

# Guest Editorial

**T**ODAY, trends like the Internet of Things are nearing large-scale implementation. They rely on solutions enabling objects to become cyber-physical systems capable of perceiving their environment or their internal state. Sensing provides the information gateway to achieve this coupling between object and environment, as well as their interaction. This understanding has fuelled considerable research efforts on intelligent and sensor-equipped structures. Among the obstacles that impede their introduction are economic ones. Material rather than component-integrated sensing and intelligence has the potential to circumnavigate some of the obstacles by paving the way to economy-of-scale effects [1], [2]. Such concepts have been known for a considerable time [3]. This Special Issue on Material-Integrated Sensing, Data Processing and Communication is based on a Symposium held at the IEEE SENSORS 2012 Conference, Taipei, Taiwan, October 28–31, for which we defined our own vision of intelligent materials; perceptive matter, as we envisage it, must have the ability to gather data on its own state and environment, process this data and communicate the information derived internally or to a higher level system component. To do so, it must in itself be a complex system with sensing as basic functionality.

The high road toward realization is hybrid integration; these materials will need all the elements of a distributed sensor network plus their adaptation to actual integration within a host material. In practice, this means they need to withstand the thermal and mechanical loads that occur first during the making, and second during the life cycle of any product of which they are a part. In return, they offer measurements from within a critical component and are better protected against external influences. In terms of mechanics, miniaturization, flexibility, and stretchability [4] are requirements to prevent the embedded sensor system from becoming a possible source of fracture or delamination [2]. At the same time, limited accessibility that goes with integration affords high levels of reliability and robustness on sensor node and network level. Data evaluation must thus detect and handle defects of node or network. Artificial intelligence and agent-based technologies can help overcome such issues in large-scale distributed systems by introducing autonomy based on adaption and learning [5]. Besides, all system components must use energy resources sparingly. Coordinated energy harvesting, storage, and management thus remain central fields of research. Finally, manufacturing processes must be adapted to sensor-integrated materials.

This Special Issue addresses these issues. Individual contributions discuss sensor adaption for material integration (Dumstorff *et al.*, Hensel *et al.*, Boll *et al.*, Salowitz *et al.*,

and Winkelmann), as well as sensing materials for low-cost systems, thus introducing an economic dimension (Saha *et al.*). Solutions for embedding in fiber-reinforced polymer (Gupta *et al.*, Mariani *et al.*) add to the picture. Energy is considered in view of energy harvester production (Dorey) and harvesting systems (Goudar *et al.*), as well as transfer of power to actual material-integrated systems (Salas *et al.*). Additional contributions touch upon data evaluation, considering, e.g., tensor- (Valle *et al.*) and multiagent-system-based solutions (Bosse). These are complemented by studies on application-oriented sensor/sensor system developments, including concepts for vibroacoustic control (Collet *et al.*), artificial skin (Cabibihan *et al.*, Valle *et al.*), pressure sensitive textiles (Samy *et al.*), microfluidics (Kang *et al.*), or proximity sensing (Chao *et al.*).

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