Materials Workshop

Background: New technologies and climate policy will change markets for materials throughout the economy. The production of raw materials such as steel and cement are responsible for a major share of industrial energy use and emissions. The companies that make them are key parts of the economy. Innovative materials also enable the production of products that can greatly reduce production of greenhouse gases. These include materials that can provide improved function at reduced weight, materials designed for recycling, and materials that enable novel energy production, conversion, and storage. Federal investment in novel materials has been consistently strong but typically projects are embedded in programs with other missions. Major investors include the Departments of Defense, Energy, Commerce, and NASA and NSF. Efforts to create a coordinated innovation strategy, and to ensure that investments are targeted where they can have maximum impact on the future of US manufacturing and maximum impact on meeting climate goals have not been fully successful.

Innovations that can reduce the climate impacts of raw material production are covered in the workshop on "high temperature processes". This workshop will focus on innovations in the design and use of materials. It will consider four key areas:

1. **Materials by design:** Rapid improvements in the field of *Integrated Computational Materials and Engineering* coupled with innovations in methods of characterizing materials down to the molecular level, are making it possible to design materials with greatly improved characteristics including strength, durability, optical properties, selective permeability, and many others. Substitutes for rare and expensive materials can also be explored. Computational tools make it possible to explore an enormous range of designs, materials, and processing methods at comparatively low cost
2. **Efficient use of materials:** Advanced computational tools and production methods like additive manufacturing (3D printing) at scales from millimeters to tens of meters have made it possible to consider designs that could cut the mass of materials needed to provide functions ranging from auto parts to bridges.
3. **Materials for a circular economy:** The biggest barrier to recycling materials is undoubtedly the comparatively low cost of raw materials in the absence of externality prices such as a carbon tax. Innovative materials, however, could dramatically reduce the cost of reusing materials. These include plastics, steel alloys, and other materials designed for recycling and methods for efficient processing of mixed recycled products (such as mixed plastics).

4. **Biological materials:** Millenia of evolution has led to biological materials with extraordinary properties. While the workshop on "biological solutions" will focus on producing chemicals and food products using biological systems, this workshop will focus on exploiting the material properties of organic systems. This includes mimicking the use of fungi and other microorganisms to produce concrete substitutes or replacements for packaging and other products. The use of wood and other natural materials in buildings, and exploring the design of wood, bone, and other high strength/low-weight biological structures.

Issues for Discussion:

1. What are the most critical research priorities in materials design, use and reuse for ensuring that the US meets climate targets and builds opportunities for the competitiveness of US manufacturers in a global economy focused on climate goals?
    - Are critical research topics or topic areas missing?
    - Are some of the topics suggested clearly dead ends?
    - Who (what communities) should have been included in our discussion but are missing?
2. Is there a need for an integrated national materials initiative?
    - What topics should be included?
    - How should the balance between basic research and research aimed at scale-up and commercialization be managed.
    - What mechanism should be used to ensure that topics are continuously refreshed and ideas drawn from the diverse corporate, government, and academic communities interested in new materials?
    - How should it be managed (White House coordination?)
    - How can combine topics meeting climate goals with the goal of ensuring that US manufacturers capture the markets of the future?
3. Can we improve the way materials properties vital to meeting climate goals are communicated to the material science community? In many cases the priorities of existing manufacturing (e.g. fossil fuel production and processing, internal combustion engine design) will shrink in importance in comparison to materials for newly emerging manufacturers (hydrogen production, photovoltaic materials, windows and wall materials with tunable properties, separation membranes). Which mechanisms work and which don't?

4. How can we better integrate research aimed at biomimetic materials and materials production using synthetic biology with traditional materials production research.
5. How does the US materials innovation pipeline compare with those in Europe and Asia? Are there areas where US producers should be concerned? Are there research management practices and strategies for combining government and industrial research that we should learn from?

Invited Speakers:

Julie Christodoulou, Director of Naval Materials S&T Division, Office of Naval Research (moderator)
John Allison, Professor, University of Michigan
Jonathan Cullen, University of Cambridge
Per-Anders Enkvist, Founder and CEO, Materials Economics
Eric Kreiger, Structural Research Engineer, U.S. Army Engineer Research and Development Center
Jill Martin, Global Sustainability Fellow, Dow
Greg Olson, Professor, Massachusetts Institute of Technology
Patrick Rose, Science Director for Synthetic Biology, Office of Naval Research Global
Kate Simonen, executive director of the Carbon Leadership Forum and Professor and Chair of the Department of Architecture at the University of Washington