Matériaux & Techniques **109**, E501 (2021)

https://doi.org/10.1051/mattech/2022022

Matériaux & Techniques

Available online at:
www.mattech-journal.org

Special Issue on 'Materials and Society: the circular economy, design for circularity and industrial symbiosis', edited by Jean-Pierre Birat, Gaël Fick, Nicolas Perry, Andrea Declich, Leiv Kolbensein, Dominique Millet and Thecle Alix

EDITORIAL

The Circular Economy, Design for Circularity and Industrial Symbiosis

Jean-Pierre Birat

This special issue of Matériaux et Techniques presents 5 papers on the topic of Circularity and Indusial Symbiosis. They were developed from presentations made at the 15th International Conference on Society and Materials (SAM-15), 10–11 May 2021, held online.

There are two complementary ways of considering materials. One positive view [1] explains how materials have stayed at the core of technical progress since the origin of history and how this is likely to continue for a long time to come. Another view stresses the liabilities that economic activities have imposed on the environment to the point that climate change is endangering the well-being of people on the planet, while their health is threatening by pollution, especially of small particulates, and many natural resources are becoming scarce [2,3]. Materials are deeply involved as well in this negative view. As the saying goes, "materials are part of the problem but also part of the solution".

There is clearly a tension between both approaches and while technology is needed to move forward and away from bad practices, it will not continue to act as a magic wand to propel us towards a restored future. More action, politically motivated, will be needed to drive economic, social and individual (lifestyle) activity change, such as formulated in the European Green Deal, or, more generally, in the debates that have been central to the Society and Materials Conferences, for the last 15 years.

The five papers presented in this special issue address these questions on some specific and focused topics and propose answers that mix engineering and social approaches – probably with an emphasis on technology, as most authors originate from the STEM community.

The paper of Iannino et al. starts from the premise that the factory of the future for steel production will be based on *Industry 4.0,* a model of change for industry positing that a *4th Industrial Revolution* is under way, based on the introduction of cyber-physical systems in the production line. Furthermore, it proposes the method of *Agent-Based Technology* as a way to further improve the never-ending search for the optimization of process and resource efficiency. The argument is that the complexity of steel mills is such that it would benefit from this methodology that explores solutions at the local level of agents, rather than solving overarching equations describing the steel mill as a whole. It is also a kind of social modeling of steel production, focusing on decentralized "agents", rather than on a global description of technology (process engineering, physical chemistry). Some examples are worked out to show that, indeed, *Multi-Agent Systems* (MAS) do achieve better levels of optimization while making it possible to carry out foresight studies exploring new technologies, such as, for example, hydrogen enrichment of methane for methanol synthesis. MAS also demonstrate intrinsic features such as coordination and cooperation, flexibility, scalability, adaptability, robustness and leanness.

Branca et al. discuss the issue of *Industrial Symbiosis (IS) and Energy Efficiency (EE),* in the context of *Process Industries* also known as *Energy Intensive industries (EIIs).* The paper points out first at what these rather abstract words mean, practically speaking: IS is related to waste generated in an industry and to how it can be reused or recycled in a different industry as a secondary raw material (thus BF slag used in the cement industry or BOF slag as a fertilizer in agriculture), while EE is more directly obvious. The analysis also shows that beyond the environmental formulation lie benefits that are related to lower production costs. The core of the paper deals with a questionnaire that was sent to stakeholders in the various EIIs to ask them about their achievements and their expectations relative to IS and EE. The outcome shows that while actors are more fluent as far as EE is concerned rather than IS, but also points out to the need for specific skills to be developed through VET and university curricula. The paper is a very good mixture of STEM and SSH approaches.

Kautz et al. discuss the issue of circular vs. linear economy on the basis that there is a contradiction between rapidly increasing consumption and resource finiteness, which can only be resolved by switching to the circular model. This is the case of *batteries*, particularly *lithium-ion* *ones (LIBs),* which are at the core of the transition from *combustion-engine to e-mobility.* While plans for a complete transition to take place by 2050 in the context of the European Green Deal have been solidly defined and are being implemented, the future of end-of-life LIBs is not completely clear, nor the plans for taking care of their Circularity. The paper uses a robust bibliographic method, called *Systematic Literature Review,* to analyze what is available already in that area in the published literature and to point out challenges, areas of concern and possible solutions to achieve Circularity. The discussion is broad, dealing with technical, economic, social, logistical, and ecological issues.

Gehring et al. address the issue of evaluating the *sustainability of a new technology, while it is still under research and development.* This is the perfect approach to look for in the process of proposing radically new technology – as, usually, this kind of analysis is done much later, like explained in Kautz's paper. The present paper deals with the specific case of *printed electronic (PE) circuits,* which would be implemented for producing devices such as RFIDs or IoT sensors. In this technology, the ink is a very specific material, which ought to exhibit a variety of properties, including electrical conductivity provided by embedded nanoparticles.

The method, called *sustainability screening,* is based on conducting the LCA of the final device – when it is only in the design stage – following its production, use and end of life phases. It is worked out in templates, which are made available to the design engineer to help him select the proper materials and processes to minimize impacts (various indicators, actually, like in an LCA). The authors insist that going through these evaluation steps is necessary if any kind of sustainability assessment is to be performed. The method has the potential to be used in a more general context than the case study to which it is being applied.

Prentzel et al. use the methodology developed in the previous paper to discuss the technical aspects of materials related to PE. The first conclusion is that there is no "one size fits all" set of materials and production processes that could be selected as optimized for any kind of application: rather, each case study should be worked out in full details. Then they explain that the conductive ink is the source of the main environmental impacts and therefore that ink designers should explore more solutions than are currently available from the shelf (thus try to avoid silver nanoparticles and explore other metals and organic materials). Eventually, this should lead to statements about whether printed electronic is actually environmentally friendly, which is not demonstrated yet. This paper as well as the previous one reports on on-going research.

The Jean-Sébastien Thomas Award was awarded this year to the paper of Emilia Kautz, Ömer F. Bozkurt, Philip Emmerich, Manuel Baumann and Marcel Weil1.

In order to put the 5 papers in perspective, the program of SAM-15 is given in the appendix.

Appendix: Day 1 – 10 May 2021

Session 1: Industry 4.0 and Sustainability, Chair: Nicolas Perry, ESAM

Influence of design properties of printed electronics on their environmental profile, Prenzel, Fraunhofer Institute for Building Physics, Germany

Carbon and material impacts of urban transport policy – an econometric open data approach, J. Peters, Universidad de Alcala, Spain

Sustainability screening in the context of advanced material development for printed electronics, Gehring, Fraunhofer Institute for Building Physics, Germany

Multi-agent systems to improve efficiency in steelworks, Iannino, Scuola Superior Sant'Anna, Italy

Session 2: Social Sciences visions of SAM topics, Chair: Fabio Feudo, K&I

Keynote Lecture: J.-P. Birat, IF Steelman, France, *Transitions as a model of energy, ecology and social changes.*

Societal acceptance of emerging energy technologies in the context of the energy transition, Baur, KIT, Germany

Industry 5.0: the triple transition digital, green, and social, A. Schroeder, TU Dortmund, Germany

The beginning and the end of the aluminum value chain, L. Kolbeinsen, NTNU, Norway

SME's, energy efficiency, innovation: a reflection on materials and energy transition, A. DECLICH, Knowledge & Innovation, Italy

Social life cycle assessment of novel flotation technology, CECERE, Politecnico di Milano, Italy

Session 3: Strategic and geopolitical approaches, Chair: Jean-Pierre Birat, IF Steelman

Keynote Lecture: Cédric Philibert, IFRI, France, *Decarbonising the world economy: the roles of electricity, hydrogen and electrofuels*

A general theory for stock dynamics of populations and built and natural environments, R. Billy, NTNU, Norway

Future metal stock and flows by sector based on shared socioeconomic pathways: the example of Aluminium alloys, Pedneault, CIRAIG, Canada

Engineering new materials from biomass. a multidisciplinary object in material science and beyond: compost, J.J. Gaumet, Institut Jean Barriol, France

Gallium availability for regional energy transition: the challenging from dynamic aluminum cycle in China, Song, University of Southern Denmark, Denmark

Global scenarios of resource and emissions savings from systemic material efficiency in buildings and cars, S. Pauliuk, University of Freiburg, Germany

Day 2 – 11 May 2021

Session 4: Sustainable mobility and sustainable cities, Chair: Guido Sonnemann, University of Bordeaux

Keynote Lecture: Arnaud Delebarre, Mines ParisTech, France, *Teaching Climate Change for responsible individuals and pro-active companies*

Challenges and options for the recycling of present and future batteries, M. Weil, KIT, Germany

Analysis of EU-funded research activities on reuse and recycling of residual materials in the steel sector, V. Colla, Scuola Superior Sant'Anna, Italy

Potentials and challenges of a circular economy: a systematic review for the future of lithium-ion batteries, Emmerich, TU Berlin, Germany

Ecological evaluation of process heat generation in steel processing with special consideration of the energy transition, Kaiser, RWTH, Germany

Aluminium-based energy storage: techno-economic evaluation of energy storage use cases, Ersoy, KIT, Germany

Current state of industrial symbiosis and energy efficiency in the European energy intensive sectors, T. Branca, Scuola Superior Sant'Anna, Italy

Understanding design process at the base of the pyramid: exploratory analysis of a water access solution, Lopez Santiago, CREIDD, France

Early stage sustainability screening of Na-ion cathode materials, BAUMANN, KIT, Germany

Session 5: New Green Deal, Circular Economy & Energy Transition, Chair: Dominique Millet, Eco-SD

Keynote Lecture: A. Allanore, MIT, USA, *Sustainable Materials & Electrons: from curriculum development to processes*

Personalized life cycle assessment – quantification of the carbon footprint of passenger cars taking individual aspects into account, K. Briem, University of Stuttgart, Germany

Challenges and pitfalls of conducting prospective LCA for emerging technologies – the example of metal-free organic battery, Erakca, KIT, Germany

Valorisation of all the fractions of CDW, a route to circular economy: LCA of the Leroy Merlin Project, S. Groslambert, University de Liège, Belgium

Applying the GeoPolRisk method at Midpoint and Endpoint level AS A COMPLEMENT TO LCA: The case of Li-ion batteries for the EU, Santillan-Saldivar, Université de Bordeaux, France

Ex-ante evaluation of novel biotechnology processes for the production of bio-based succinic acid, Merchan, RWTH, Germany

Improving the climate footprint of cement: a modelling-based approach integrating demand and supply, Keramidas, JRC/Grenoble University, France

References

1. Les matériaux au cœur des enjeux stratégiques post-COVID, Livre Blanc, SF2M, 2021, http://sf2m.fr/livre-blanc/
2. J.-P. Birat, Sustainable Materials Science – Environmental Metallurgy, Volume 1 – Materials: Origins, basics, resource and energy needs, EDP Sciences, 2020, 476 p.
3. J.-P. Birat, Sustainable Materials Science – Environmental Metallurgy, Volume 2 – Materials: Pollution and emissions, biodiversity, toxicology and ecotoxicology, economics and social roles, foresight, EDP Sciences, February 2021, 650 p.

Cite this article as: Jean-Pierre Birat, The Circular Economy, Design for Circularity and Industrial Symbiosis, Matériaux & Techniques **109**, E501 (2021)