Front Cover Image – Recrystallised Grain Boundary

Single crystal Ni based superalloys can be sensitive to stress induced recrystallisation. In this example above a developmental alloy SC² (Strong Corrosion Resistant Single Crystal) experienced recrystallisation during the knocking out of the casting mould. Pneumatic hammers are often used to remove the ceramic shell from the casting. Without grain boundary strengtheners large recrystallised grains can form and although macroscopically can appear smooth on high magnification can be serrated forming along preferential crystal orientations.
EMG newsletter lead - Innovative building materials

A significant fraction of energy consumption relates to buildings. By the time a building is occupied, between 30% and 70% of its lifetime carbon may already have been accounted for; the fraction varies depending on the type of building with low fractions for shops and offices; high fractions for warehouses and intermediate values for housing [1]. There are challenges and opportunities related to several aspects of buildings; this article considers two technologies where innovation offers scope for improvements that have been the topics of meetings at the West of England Metals and Materials Association (WEMMA), bamboo construction (Héctor Archila, University of the West of England) and geopolymer-stabilized soil materials (Alastair Marsh, University of Leeds).

Bamboo construction

While unfamiliar in the UK, bamboo is widely used for buildings in Southeast Asia and Latin America. Bamboo has a number of exceptional features that allow buildings to be constructed with neutral or beneficial results for decarbonisation and global warming.

Bamboo can grow rapidly, from the ground to a height of 25 m in five years. During this growth, bamboo captures and stores atmospheric CO₂ and, if it is used in durable products, such as building materials, the release of the captured CO₂ can be delayed for as long as the product or building is in service. Calculations confirm that bamboo-based construction systems give a negative CO₂ balance; that is, their use can reduce levels of atmospheric CO₂; in contrast, the cement industry accounts for a significant fraction of global CO₂ emissions.

Traditional methods of construction that use unmodified bamboo poles as a structural material are labour intensive and unsuitable for buildings more than two stories high. However, new construction methods have been developed that use engineered bamboo products (EBPs) for structural elements. These use cross-laminated bamboo elements and are similar to other laminated timber products; with consistent geometries and relatively low variations in materials properties, allowing the use of standardised design and construction. Moreover, bamboo has a specific stiffness comparable to steel and a high strength to weight ratio. In comparison, engineered bamboo products can be used to build multi-storey buildings.

The shift on bamboo processing technologies is required if bamboo is to be considered as a truly sustainable and high performing mainstream material and alternative to wood. Recent research on bamboo manufacturing technologies has demonstrated that there is an untapped potential for developing engineered bamboo products with improved mechanical and physical properties and reduced carbon footprint.
Geopolymer-stabilized soil materials (GSSM)

By 2050 there will be over a billion more people on earth than today, mostly in less economically developed countries (LEDCs) - all needing somewhere to live. Geopolymer-stabilized soil materials (GSSM) have potential to contribute to affordable, sustainable and attractive buildings in poor areas. The manufacture of geopolymer building materials emits less CO₂ than fired bricks or concrete and can consume industrial waste.

The process of geopolymerization uses alkaline chemicals to transform clay soil into a type of ceramic polymer that can bind materials to produce a solid structure commonly referred to as a geopolymer. Production of GSSM requires an aluminosilicate precursor, an alkaline reagent and water. Of traditional building materials, the manufacture of bricks and cement require firing temperatures of typically 1000 °C and 1450 °C respectively; these energy-intensive processes are costly and result in high carbon emissions. In contrast, the geopolymerization of soil requires much lower temperatures of between 80 and 100 °C. Thus, depending on the source materials and required properties, geopolymer-stabilized soils could have as low as half the carbon emissions impact of concrete and a quarter those of fired bricks. People living in LEDCs use a variety of traditional and conventional modern building materials to construct their homes, which can damage the environment if not sustainably sourced; for example, the use of fired brick in Uganda has resulted in deforestation from gathering wood to fuel kilns.

Although GSSM can achieve mechanical properties (compressive strength and elastic moduli) that are similar to those of Portland cement concrete, there are numerous compositions of soil across the world and a knowledge gap in the understanding of how the manufacture of GSSM varies between them. Work is under way to overcome this by testing a range of soils to understand what happens when they are used to make GSSM and ultimately determine whether these new materials can be used to build quality, affordable and sustainable housing.

Training in construction in Uganda using geopolymer modified clay bricks - [source]


Dr Martin Lamb
Member of EMG
Energy Materials Information Streams

The EMG microsite is a mine of information relating to Energy Materials with links to various sources of information, including funding sources for collaborative research/development.

The EMG microsite is actively managed and regularly updated; the link to the appropriate location on the microsite is given below


Materials Today Energy, Volume 10, Dec, 2018

- Effect of oxidizer in the synthesis of NiO anchored nanostructure nickel molybdate for sodium-ion battery
- Enabling selective aerobic oxidation of alcohols to aldehydes by hot electrons in quantum-sized Rh nanocubes
- Boosting electrocatalysis of oxygen reduction reaction through photovoltaic-driven potential manipulation strategy
- Understanding the effects of surface modification on improving the high-voltage performance of Ni-rich cathode materials
- Investigation of metal oxides, mixed oxides, perovskites and alkaline earth carbonates/hydroxides as suitable candidate materials for high-temperature thermochemical energy storage using reversible solid-gas reactions
- Synthesis of flower-like NiCo$_2$O$_4$ via chronopotentiometric technique and its application as electrode materials for high-performance supercapacitors
- Solid-state supercapacitors based on poly (3, 4-ethylenedioxythiophene) (PEDOT) – Manganese oxide (MnO$_2$) composite electrodes synthesized by single-step Co-Deposition for electrical energy storage
- Silicon expansion at the service of safety – A reversible potential-dependent switch for safer batteries
- Air-stable metal hydride-polymer composites of Mg(NH$_2$)$_2$–LiH and TPX™
- Ni-doped MnO$_2$/CNT nanoarchitectures as a cathode material for ultra-long life magnesium/lithium hybrid ion batteries
- Tridimensional few-layer graphene-like structures from sugar-salt mixtures as high-performance supercapacitor electrodes
- Enhanced photocatalytic hydrogen evolution activity of carbon and nitrogen self-doped TiO$_2$ hollow sphere with the creation of oxygen vacancy and Ti$^{3+}$
- Phosphorene as cathode for metal-ion batteries: Importance of F decoration
- Spray-assisted deposition of CsPbBr$_3$ films in ambient air for large-area inorganic perovskite solar cells
- Ultrafine iridium oxide supported on carbon nanotubes for efficient catalysis of oxygen evolution and oxygen reduction reactions
Organisation Profile

The International Renewable Energy Agency

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

With more than 180 countries actively engaged, IRENA promotes renewable resources and technologies as the key to a sustainable future and helps countries achieve their renewable energy potential.

IRENA’s REmap programme determines the potential for countries, regions and the world to scale up renewables. REmap assesses renewable energy potential assembled from the bottom-up, starting with country analyses done in collaboration with country experts, and then aggregating these results to arrive at a global picture. The roadmap focuses not just on renewable power technologies, but also technology options in heating, cooling and transport. REmap focuses on possible technology pathways and assesses numerous other metrics, including: technology, sector and system costs; investment needs; externalities relating to air pollution and climate; CO₂ emissions; and economic indicators such as employment and economic growth. Based on these country driven results, REmap provides insights to policy and decision makers for areas in which action is needed as given in their recent report “A Roadmap to 2050”, see link below.


IRENA has an extensive database of energy related statistics for every country member, covering capacity, generation, energy balances, costs, etc. see examples below and produces many reports, e.g. “Renewable Capacity Statistics 2019”

For more information on the activities of International Renewables Energy Agency please visit https://www.irena.org/aboutirena
Editor's Titbits Section

A National Trust pub in Cumbria has added information about the carbon impact of food to its menu

A National Trust pub in Cumbria has added information about the carbon impact of food to its menu. The Sticklebarn pub restaurant now displays the environmental footprint of each meal next to the item in a bid to provide diners with more choices and given them freedom to eat sustainably. The menu shows one of the most carbon-heavy dishes is nachos with chilli, chocolate, coffee, sour cream and guacamole – together these ingredients add up to a massive 5.74 kilogrammes of greenhouse gases, equivalent to driving around 14 miles in a typical car.

The lamb burger served with wedges also packs a significant carbon punch, with emissions weighing in at 4.53 kilogrammes for the entire meal. This is largely because of the methane released by sheep – the burger is sourced from local farms and would likely be even more emissions-intensive if sourced from farther afield, due to transport-related fuel use. The lowest impact items on the menu are vegetarian and include a black bean burger, which generates only 860 grammes of greenhouse gases per dish.

A credit card with a carbon emissions spending limit!

A new credit card that helps users track and measure their carbon emissions associated with their purchases as well as cap the climate impact of their spending has been launched. Swedish fintech company Doconomy’s ‘DO Black’ credit card, developed in partnership with Mastercard, is linked to an app that enables consumers to track and measure their carbon footprint from each purchase and allows them to put limits on the climate impact of their spending.

It is the first credit card ever to stop people from overspending, not based on available funds but on the levels of CO₂ emissions caused by their consumption. Those who sign up to DO will receive access to a savings account that helps them understand their carbon footprint, UN-certified climate compensation projects and investment funds that have a positive impact on people and the planet.

UK drones map Chernobyl's 'Red Forest', (BBC News Website 8 May 2019)

Chernobyl's "Red Forest" - one of the most radioactive locations on Earth - has recently been surveyed by UK scientists using a suite of drones. The robotic aircraft flew novel sensors that have given Ukrainian authorities more up-to-date information on the sites with the greatest contamination.

The Red Forest is just 500m from the Chernobyl nuclear complex. It was hit by the immediate fallout from the 1986 explosion and fire in the plant's number-4 reactor. Many of the forest's trees died and turned orange. Some areas are still strictly out of bounds to humans. The UK's National Centre for Nuclear Robotics (NCNR) has developed a drone-mapping system that allows scientists to investigate hazardous places from a safe distance.

Fixed-wing craft are first used to make a general radiation map by flying at about 40mph (65km/h) just above the treetops, in a grid pattern. Places of interest are then followed up with rotary-wing drones. These can hover and use their sensors to acquire high-resolution, 3D information.

The survey conducted in April 2018 essentially confirmed the current understanding of the radiation distribution in the forest, but in far greater detail than has previously been available. The
drones also identified a few unexpected hotspots. One of these, a few km to the south of the forest, turned out to be an old soil separation unit used during the original clean-up efforts. The legacy left at that facility is essentially spent nuclear fuel scattered on the floor, which was giving a very high radiation dose of about 1.2 millisieverts an hour.

"Mechanical trees" capture CO\(_2\) in the atmosphere (marie.donlon@ieeglobalspec.com)

“Mechanical trees” developed by researchers at Arizona State University and brought to market by a Dublin-based company will be erected in parts of the U.S. to capture carbon dioxide (CO\(_2\)) from the atmosphere, thereby removing the gas thought largely responsible for climate change.

Dubbed “mechanical trees” for their resemblance to actual trees in both stature and carbon-capturing ability, Silicon Kingdom Holdings (SKH) intends to erect 1,200 of the slender metal columns — enough to capture roughly 8,000 cars’ worth of CO\(_2\) emissions each year — in the U.S. within a year. The company’s objective is to capture CO\(_2\) using the filter-like components installed in the mechanical trees for less than the cost of other carbon-capturing measures. Reliant on wind to force air through its system rather than energy-intensive mechanisms, the mechanical trees capture the CO\(_2\). Once extracted the CO\(_2\) can either be sequestered or sold for commercial use.

Technology to fight air pollution whilst creating food (marie.donlon@ieeglobalspec.com)

Researchers from Imperial College of London and British startup Arborea are preparing to test technology that could battle air pollution while simultaneously creating a food additive. Called BioSolar Leaf, the technology uses microscopic plants like microalgae and phytoplankton on solar-panel-like devices that can be installed anywhere a solar panel could be. During photosynthesis, the microscopic plants eliminate carbon dioxide from the air while simultaneously generating oxygen. According to the team, just an acre of the system cleans as much air as 100 acres of trees would. Simultaneously, the plants also generate an organic protein that can be extracted from the system and used to manufacture food additives for plant-based foods.

Health Secretary launches review into ‘slow and deadly poison’ of air pollution

Health Secretary Matt Hancock has launched an in-depth review into the impact of dirty air on health in the UK. He describes polluted air as a “slow and deadly poison”, which is estimated to result in 2.4 million new cases of disease by 2035, according to Public Health England (PHE).

The review will provide updated estimates of new diseases caused by toxic air as well as up-to-date modelling to identify how many cases of disease the government’s Clean Air Strategy could prevent and where more attention could be placed. It supports the plans of the NHS to go green, which includes a target to cut business mileages and fleet emissions by 20% by 2023/24.

In 2017, around 3.5% of all road travel in England – 9.5 billion miles – was related to patients, visitors, staff and suppliers to the NHS. Under the new plans, at least 90% of the NHS fleet will use low emission engines – including 25% ultra low emissions – and primary heating from coal and oil fuel in NHS sites will be phased out by 2028. Over the next five years, patients will be offered online digital GP consultations and redesigned hospital support is expected to avoid up to a third of outpatient appointments, significantly reducing transport pollution.

Editor’s Note: The source of many of these titbits is Energy Live News.
Mini Feature

Novel process derives algae-based biofuel from wastewater
(Courtesy Engineering 360, May 9th, 2019)

Researchers at Idaho National Laboratory have developed a way to grow blue-green algae - known as cyanobacteria - for bioenergy, which can also help clean up water from wastewater treatment plants. Blue-green algae blooms can become a real problem by clogging waterways around the world, and their toxins can be harmful to humans and wildlife. These photosynthetic organisms thrive on human sources of nitrogen and phosphorus, including effluent from waste treatment plants and fertilizers that wash into watersheds from farms.

These nutrient-loving algae also can serve as a feedstock for biofuels and power. Researchers say that the amount of oil from algae is 10 times that of palm oil and 131 times that of soybeans. Cyanobacteria have four times the energy productivity as algae under laboratory-scale conditions.

Growing cyanobacteria at an industrial scale requires a lot of water and nutrients so the research team worked with the Drake Water Reclamation Facility (DWRF) in Fort Collins, Colorado. They settled on the point in the treatment process where a centrifuge is used to separate solid waste from liquid waste. The solid waste is dried and sent to a landfill. The nutrient-rich liquid waste, called the "centrate," is recycled back into the wastewater treatment plant before it is discharged.

Once the centrifuge separates the solids from the centrate, the centrate is pumped into a photobioreactor, a device where the cyanobacteria are cultivated using nutrients and sunlight. This process clears the nitrogen and phosphorous from the centrate to levels consistent with state and federal water-quality standards. The cyanobacteria multiply and another centrifuge separates the cyanobacteria biomass from the water.

That biomass then moves to a biodigester, which uses microbes to turn biomass into biogas. The biogas is then burned for heat and power. The resulting CO₂ is pumped back into the photobioreactor to aid with photosynthesis and reduce the carbon footprint. When the researchers started to look at nitrogen concentration and cyanobacteria growth, there were some trade-offs. At lower nitrogen concentrations, with a slower growth rate, the water reached the water quality standards faster. The trade-off was that a slower growth rate at lower nitrogen concentrations required more acreage for the photobioreactor which, in turn, consumed more electricity.

Cyanobacteria are a group of photosynthetic bacteria, some of which are nitrogen-fixing, that live in a wide variety of moist soils and water ranging from unicellular to filamentous and include colonial species. Colonies may form filaments, sheets, or even hollow spheres. Genetically modified cyanobacteria have been developed so they first make sugar (pyruvate) from CO₂ via photosynthesis. The bacteria then secrete ethanol from the cell. As the day progresses, and the solar radiation intensifies, ethanol concentrations build up and the ethanol evaporates and as the sun recedes, evaporated ethanol and water condense into droplets, which run into ethanol collectors. It is reported that yields of 9,000 US gallons per acre per year have been achieved. This could potentially meet US demands for ethanol in gasoline by 2025, from an area of around 25,000 km², which is less than one-tenth of the area than ethanol from other biomass, such as corn, and would only very limited amounts of fresh water.
## Upcoming Events

### NEXT COMMITTEE MEETINGS

09:30 24 July 2019, Webex

### EMG WORKSHOPS/CONFERENCES

**Parsons 2019**, 16–18 September 2019, Cranfield University, UK

### OTHER WORKSHOPS/CONFERENCES/COURSES OF INTEREST


**ATOMS 2019**, 4 July 2019, Birmingham, UK

**21st International Conference on Advanced Energy Materials and Research**, 11-12 July 2019, Zurich, CH

**4th Functional Oxide Thin Films for Advanced Energy and Information Technology Conference**, 17-20 July 2019, Lisbon, PT

**NECEM International Conference on Energy Materials & Interfaces**, 29 July–1 Aug 2019, Newcastle, UK

**Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors**, 8-22 Aug 2019, Boston, USA

**Collaborative Conference on Advanced Materials 2019**, 26-30 Aug 2019, St. Julian’s, MT

**24th International Conference on Advanced Materials and Nanotechnology**, 19–20 Sept 2019, Brussels, BE

**World Congress on Carbon and Advanced Energy Materials**, 23-24 Sept 2019, Hong Kong, CN


**International Conference on Coal Science and Technology 2019**, 24-28 Nov 2019, Krakow, PL

**Asset Integrity Management Operational Excellence Forum**, 28-29 Nov 2019, Amsterdam, NL


**ECCC2020**, 14–16 Sept 2020, Edinburgh, UK