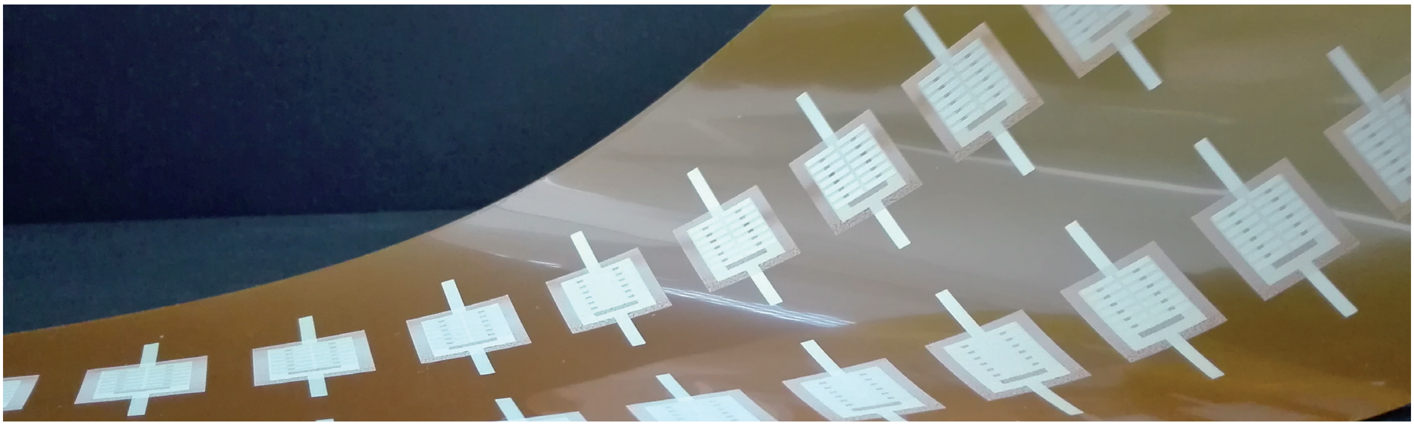
HIGHLY-SENSITIVE HUMIDITY SENSORS BASED ON NANOCOMPOSITES



Contact

Fraunhofer Institute for Electronic Nano Systems ENAS
Technologie-Campus 3
09126 Chemnitz | Germany

Contact persons
Prof. Dr. Thomas Otto
Phone: +49 371 45001-231
E-mail: thomas.otto@enas.fraunhofer.de

Dr. Joerg Martin
Phone: +49 371 45001-244
E-mail: joerg.martin@enas.fraunhofer.de

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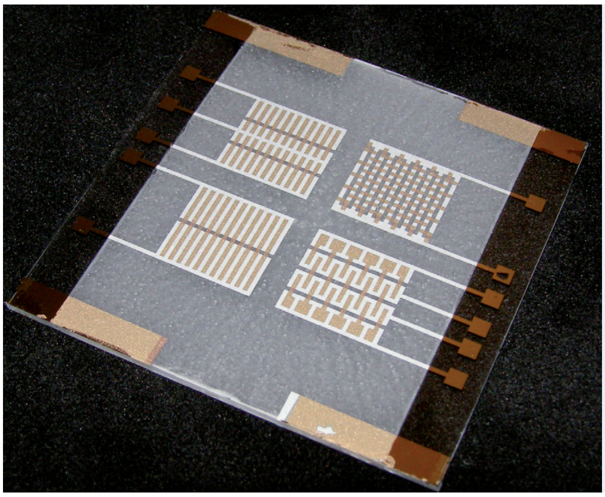
Overview

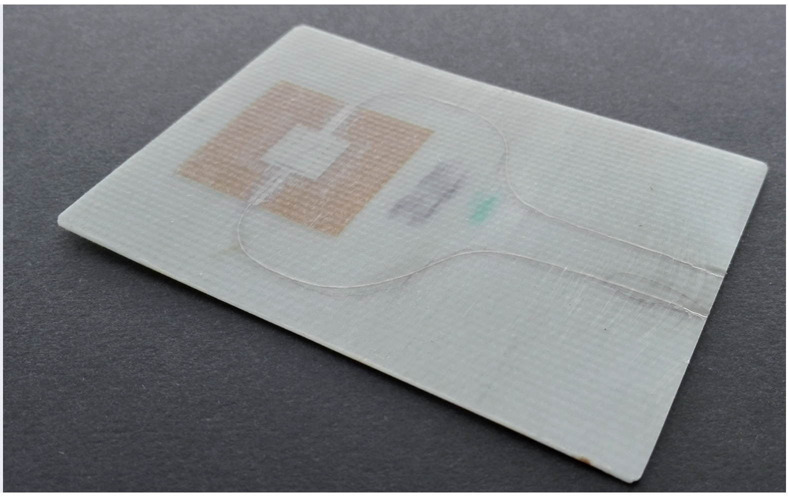
For the determination of humidity, many different measurement techniques have been developed, reaching from early mechanical systems to resistive or capacitive methods to support electronic readout. Modern thin-film sensors usually use polymers or ceramic materials as sensitive dielectric. This can be complemented by polymeric nano- and microcomposites, which offer the opportunity to combine the advantages of ceramics and polymers, like high sensitivity and easy processing technology, while minimizing the disadvantages. Such innovative composite humidity sensors can be prepared with a large scale on rigid, bendable or even curved surfaces employing a large variety of electrode structures.

Functional principle

The manufactured nano-/microcomposite humidity sensors work on the capacitive readout principle based on a hygroscopic dielectric layer. This dielectric consists of nanoporous ceramic particles, which are embedded in a polymeric binder. Since the dielectric permittivity of water is much larger than that of the polymer or ceramics, adsorbed water changes the dielectric permittivity drastically and hence the capacitance of the assembly. In addition to the determination of relative humidity in various fields of applications, the highly-sensitive sensors also enable the determination of water penetration and diffusion especially in plastic materials with or without fiber-reinforcement.

A Part of this work was performed within the Federal Cluster of Excellence EXC 1075 "MERGE Technologies for Multifunctional Lightweight Structures", which is funded by the German Research Foundation (DFG).





Technologies

The moisture-sensitive dielectric is sandwiched between bottom and intermittent top electrodes. Here, the electrodes and the dielectric layer can be applied on various rigid (e.g. glass) or flexible films (e.g. Polyimide or PET). The composite dielectric is preferably applied via screen-printing, while the electrodes can be prepared by evaporation, sputtering or printing processes. The humidity sensors on flexible films offer the unique possibility of sensor integration in thermoplastic and thermosetting components. For data transfer, wire-based and wireless technologies (e.g. Bluetooth Low Energy) are available.

Fields of application

- Air conditioning of buildings, warehouses, greenhouses
- Sensor for logistics; monitoring of enclosures, packages, boxes
- Material-integrated sensor for monitoring of water penetration and diffusion
- Irrigation sensor for optimization of plant growth

Picture description:
page 1: Screen printed composite humidity sensors on polyimide film.
page 2 (left): Various composite sensor layouts on glass substrate.
page 2 (right): Composite humidity sensor embedded in glass-fiber reinforced polyamide.

Key Parameters

Parameter	Typical value
Sensor area	10 x 10 mm² to 50 x 50 mm², other areas and forms possible
Sensor thickness	< 50 µm plus substrate thickness
Operating temperature range	0 °C up to 60 °C, extendable to 125 °C depending on substrates and polymer binder
Operating humidity range	0 % r. h. up to 100 % r. h.
Maximum sensitivity	0.125 nF per 1 % r. h.
Response time	approx. 20 seconds

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