Selection Framework for the Implementation of Functional Materials in Product Design

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Functional materials and material selection

Functional materials, also called “smart materials”, are materials that can “sense environment events, process that sensory information and then act on the environment” [1]. These materials are able to transform a given stimulus into a response. We use the general term “transition phenomenon” to account for the diversity of the underlying physical phenomena (e.g.: mechanoluminescence, which is a light emission produced by the application of a strain [2], or thermoelectricity, the conversion of a temperature difference into an electric potential [3]).

Using the general framework proposed by Ashby [4] : (i) translation by expressing the dominant functionality ; (ii) screening based on constrains and (iii) ranking based on objectives, we develop a specific database in the Cambridge Engineering Selector software [5] and propose an associated selection process. The central object is a data table of stimuli-responsive phenomena, since they express the main functionality sought by product designers. Additional tables containing information about materials, processes and products are added to support designers and engineers at implementing functional materials

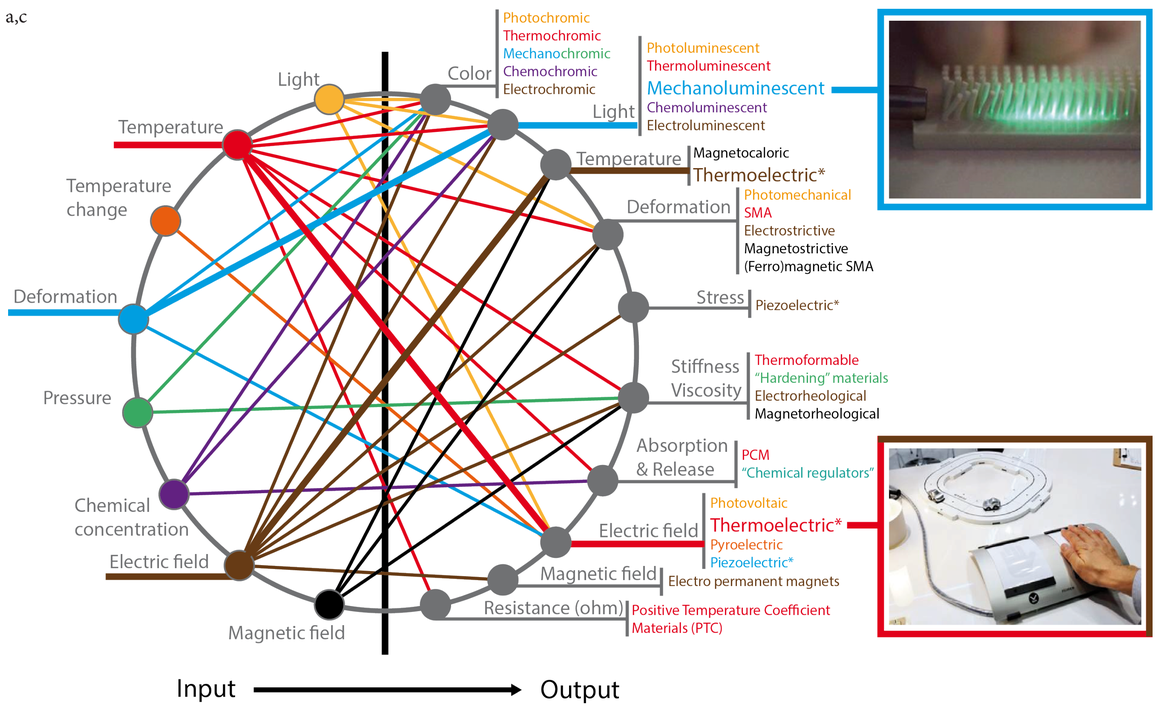
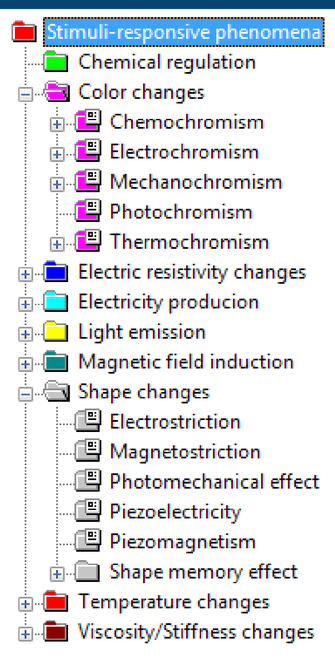


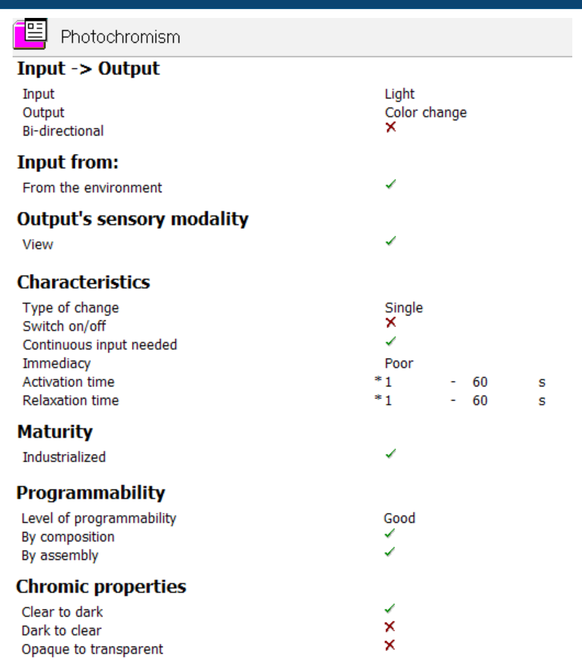
Figure 1: Stimuli-responsive materials: classification and examples

Stimuli-responsive phenomena

The stimuli-responsive phenomena table describes all the possible behaviors the functional materials can exhibit.

The tree structure of this table starts from the response as families, since it is the first element of the functional material’s behavior the end user will perceive. Then the stimuli-responsive phenomena are reported as sub-families, making further partition thanks to the stimulus.

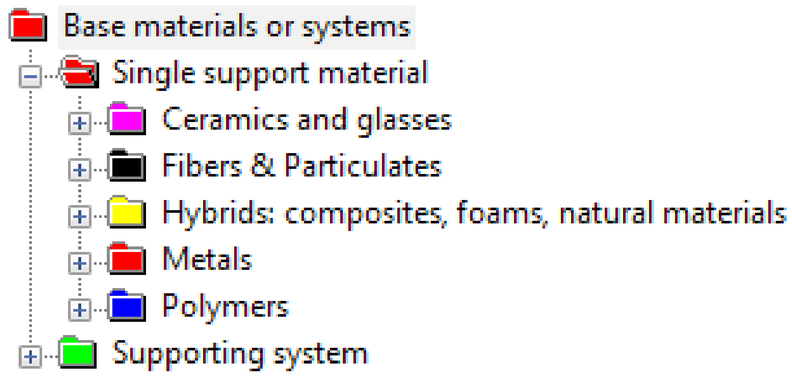




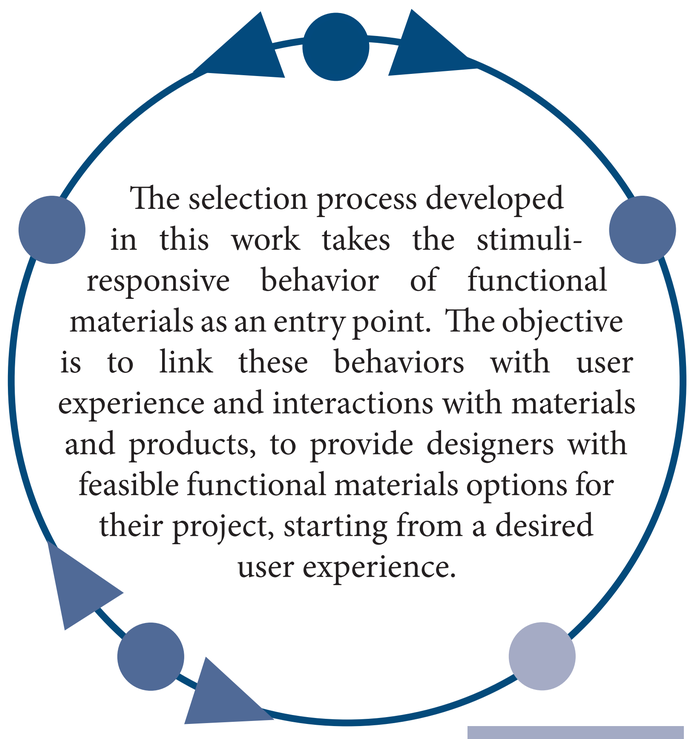
Each type of stimuli-responsive phenomena is described in a dedicated datasheet. Basic information common to all phenomena is their related stimulus (or input) and response (or output), and main characteristics such as reversibility, immediacy, etc... Information linked to the user perception of the phenomena is also included.

Other data are specific to a phenomenon, or to a response. For example, chromatic properties will be described when the phenomenon’s response is a color change.

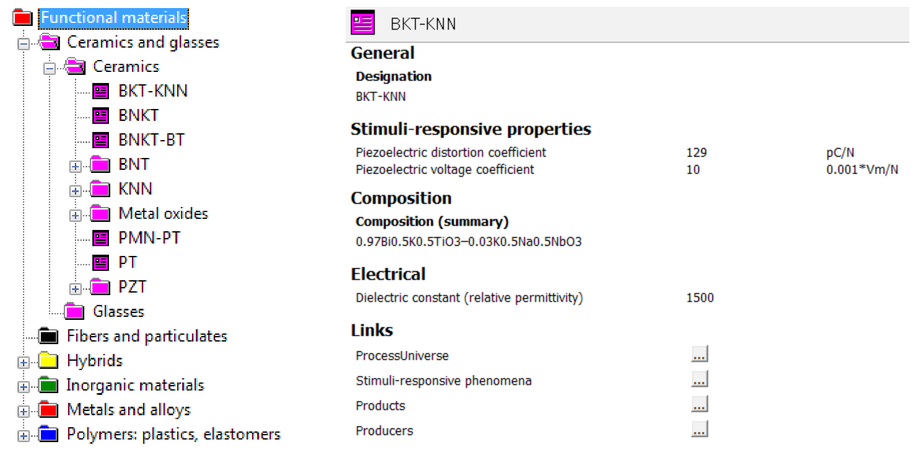
Base materials or systems



Some functional materials can be used as bulk materials, but many others are used as in-mass additives, as surface treatments, or as part of a system. Therefore, to implement functional materials, it is necessary to know in and/or on which base materials they can be used, or if it is necessary to surround the functional material with a particular system. The «Base materials or systems» table is an attempt to describe the materials that can be functionalized. Each member of this table, i.e. each material or system, is linked to the functional materials that can be used with it.



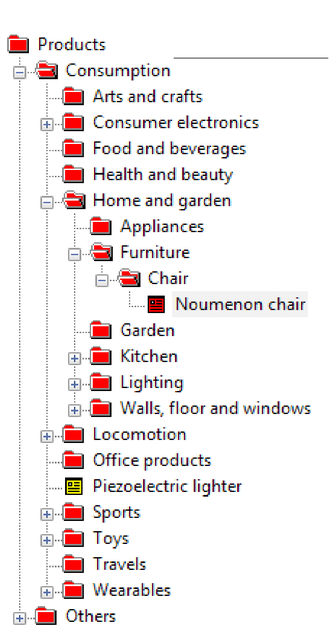
Functional materials

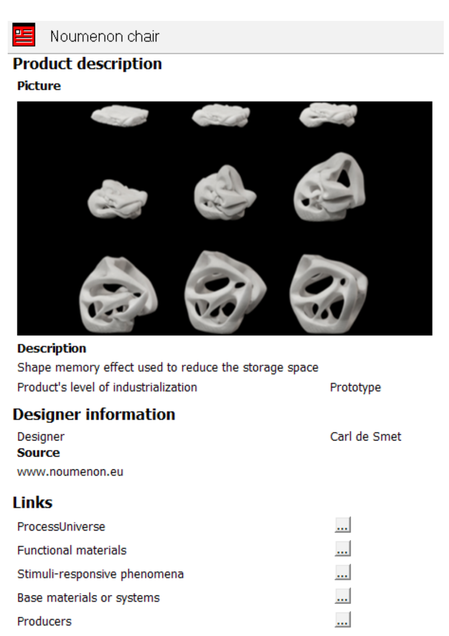


The functional materials table describes the materials themselves, including their mechano-physical properties. Some sensory properties are also described. The relationship between materials and stimuli-responsive phenomena is made by linking the tables together. Some attributes describe more precisely the stimuli-responsive properties of the materials. Some of them are specific to the type of stimuli-responsive phenomenon the materials exhibit, and some are common for all materials.

Products

The «product» table describes products where functional materials have been implemented. It aims at providing examples of the use of functional materials and illustrating some of the possibilities that they offer. The table is organized by «departments» as usually done in commercial resources. The datasheets present basic information about the product, with images and a description of the effect of the implementation of functional materials. Each product is linked to the functional material(s) it embeds.





Conclusion and future works

Because of their stimuli-responsive phenomena, functional materials are being implemented in a way that differs from structural materials. For this reason, the selection framework of functional materials must also be different. For this reason, we proposed an adaptation of existing selection tools and methods. Using CES constructor, we developed specific tables that describe the different stimuli-responsive phenomena, functional materials, and the possible way of implementation, through the «Base materials or systems» and «Product» table. A «Processes» table will also be implemented to give further information on the way functional materials can be used in industry.

In parallel with the database, we are developping the associated selection method as well as other tools that aim to support designers in the implementation of functional materials. These various tools will be test with designers and adapted in function of their feedback.

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[5] http://www.grantadesign.com/products/ces/