# Design for New Materials and New Manufacturing Technologies

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**Abstract** Designing new materials introduce new challenges – from the setting of materials physical characteristics to the project of their cultural identity. Such a complex challenge is being embraced by many designers in the present, however, this comes to a price. The large number of materials is already problematizing the traditional modality of direct experience upon them. For example, the traditional systems for classifying materials, commonly referred to as "material families", struggles to incorporate some new materials' unusual and contradictory properties. But also, technologies are characterized by a great dynamism and rapid evolution. This poses significant challenges but also great potential for the design of our future physical world: from the ecological to the social one's.

The human ability to shape the ecosystem is, for most of us, unquestionably evident. As has been shown, especially since the beginning of the industrial age in the nineteenth century together with the development of design as a subject, humankind is capable of actively shaping and reshaping the ecosystem and its environment. This, however, is associated with severe changes. With resource scarcity and climate change, it is time again to see the design of our environment as part of a complex overall system more clearly.

The quantification of what humanity has produced so far (anthropogenic mass) when compared to the mass of what nature currently maintains (biomass) has demonstrated that the first has already exceeded the second [4]. This is explicit proof of the overwhelming capability of humans to impose long-lasting changes on the planet.

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The modifying role and the scale of action of the human species gives some credit to the claim that we are already living in the Anthropocene geological era. [2].

Given dwindling resources, minimizing the use of materials and energy is becoming increasingly important.

Paradoxically, the scope of optimizing material use (the new "less is more") has induced the demand for new materials and improved traditional ones. Research into new materials and the study of their applications and impact at several levels (economic, cultural, social and environmental) has visibly increased.

New Materials and New Manufacturing Technologies are of central importance, since they create new possibilities and new solutions. Contrary to prediction, materials have not lost their significance or relevance.

The weight of what humanity has produced is overwhelming, as is the number of different materials it has developed. Attempts to quantify the number of materials currently available estimates them to be between 50,000 [3] and 100,000 ([1], p. 33), or even more. If this immense quantity of materials could be seen as pointing towards future disinvestment in research and development in this area, the evidence shows just the opposite. The pace at which new materials are being researched and developed is steadily increasing. Many areas of human development seek to optimize their actions (and solutions) in different ways. And two of them are precisely the New Production Technologies and New Materials. Both areas of development are oriented, as in the past, towards exploring new and improved performances. This is why designers now have so many materials at their disposal. And many more are being developed to meet growing manufacturing requirements and environmental necessities.

## 1 Opportunities and Challenges

It is now recognized that materials play a key role in the design process to satisfy technical and technological needs and the experiential dimension [7, 14] (Ashby & Johnson, 2002). The designers' ideas and purposes can only be grasped through their materialization. The playful exploration of such material approaches leads to new functional and formal impulses. We can refer here to many historical models, such as Le Corbusier, Ray and Charles Eames, Konrad Wachsmann, Jean Prouvé and Frei Otto [5]. It has also been seen that the materials themselves inspire and drive the design process [8]. The available number of materials presents both unparalleled design opportunities as well as posing new responsibilities relating, first and foremost, to environmental sustainability. In the history of design, there have been times when the available quantity of materials and related production technologies were understandable to the individual. But nowadays, to imagine such a possibility is unrealistic: there are simply too many. Furthermore, they appear in multiple performances, their identity scattered. Some important research on this has been produced in recent years (e.g. [12, 15, 18]).

Both materials and technologies are characterized by great dynamism and rapid evolution. It means that the amount of new production and the exponential speed of its generation will only widen the gap between what can be grasped and what exists—and thus, questions of form, function and meaning are also to be renegotiated. This poses significant challenges but also great potential for the design of our future environment. It is valid in terms of form, function and meaning, as well as sustainability and ecology, together with sociological and social developments.

There are expressive-sensorial qualities in materials that are difficult to describe theoretically [19, 20]. The recognition of these specific material qualities—beyond given physical properties, such as tensile strength or elasticity modulus—offers great potential for designers and is, therefore, of interest for future research. What do we learn from the texture or the smell of a material? How is it possible to exploit them to create meaningful material experiences?

Designers have started to experiment with materials. There are, in fact, many cases of them producing their own materials, as if those already available were not enough or were not sufficiently responsive to the needs of the new projects [16, 17]. Consequently, various challenges have arisen for (new?) professionals: being expected to know new materials' behaviour and properties, together with being up to date on new technologies; and also how to develop new materials by drawing on a multidisciplinary approach that involves material science, interaction and biology, to name but a few. Such a complex task increasingly requires the ability to cross the quantitative data of materials (necessary "engineering" data) with qualitative information—from sustainability to cultural associations—, dimensions in which designers demonstrate good interpretation skills.

## 2 Between the Taxonomies

The extremely high number of materials is problematizing the traditional modality of direct experience upon them [10]. In other words, the process of learning the physical limits and the perceptual qualities of materials is no longer compatible with direct experience. This is partially due to the speed of production. Design today is characterized by increased links with other areas of knowledge. Material quantifiable parameters are being integrated into digital models. Learning from the natural sciences and technical disciplines is being drawn on. Increasingly more work is being done on systems that are physically, chemically or biologically inspired [6]. This development can also be seen at the level of materiality. The new logic of design concepts and hybrid materials no longer correlates with materials' familiar properties.

The classic material categories seem to be increasingly dissolving. That is why Sabine Kraft wrote that the "relationship between form and material has become as diverse as it is ambiguous. A recourse to clear rules and specifications as to what can be conceived and constructed in which material and how, and what aesthetic message would be conveyed with it, is hardly possible any more—if they ever existed" ([9], p. 24; authors' translation). This leads us to ask whether the discussion about constructions suitable for the material or design ideal for the material is now an outdated approach. Today, materials can be developed for specific situations. The question of material design arises as a notable decision and development at the beginning of a design task and not necessarily a selection from a palette of pre-existing materials.

Humanity has evolved from a "Materiocentric" approach (in which materials were conceived as static—with an unchangeable set of characteristics) to an "Ideocentric" approach (in which the "purity" of ideas is no longer assumed to be compromised by material limitations). Ideas are steadily becoming less subject to adaptation in order to conform themselves to the material possibilities of production limitations. Material oriented design is increasingly turning into "design with designed materials" [5]. The traditional systems for classifying materials, commonly referred to as "material families", struggles to incorporate some new materials' unusual and contradictory properties. Many new materials are characterised by a hybridisation, which may be derived from the combination of different material "genotypes" and technologies. These material hybrids also result in hybrid properties. Formerly existing material properties are overwritten or exchanged. These informed or charged material hybrids link different contexts. Many new design solutions integrate materials and technologies whose complex structure no longer allows conclusions to be drawn about performance or function.

Metals, wood, glass, ceramics, stones, plastics are generic taxonomies whose "cultural image" is more and more outdated in the face of a much more complex material world. Therefore, in certain aspects, the inclusion of new material in any of these families involves some unavoidable stereotyping—which may very well hinder its full application potential being envisioned. Because of the current abundance of different materials and their almost inevitable complex "genotype", belonging to a traditional material family becomes more of a perceptual limitation than understanding new materials' possibilities. If for no other reason, because these nomenclatures base their members on a visual, functional, and performance identity that may be far from what they can be. In addition, the grouping of materials according to physical characteristics requires systematic corroboration in daily life that no longer occurs with the necessary consistency. That is why Manzini ([11], p.55) said that the question "What is this?" should be replaced by the question "What do I need?".

## 3 Research Directions

Materials emerge as cultural expressions of a social interest in overwhelming complexity and, therefore, any reflection upon materials cannot be set apart from a more comprehensive (social and cultural) framing.

A great deal of the most recent I&D involving the areas of design, materials, and production focus on the cultural dimensions simultaneously.

Many of today's approaches follow sustainability and focus on intelligence that is not always inscribed in the material itself, but how it is joined, constructively formed, and applied. New design concepts can also create entirely new relationships between form and function through the micro-scaling of new materials or new technologies. Many of today's design solutions integrate new technologies and materials in scaling and complexity that no longer allow conclusions about the performance or function of the hybrid solutions. This is also linked to the ambivalence of the new hybrid concepts. Such articulation of the new material solutions and hybridizations of design is an essential cultural mission [13].

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