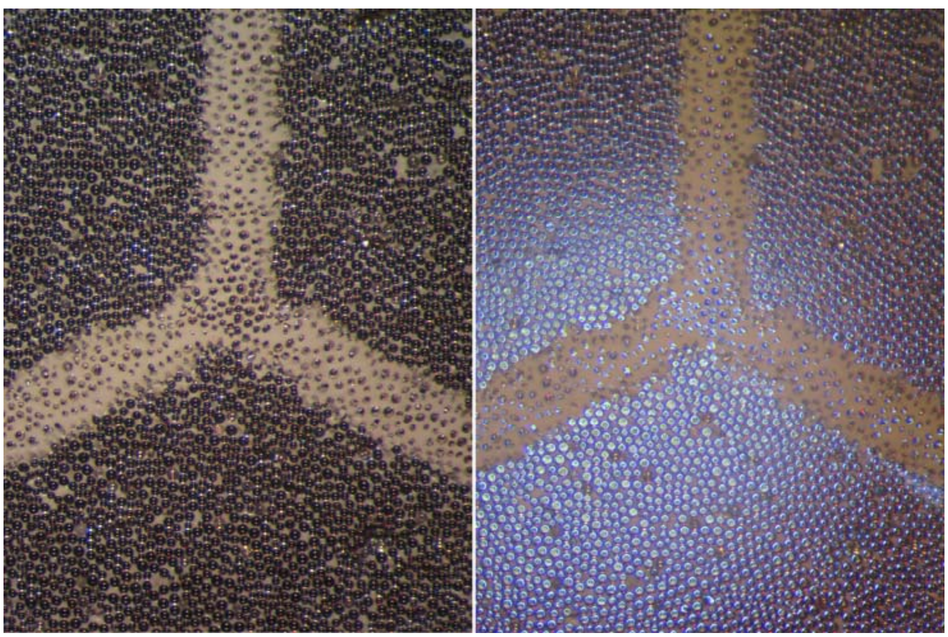
Malleable Matter: Adaptable and Responsive Space

Filiz Klassen, Associate Professor
Ryerson University, Faculty of Communication and Design
350 Victoria Street. Toronto.Ontario M5B2K3 Canada
fklassen@ryerson.ca

PhD Candidate
Delft University of Technology, Faculty of Architecture
Berlageweg 1, Postbox 5043, 2600 GA Delft, The Netherlands

Biography: Associate Professor Filiz Klassen of Ryerson University is the co-editor of Transportable Environments 3, the third book on portable architecture and design that is published by Spon Press, UK (2006). She is the recipient of a research/creation grant from the Social Sciences and Humanities Research Council of Canada for her project entitled 'Malleable Matter'. Scheduled to be exhibited in 2008, this project involves a life-size architectural installation of building components that makes creative use of textiles and related materials innovations.

Keywords: Materials research, design flexibility, responsiveness



1. Reflective fabric microphotography

Abstract

This paper is an investigation of the recent research and developments on high performance textiles, smart textiles and hybrid materials. The term high-performance connotes the designed or enhanced properties that improve the materials' performance in specific conditions but stay fixed or static in response to external stimuli. The term smart, or intelligent refers to materials that change their properties in response to varying thermal, luminous, acoustic or structural stimuli. Although the terms 'fabric' and 'textile' are used in construction and resemble the properties of

‘cloth’ with natural fibers (such as cotton, wool and silk) , high-performance or smart textiles are engineered with synthetic fibers (such as nylon, polyester, carbon and glass fibers), special coatings, embedded technology, sensors and electronics. Many other composite materials that are flexible and layered are termed as hybrid materials as they share properties of the originating materials such as textiles and plastics. These materials have the potential for weaving a new direction towards materiality in design and construction.

Adaptability/Responsiveness: Shift in Perceptual Boundaries

I believe that the material landscape in built environments is currently in a state of transition in which our current design practices will inevitably be transformed in a direction compatible with the theme of responsive environments. Recent high-performance and smart material innovations are demonstrating a new kind of adaptability and transformability of space that are different than those that simply focus on mechanical expansion of spaces and objects. This phenomenon perhaps can be best explained with Philip Ball’s concept that smart ‘[m]aterials can replace machines’. He suggests that ‘[s]ubstances that change their shape or properties in response to various stimuli—electrical signals, light, sound waves—can be used as switches and valves with no mechanically moving parts’ [Ball, 1999, p.103]. In the hands of material scientists this may mean the development of certain types of advanced materials that , for example, not only give warnings of structural malfunctioning (by coloration or discoloration of material) but also counterbalance, amorph or provide temporary strength to deflect the external or extreme forces, such as high winds or eartquakes.

The integration into architecture of materials that change their static state through deformation, re-formation or even destruction under stress, or temperature differences, presents a scientific as well as a design challenge. ‘In the past, a change in a material’s properties (its elasticity, or its volume) in response to a change in the environment was generally seen as a potential problem, as a thing to be avoided….Even in applications where one might imagine a dumb [static] material would suffice, a degree of smartness may prove tremendously useful…A house built of bricks that change their thermal insulating properties depending on the outside temperature, so as to maximize energy efficiency?’ [Ball, 1999, p.104].

New Directions in Materials Research and Architecture

Scientific research is continually improving mechanical, thermal, electrical, chemical and optical properties of materials in architecture. Therefore it seems obsolete to choose materials solely based on their visual characteristics in conception and creation of spaces. What becomes relevant is to find out what a material might do in a space to enhance our all-sensory experience.

In his book ‘Made to Measure’, Philip Ball predicts that there will be always room for so-called ‘dumb’ i.e. static materials that do not change their properties or display their changing characteristics. Nevertheless, it will increasingly pay to be ‘smart’ in the manner discussed above, although he maintains that this is still not nearly sufficient. In the future, material scientists hope that materials will be developed that are able to take into account changes, maintaining ‘a memory of what has transpired before and that learn from these previous experiences’ [Ball, 1999, p.105] and becoming more active and ‘smarter’ or ‘intelligent’ as they get older. He further comments that in the 1995 aircraft prototype developed by researchers at Auburn University, ‘all of the ailerons and tail flaps that are used to control the flight of conventional aircraft were replaced by wings and tail fins containing piezoelectric actuators (that convert electrical to mechanical energy) that altered their shape (in response to flying conditions). One advantage of smart wings is that they can be continually adapted to maximize aerodynamic (and thus fuel) efficiency in a way that is just not possible for today's aircraft' [Ball, 1999, p.118].

Michelle Addington and Daniel Schodek, authors of 'Smart Materials and Technologies', suggest that '…by investigating the transient behavior of the material, we [can] challenge the privileging of the static planar surface' that long dominated the architectural vision. They further propose that '[s]mart materials, with their transient behavior and ability to respond to energy stimuli, may eventually enable the selective creation and design of an individual's sensory experiences' [Addington & Schodek, 2005, 7-8]. Although they conclude that architects are not in a position to exploit this alternative paradigm shift in material innovations, by examining the knowledge gained from other industries such as aerospace engineering perhaps we may understand that spatial boundary of an enclosure is not limited to the material surface but it can be reconfigured as the zone in which change of energy fields occur. Thus smart materials enter the domain of architecture not as alternatives that replace existing static materials but as dynamic matter that alter their behavior capable of responding to thermal, luminous, and acoustical energy fields.

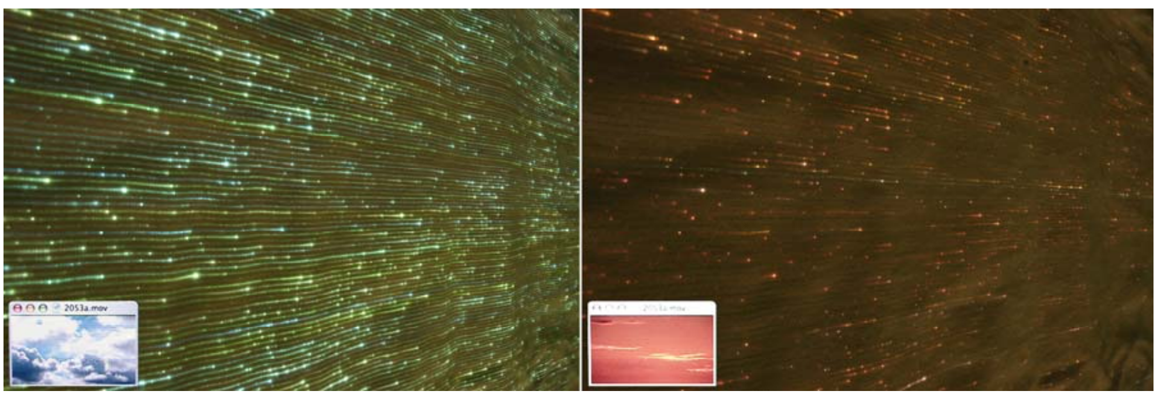
Smart Fabrics

The field of high-performance textiles and flexible fiber based materials is one of the most dynamic areas of material innovation currently reshaping the practice of fashion, industrial design, architecture and engineering in a cross-disciplinary context. A 'fabric' refers to a material that in some way resembles or shares some of the properties of cloth either woven or flexible layered materials [Addington & Schodek, p.158]. New fabrics as well as existing ones that integrate new material properties are progressively being tested in the field of construction to generate more transparent, lightweight, adaptable and responsive environments that we can inhabit [Klassen, 2005, 122-135].

Michelle Addington and Daniel Schodek also focus on actions and effects that are made possible via smart materials and technologies. Although many applications do exist exclusively in clothing, they point out that similar products and technologies that can be envisioned for use of smart fabrics in architecture and design. For example, if a coffee mug changes its colour based on the temperature of the beverage it contains, would it be possible to change the colour of a room based on its exposure to sunlight by integrating a photochromic textile on its walls? The authors organize high-performance and smart fabrics according to what they might do in a space [pp. 158-162]. The first group are the high performance fabrics or flexible materials that are combined with other materials (composites or weaves) to accomplish some specific objective related to variables in the luminous, thermal or acoustical environment and structural forces. These applications may lead to design of surfaces and structures that specifically reflect, absorb or transmit light, sound and heat or react to building and gravitational forces in a designed way. This group of materials, however, are not smart in the sense that they do not display changing characteristics i.e. their properties are engineered for better performance yet remain static. The second group of fabrics exhibit some form of property change in response to the above listed external conditions, most commonly color-change based on impregnation or layering of thermochromic (heat sensitive) or photochromic (light sensitive) materials with the fabric. The third group of fabrics that provide an energy exchange function are known mostly as phase-change materials. These fabrics involve absorbing, storing or releasing large amounts of energy in the form of a latent heat and thus control thermal environments. For example, water is a phase change material that transforms from solid to water to gas at freezing or boiling temperatures. This is not, however, of any use in construction industry as the energy exchange takes place at low temperatures. Outlast Technologies Inc. that has already developed a phase change textile material for use in sports clothing (to keep us cool or warm), hopes to develop a similar material for the building industry. Phase change particles can be encapsulated at microscopic level and integrated into the fabric either as surface coating or an integral part of the fabric's fiber (by using a wet-spinning process) [Braddock & O'Mahony, 1999, p.156]. And finally the fourth category of fabrics, known as electronic textiles, are in some way specifically intended to act as sensors, and to be used in energy distribution, or in communication networks [pp. 158-162].

Conclusion

These advancements in materials research exemplify the potential changes (functional, structural, design, and cultural) that may occur in the perceptual and practical characteristics of the built environments in the future. In return, continued demand for high-performance and responsive built environments will derive the specific material developments away from a mere experiment with the static qualities of materials towards a multi-layered and active manipulators of external energy fields. The integration of building materials and the mechanics that regulate thermal, luminous, acoustical and visual requirements is of vital importance in successfully translating and realizing innovative building concepts. We still are far from achieving a built environment that morphs itself for best performance in response to varying external forces. We are, however, slowly moving in a direction that is compatible with innovations that are reshaping other fields.



2. Fabric with fiber optic light emitter

References

A longer version of this article was originally published in Klassen, F. (2006). Malleable Matter: Adaptable and Responsive Space. *Proceedings of the Adaptables 2006 TU/E International Conference on Adaptability in Design and Construction*, Eindhoven, The Netherlands, v.2, pp. 192-207.

Addington, D. M. & Schodek, D. L. 2005, *Smart materials and new technologies for the architecture and design professions*. Architectural Press, Oxford, 7-8, 158.

Ball, P. 1999, *Made to measure: New materials for the 21st century*. Princeton University Press, Princeton, New Jersey, pp. 103-105, 118.

Braddock, S. 1998, *Techno textiles: Revolutionary fabrics for fashion and design*. Thames & Hudson, New York, p. 156.

Klassen, F. 2006, Material innovations: Transparent, lightweight and malleable. In Klassen, F., & R. Kronenburg (Eds.). *Transportable Environments 3.* Spon Press, London, pp.122-135.

Image captions

1. Carbonfiber micro-photography
2. Reflective fiber micro-photography

Image Credits