Fully-integrated nano-sensors for the Internet of Things

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The Internet of Things (IoT) is the inter-networking of physical devices, vehicles, buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data. The idea of a widespread sensor network is also one of the features of future "smart cities". As far as the manufacture world or agronomy are concerned, the concept has become a paradigm of the so-called “industry 4.0”, or of “precision farming”, respectively.

To target these issues, a possible approach consists in the realization of miniaturized devices to be stuck in the appropriate position. On the contrary, our approach is to make "sensitive" items of common use or production tools through the direct use of multifunctional materials capable of generating appropriate signals. The object becomes, thus, capable of fulfilling its traditional function and, at the same time, monitoring the surrounding world, creating also a life cycle more "biological", envisaging its ecological disposal.

In this talk, some applications of this concept, developed by our research group, will be shown.

Carbon fiber based composites are nowadays largely exploited for their exception mechanical properties and low weight, but due to the lack of reliable break-predictive models, lifetime expectancy of the material should hardly be forecasted. Wit this in mind, we have developed strain-sensitive piezo sensors fully embedded in the composite and based on zinc oxide nanorods grown directly on the carbon fibers.

Another important research fields concerns the development of continuous health monitoring through wearable devices. For this purpose, we have developed electrochemical transistors, by means of properly functionalized cotton fibers, and thus on clothes, able to monitor the composition of human sweat. This data can be used to prevent panic attacks, dehydration, and hopefully, in the near future, to measure glycemia. Moreover, by functionalizing foam rubber, we have realized insoles able to monitor the distribution of body weigh, to be used by athletes or by people recovering after orthopedic surgery.

Finally, I will show that electrochemically transistors realized on cotton fibers were successfully integrated into plants to monitor in vivo and in continuous plant physiology with the aim to maximize production yield and to minimize, at the same time, the use of water, fertilizers, and pesticides.