

From Smart Materials to Cognitive Materials – Requirements and Challenges

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Smart materials are materials that are either capable of changing some of their properties according to external stimuli (e.g., light or electric impulse) or to provide sensorial perceptions from sensors integrated within the material itself. The latter is also called *sensorial material* (Lawo et. al., 2009). Recently, this kind of materials is gaining increasing importance in application fields as for example automobile construction, production engineering, or wearable computing.

Smart and sensorial materials provide a variety of new possibilities for intelligent applications. For example, a work piece in production could have embedded sensors to measure the pressure put on it. However, at the current state, it is more this application than the material itself that can be considered being "smart". In this contribution, we proceed some steps beyond the state of the art in smart materials and look at the requirements for making them extend their current capabilities and become what we call *cognitive materials*. Cognitive materials must provide more than to deliver a big and unstructured amount of sensor data or to adapt themselves in a closed-loop control process triggered by external stimuli. Instead, they must become an integral part of decision making in the

overall system – may it be completely computer-driven or a shared human-machine environment.

New challenges emerge from this requirement: Cognitive materials must be enabled to make decisions autonomously, according to a task at hand. In our example, the work piece should decide on its own whether it can bear more pressure or not – and this might also depend on past experiences that have to be stored and considered appropriately. Cognitive materials have to provide a tight coupling between perception and intentions and loop decisions back to the sensory level. In particular, the material must be able to shift its attention and abstract from irrelevant details to become able to conceptualize its current state and to deliberate about actions to take to fulfill a particular purpose. How much of these decision competences can be shifted from external computing systems into the materials themselves is a challenging field of future research.

References

- Lawo, M., Langer, H., Lehmus, D., Busse, M., Burblies, A., & Lang, W. (2009). Simulation techniques for the description of smart structures and sensorial materials. *Journal of Biological Physics and Chemistry*, 9, 143–148.

