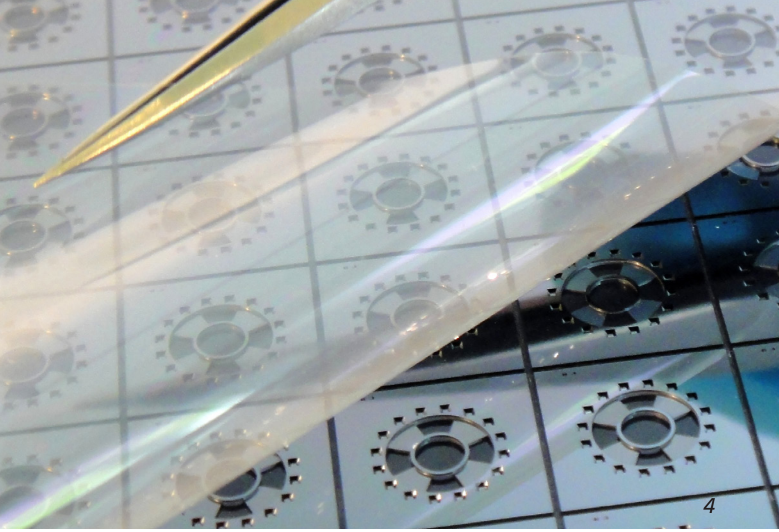
Fraunhofer
IPMS

Smart Materials



Applications

- Electro-optical waveguide with liquid crystal on a silicon backplane for components such as switches, modulators, variable power splitters, variable optical attenuators, tunable optical filters or polarization controllers
- Polymer micro-actuators
- Tunable micro-lenses with an integrated polymer actuator
- Polymer energy harvester

Services - Characterization and Processing

- Determination of (electro)-optical and mechanical properties of thin films made of polymers, liquid crystals and blends
- Thermal analysis by differential scanning calorimetry
- Polymer thin film stack processing
- Embedding organic materials into customized integrated photonics and MEMS devices and their wafer-scale fabrication.

Front Page: Texture of a cholesteric liquid crystal.

Fig. 1: Electro-active organic materials.

Fig. 2: Polarization microscope image of a nematic liquid crystal phase.

Fig. 3: Electro-optical waveguide switch device with liquid crystals on a silicon backplane.

Fig. 4: Tunable micro-lenses chips structured on a silicon wafer.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Electro-active organic materials

At Fraunhofer IPMS electro-active organic materials are implemented in the design of new and "smarter" micro-optical components as alternatives to traditional silicon or silicon oxide based components. The focus lies on one side in the research and development of organic materials for micro-actuator and energy harvesting applications. For these applications piezoelectric and electrostrictive polymers such as elastomers, fluoropolymers and high-k nanoparticle-fl uoropolymer blends are employed. On the other side, electro-optic (EO) polymer-chromophore blends, liquid crystals and liquid crystal-polymer blends are developed for various wafer-scale fabricated components such as EO waveguide-based Photonic Integrated Circuits (PIC).

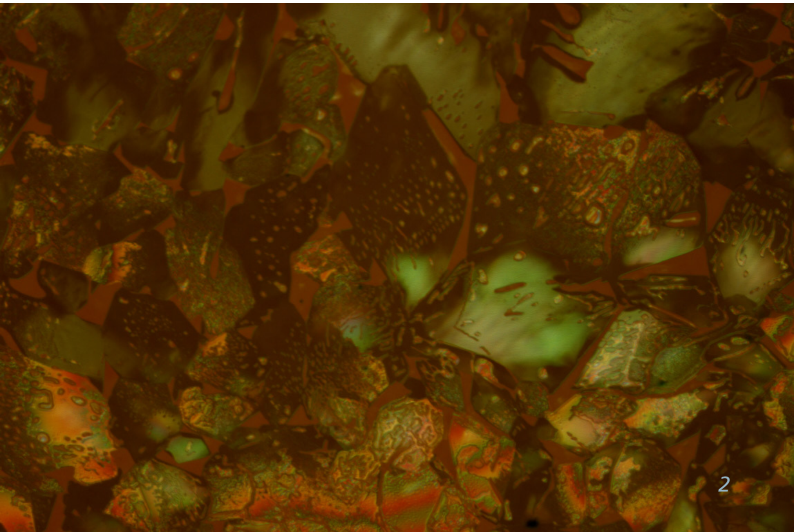
Electro-active polymers properties

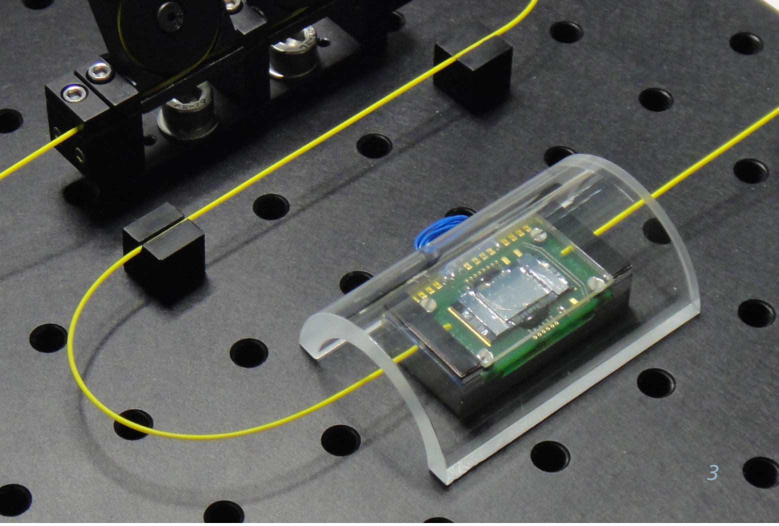
Electroactive polymers (EAPs) are electrically responsive materials, which have become the materials of choice for technologies such as actuation, sensing, energy harvesting or robotics. Some of the properties that make EAPs attractive for these applications are their large actuation strain, robustness, easy processability and low cost. In addition, some EAPs have good optical characteristics throughout the visible spectrum. Their electro-mechanical and optical properties can be improved by adjusting the polymer composition. EAPs are developed and processed at the Fraunhofer IPMS for specific applications and components.

Liquid crystals and blends

Liquid crystals exhibit unusual optical and electrical properties because of their anisotropic structures. Because the molecules are polar and the intermolecular forces rather weak, the molecules orientation is easily perturbed by an applied electric field. This leads to an additional increase in the birefringence of the liquid crystal, which is associated with a strong electro-optical response. Liquid crystals, polymer-liquid crystal mixtures and liquid crystals micro-emulsions are useful for a variety of applications involving light manipulation and control. Fraunhofer IPMS develops liquid crystals which can exhibit large electro-optic coefficients, very good transparency from visible to infrared range and sub-microsecond response times.

Furthermore, blends with improved optical, mechanical and thermal properties are obtained by mixing several organic components together. Particularly, blends of polymers or / and liquid crystal of low optical loss, adjustable refraction index and high electro-optic coefficients are developed and implemented both as core and cladding materials in electro-optical waveguide structures.





Tunable devices

Characteristic parameters of devices can be dynamically manipulated with integrated electrically tunable elements made of intelligent, electro-active organic materials. Fraunhofer IPMS successfully develops innovative components for specific applications by making use of these materials in combination with the available silicon technology.

First examples of such components are optical switches based on the principle of electro-optically induced waveguides in thermotropic liquid crystals in isotropic phase. The underlying electro-optical Kerr effect in these liquid crystals makes fast switching possible. Combined with the excellent transparency of the liquid crystals over a broad wavelength range, this technology opens up the most diverse range of applications. The components could be used, for example, in optical telecommunication or in fiber optic sensor technology.

Other components based on electro-active organic materials and developed at the Fraunhofer IPMS are micro-lenses with an adjustable (variable) focus. The driving element here is an integrated electrostrictive polymer actuator of high deformation. They can find practical usage, for example, in manufacturing compact optical zoom objectives for micro-cameras in mobile phones.

Fraunhofer IPMS, with more than 450 employees, is dedicated to applied research and development at the highest international level in the fields of photonic microsystems, microsystems technologies, nanoelectronic technologies, wired and wireless data communication. Innovative processes and products which are based upon our various technologies can be found in all large markets – such as information and communication technologies, consumer products, automobile technology, semiconductor technology, measurement and medical technology.

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