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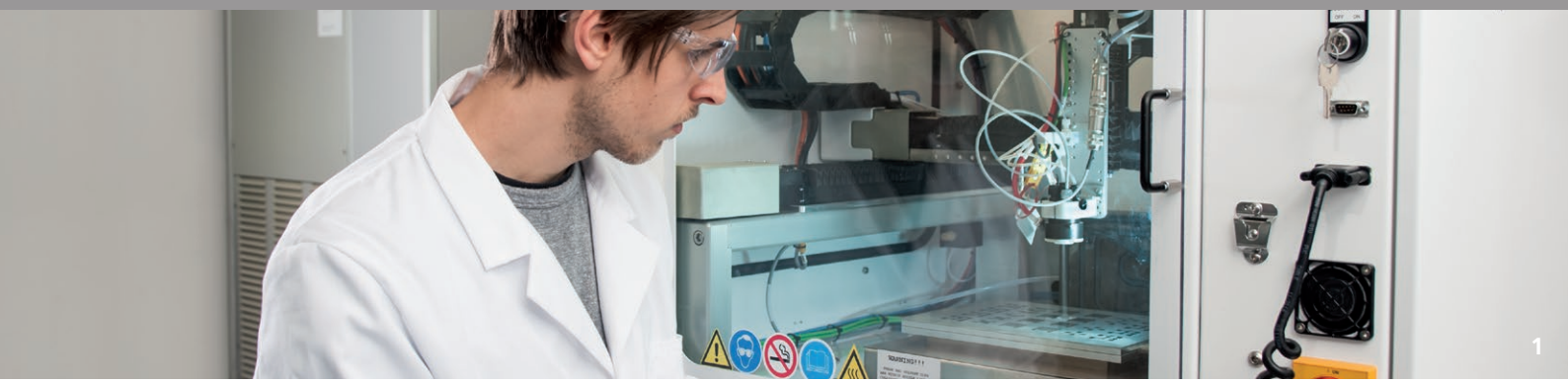

1 *Spray coating tool for automatic film deposition*

THIN-FILM MATERIALS PYROLYTIC SPRAY COATING

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Functional Materials

Fraunhofer IISB develops novel routes for deposition of functional thin-films addressing electronic applications in automotive, industrial, and energy electronics. Future technologies for thin large area electronics (TOLAE) will be based on solution processing of functional materials. Even today, thin-film coating from liquid phase is applied in large-area applications like batteries or solar cells. Natural benefits of solution processing are low investments for equipment, high materials utilization, and integration capabilities (e.g. roll-to-roll) with competitive costs per unit.

Spray Coating

The unique competence of Fraunhofer IISB is its long standing expertise in all film deposition techniques relevant for electronics manufacturing. Experienced operators, engineers and scientists perform service and development tasks in dedicated laboratories for chemical development and materials characterization. Focus of the ongoing work at the thin-film systems group is the advancement of precursor solutions and deposition methods for a wide range of applications.Spray pyrolysis utilizes thermal shock to remove auxiliary constituents of the precursor solution, mainly the solvent. It thus enables the deposition of high quality thin-film layers with highly controlled stoichiometry at low temperatures.

Stable and reproducible development is conducted using an advanced spraying system with a programmable 3-axis robot. On a working area of 400x400x100mm a wide range of substrates can be mounted. The fully-enclosed housing with inert gas (N_2) supply allows for working in air or atmospheres with less then 5% oxygen content. The use of replaceable nozzles allows customization of shape and width of the spray pattern. An integrated hot plate permits working with substrate and conversion temperatures of up to 500°C.

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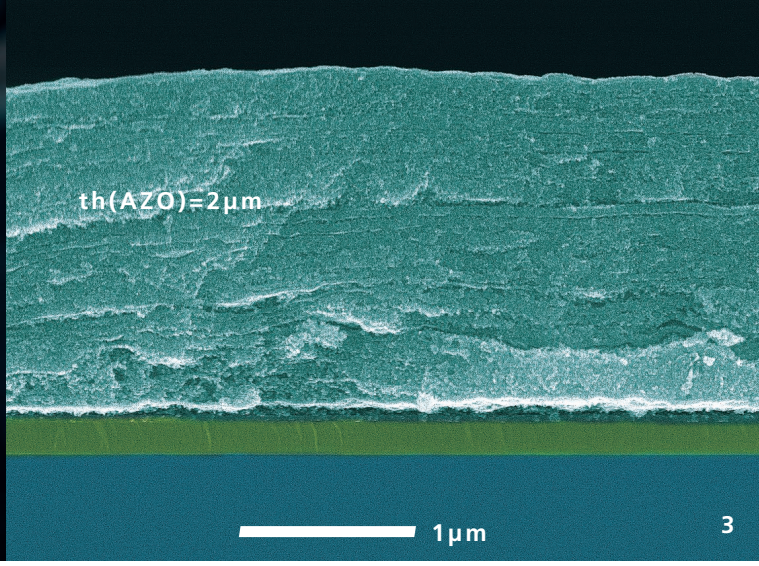

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2 *Ultrasonic atomization of "AccuMist nozzle"*

3 *Spay-coated Aluminum doped zinc oxide (AZO)*

Precursor development

Molecular precursors offer interesting routes for solution processing of metal-oxide thin-films for use as semiconductors, conductors and insulators in electronic applications and beyond. However, the majority of precursor chemistries is environmentally harmful and/or air sensitive thus requiring processing in controlled or shielded environment. In response, IISB synthesizes novel, versatile and non-toxic precursors for ambient-air deposition. The facile precursor preparation route comes with low-level handling requirements (i.e. air compatibility) and delivers miscibility for the combination into customized mixed metal oxides.

As an example, the developed precursor route allows the layer formation of ternary, e.g. indium-zinc oxide (IZO), and quaternary, e.g. gallium-indium-zinc oxide (GIZO) metal oxides.

Single precursors for binary metal oxides, e.g. Al_2O_3, are tunable to suite (semi)insulating properties for application in capacitors or insulator layers. Others like aluminum-doped zinc oxide can serve as both a poorly conductive passivation, as a highly conductive interlayer, or even as transparent conductor for use in optical applications like photovoltaics or OLEDs.

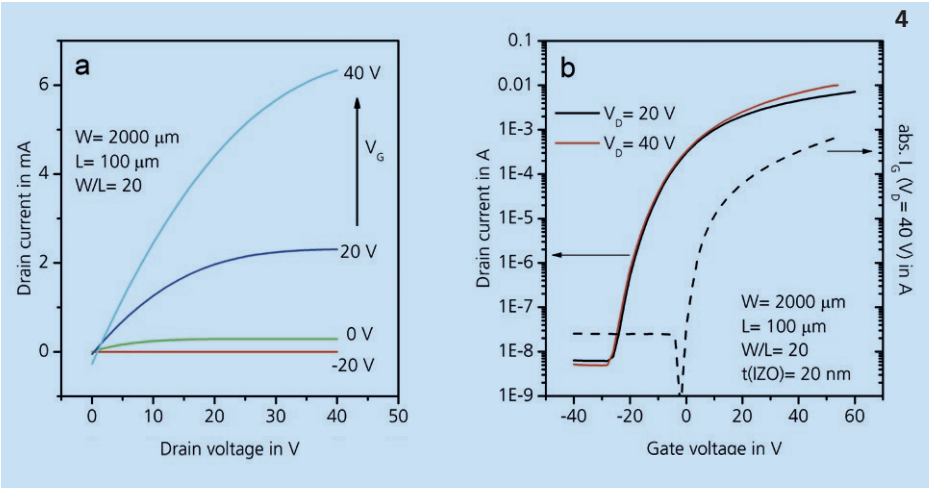
Meeting the demands of out customers, IISB can perform combinatorial development of functional materials from the precursor synthesis, via spray coating until the final thermal conversion in dedicated atmospheres. Samples or integrated products are analyzed in our thin-film laboratories with respect to morphological and compositional homogeneity, thickness variations, and crystallinity.Integration with a large variety of complementary thin-films or substrates as well as integration with the customer application are supported by characterization of interfaces and chemical interactions.

Examples for device and application development

Long-term experience in (printed) semiconductor characterization and device development utilizing our laboratory environment allows for rapid testing of novel materials.

For device characterization, standard and advanced electrical measurement techniques are available. The physically close integration of our abilities ensure fast progress. A case in point is a novel low temperature spray-coated IZO process. The TFT characteristics of IZO TFTs fabricated at below 200°C, see in Fig. 4, display an ON/OFF ratio of 10^6 with a calculated saturation mobility of 14.1 cm^2/V s at a drain voltage of 40 V.

4 *Output and transfer characteristics of IZO bottom gate top-contact transistor on p doped silicon with 200nm thermal grown SiO_2 devices with aluminum source drain electrodes evaporated*



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