Printed - Flexible Electronics: Contemporary Challenges and Device Applications

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Flexible and printed electronics refer to electronic devices and systems that are manufactured by printing or depositing electronic materials onto flexible substrates, such as plastic, paper, or textiles. These technologies enable the development of lightweight, bendable, and even stretchable electronic devices, which can be integrated into various products and applications. Sensors and systems in flexible and printed electronics play a crucial role in diverse fields such as healthcare, Internet of Things (IoT), robotics and prosthetics, automotive industry and so on. The advancement in materials, printing techniques, and manufacturing processes has significantly expanded the possibilities of flexible and printed electronics. These innovations have led to the development of a wide range of sensor-based systems that offer flexibility, cost-effectiveness, and adaptability for various industries and applications. In this lecture, a general overview of the printed electronics area will be given. Moreover, various flexible devices that were developed in microSENSES lab (https://microsenses.eee.uniwa.gr/) will be demonstrated along with the potential future prospects for improvement and adaptation to special applications.

The evaluation of a multiparametric sensing device on paper fabricated by inkjet printing will be presenting, for applications such as smart packaging-labeling and disposable biosensors, where biocompatibility and low cost are key factors. The device is able to measure simultaneously relative humidity, temperature, and compressive and tensile bending. The development and evaluation of a fully printed multi-directional thermal flow sensor on PET substrate will also be presented. The device consists of conductive Ag tracks and printed thermistors based on $BaTiO_3$, activated carbon and a solvent based thermoset polymeric system. The device was capable of successfully detecting the flow direction throughout the flow range without being affected by the flow magnitude.

Thermal sensors are mainly based on selective heating of specific areas, which in most of the cases is a critical feature for both the operation and the performance of the thermal device. We will demonstrate the evaluation of the thermoelectrical response of two graphitic materials, namely a) a commercial graphene (Gr) ink and b) a custom functionalized reduced graphene oxide (*f*-rGO) ink in the range of -40 to 100 ^{o}C. The inkjet-printed devices were evaluated as microheaters, in order to exploit their advantage for cost-effective production with minimal material waste. Both static and dynamic evaluation was performed in order to study the device behaviors and extract the corresponding parameters.