Stimuli-responsive materials: Definition, classification and descriptions

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Definition

Stimuli-responsive materials (SRMs) have the particularity to change one or more of their properties under a defined stimulus. To account for the variety of underlying physico-chemical mechanisms, we call "transition phenomenon" the process by which SRMs transform an input, or stimulus, into an output, or response. For designers, this particularity of SRMs represents the possibility to proceed information on product in a new way, and to create new types of user experience. To try and help designers to use SRMs in their projects, we proposed various tools for the exploration and selection of these materials.

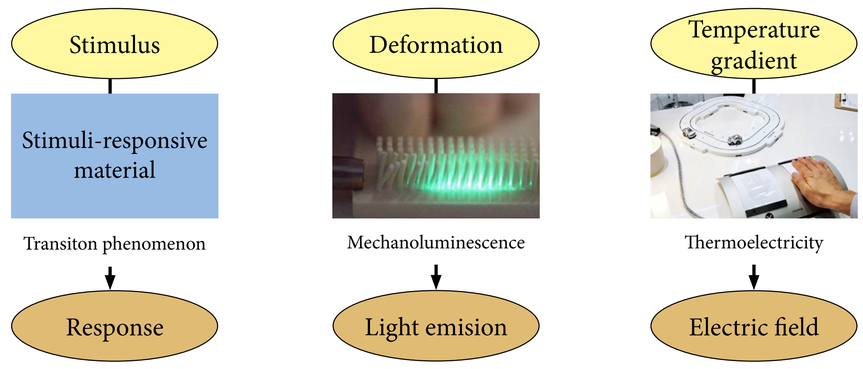

Figure 1: Stimuli-responsive materials: definition and examples

Classification: two propositions

Input -> Output graph

There are many kinds of stimuli-responsive materials . To provide a perspective on SRMs and the possibilities they offer, we propose a graph representation (Fig. 2) based on their transition phenomena, which is the main characteristic of these materials. This graph represent the transition phenomena as the links between their associated inupt and output. The color in which is written the transition phenomenon correspond to the color of the input [1].

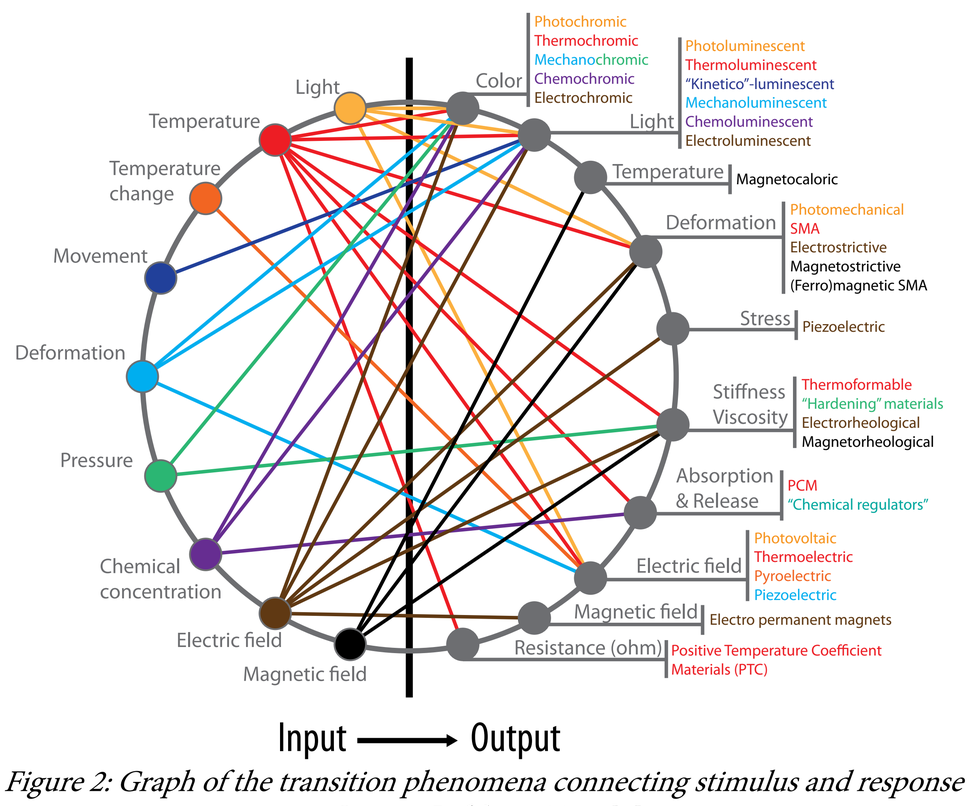

Figure 2: Graph of the transition phenomena connecting stimulus and response
Source: Lefebvre 2014 [1]

Interaction between the user and SRMs

A second representation was derived from the graph on figure 2. The map obtained gives a first account of the user interaction with a dynamic product using SRMs (Fig. 3). To read it, a designer will start from the inner circle, which represent the sensory modalities engaged by the changeable features of the product, which are represented on the next circle. Then these features are connected with the SRMs that can be used to design them, which are in turn connected to their stimulus by a color code on the outmost circle. Icons next to the stimuli indicate if the SRM are activated by the user, the environment ot a system [2].

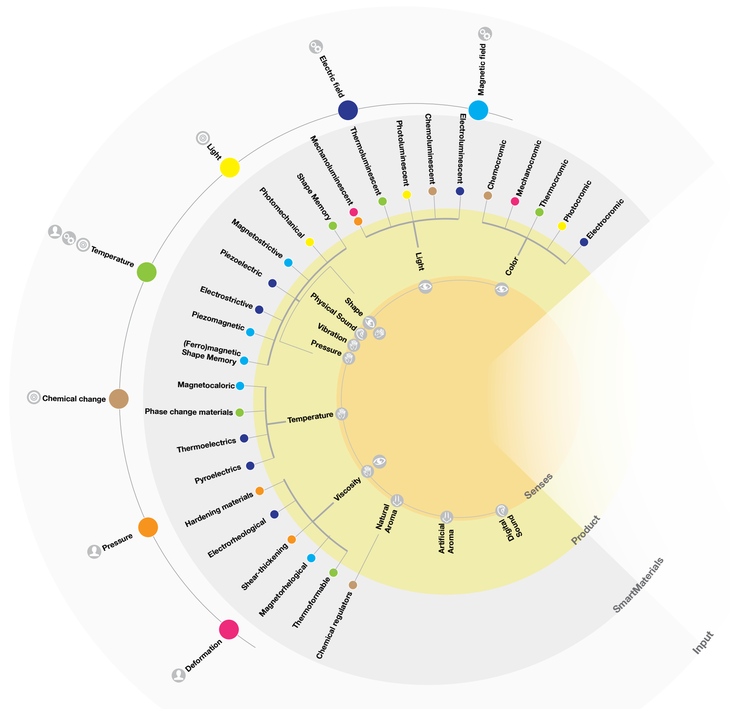

Figure 3: "Smart Material for Sensory Experiences" Map
Source: Bergamaschi [2]

After having made a classification of existing stimuli-responsive materials, the next step is to gather more detailed information about their properties and behavior and to organize and represent it in a consistent and efficient way. Two parallel approaches are being implemented: graphical descriptions of transition phenomena and a dedicated CES database prototype.

Descriptions of the transition phenomena

A set of "cards" describing in a synthetic and graphical way the main characteristics of each transition phenomenon has been created. A first version of it, presenting textual informatiom and examples, was proposed to a group of graduate students in design during a workshop on dynamic products, together with the previous map and cards presenting dynamic products. Feedbacks from the students were used to improve the card layout and information content [2]. Textual information was reorganised in a more graphical representation, so that the the various transition phenomena could be captured and compared more directly. Adjusment of the information content and representation is also in progressto increase the clarity and usefulness of the cards.

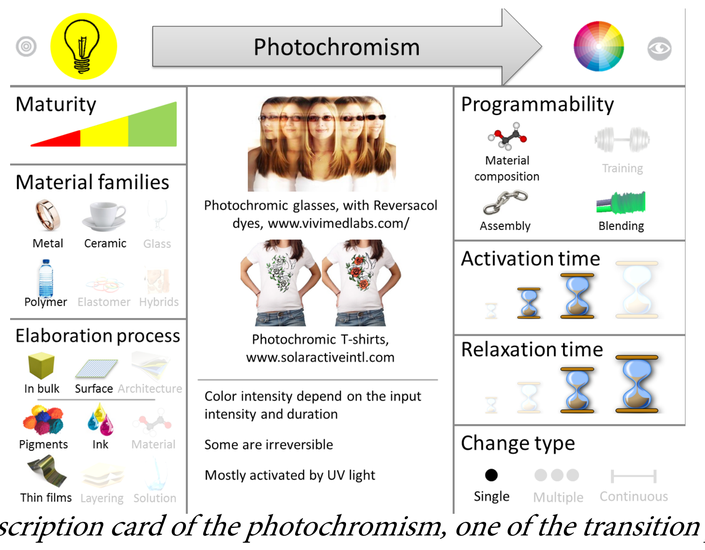

Figure 4: Description card of the photochromism, one of the transition phenomena

Database prototype

The database prototype revolves around two main tables: one describes the transition phenomena, the other one the stimuli-responsive materials.

The tree structure of the transition phenomena starts from the response as families, and then reports the transition phenomena as sub-families, making further partition thanks to the stimulus.

The materials table follow the structure of the generic CES database, but attributes specific to stimuli-responsive materials are inserted.

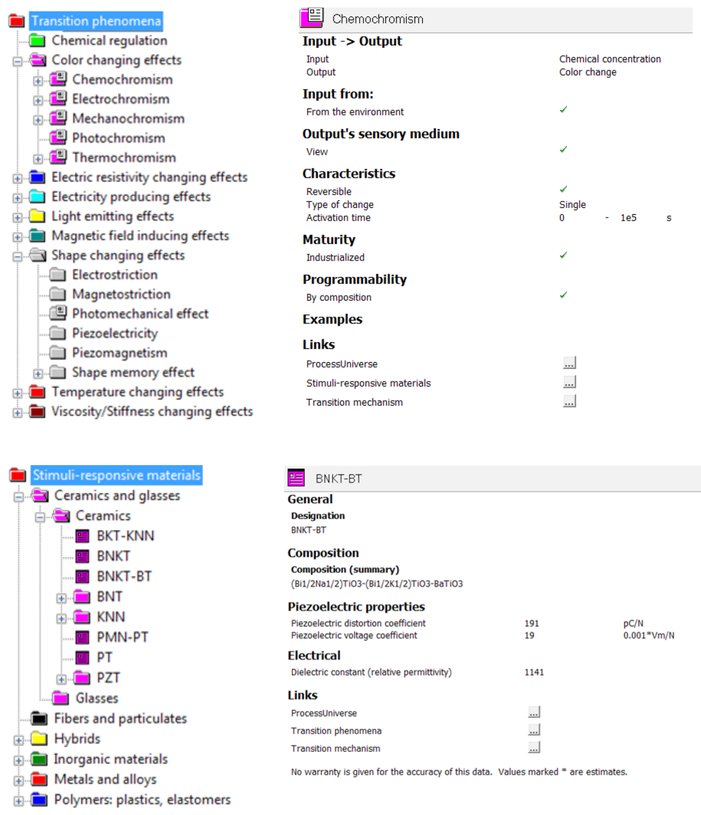

Figure 5: CES database prototype: main tables

Future developments

An additional tables will be added to the database, to describe the processes used to implement stimuli-responsive behaviors in a product. Documentation about the physical phenomena underlying the transition phenomena will be added. The possibility of adding a dedicated table for examples of applications will also be considered.
Prototypes of interactive selection tools will be proposed and tested by designers, one using the CES database prototype, others starting from the description cards. These selection tools aim at giving the possibility to designers to select a SRM starting from a desired user experience.

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[1] Lefebvre Esther, Piselli Agnese, Faucheu Jenny, Delafosse David, Del Curto Barbara (2014). "Smart materials: development of new sensory experiences through stimuli responsive materials." In A Matter of Design: Making Society trough Science and Technology. Proceedings of the 5th STS Italia Conference. Milano, 367-382

[2] Bergamaschi Sara, Lefebvre Esther, Colombo Sara, Del Curto Barbara, Rampino Lucia (in press). "Material and Immaterial". The International Journal of Designed Objects.