible to share the data including both experiments and simulations in the same system, so collaboration among projects is much easier than before."

CoSMIC is enabling industry to significantly improve safety by reducing the possibility composites fracturing or being damaged. "Platforms like CoSMIC are seamless systems that address almost any possible scenario for damage or failure; engineering design usually can't provide that kind of detail, Okabe says. "CoSMIC can also improve the use of robotics. It won't be long before Materials Integration will help us produce aircrafts without relying on human labour." ■

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SIP

Cross-ministerial Strategic Innovation Promotion Program
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