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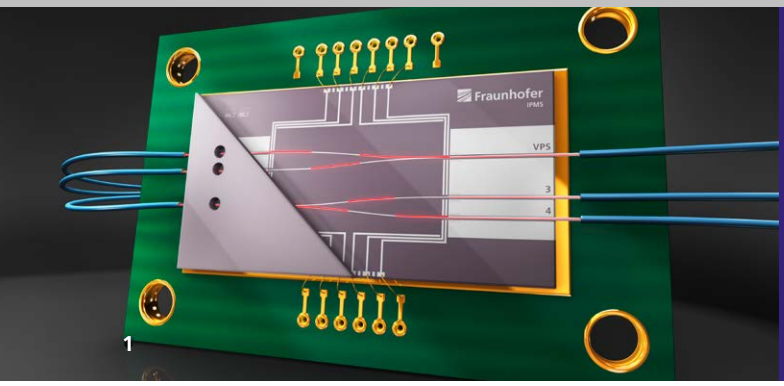

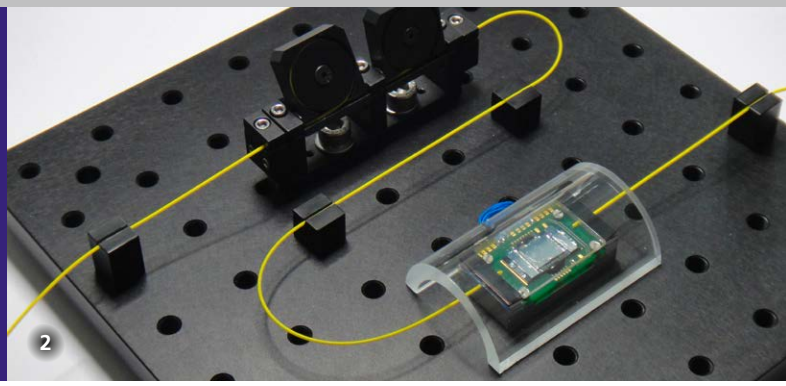

1 *1 × 2 liquid crystal switch / variable power splitter*
2 *Polarization independent liquid crystal waveguide*

POLARIZATION INDEPENDENT LIQUID CRYSTAL WAVEGUIDES

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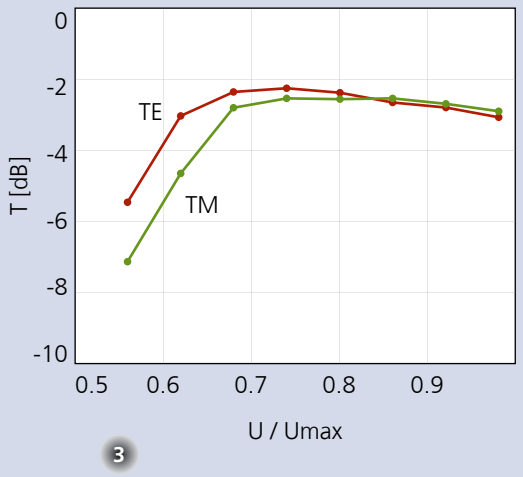
Nowadays, many applications are sensitive to light polarization and require polarization maintaining components. Equally, there are applications which demand polarization independent components, for instance when reducing fiber optic network complexity as well as costs are issues.

Fraunhofer IPMS electro-optically induced waveguides technology with liquid crystals on silicon backplane is attractive for optical switching applications. Key features stem from employing highly transparent liquid crystal blends as waveguide materials. Specifically, the optical power transmitted along the waveguide structure can be controlled by adjusting the electro-optical Kerr response strength in a liquid crystal layer on a sub-microsecond timescale with an applied electrical field.

Essentially due to the underlying electro-optical effect, the propagation behavior of a light wave along the Fraunhofer IPMS liquid crystal waveguide is dependent on its polarization state. A new polarization independent electro-optically induced waveguide design concept has been now developed. Here the optical losses in the TE and TM modes propagating along the waveguide can be controlled by varying an applied electric field distribution.

Estimates of TE and TM modes transmission as a function of the applied voltage are presented in fig. 3. The data reveal that, with the current design, for single mode operation at the telecommunication C-band centered around 1550 nm, insertion loss of less than 3 dB can be achieved for extremely low polarization dependent loss.

These waveguides are fabricated at the Fraunhofer IPMS by means of precision silicon wafer level technology. This fulfills the prerequisites for high quality, high



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Technical specifications

Parameter	Unit	Value
Insertion loss* (at 1550 nm)	dB	< 3
PDL	dB	< 0.1
Attenuation range	dB	0 - 30
Wavelength range	nm	400 - 1600
Optimized for wavelength	nm	1550
Switching time	µs	< 1
Voltage, U_{max} (design dependent)	V	40 - 80

* estimated for both TE and TM polarization

volume and cost efficient manufacturing. A demonstration of a polarization independent waveguide is available.

Advantages

Fraunhofer IPMS has demonstrated, making use of particular arrangements of polarization dependent electro-optically induced waveguides, sub-microsecond switching, and continuously voltage adjustable, full variable range power splitting at low optical loss. By employing the Fraunhofer IPMS new waveguide design, also polarization independent optical switching and polarization independent variable power splitting are now possible.

In particular, optical switching devices based on the new Fraunhofer IPMS waveguide concept can provide the following key features: fast switching speeds, polarization insensitive operation, good reliability and stability of the switching process, scalability towards high channel count and integrability with other devices, large number of switching cycles as well as low insertion loss and low crosstalk.

Usage

An optical switch device based on polarization independent electro-optically induced waveguides can be used for directing signals from multiplexed fiber optic sensors for their cycling analysis in interrogation instruments. For fiber optic sensor network monitoring, the device can ensure switching between channels at frequencies in the MHz range. Moreover due to the absence of mechanical parts, the device can operate nearly wear-free and can therefore be the technology of choice for long-term monitoring applications.

In optical telecommunications networks, devices based on polarization independent electro-optically induced waveguides can ensure dynamic switching between different channels, control of power allocated to network nodes and increased efficiency by utilizing optical resources effectively and at a lower cost.

Key features

- Small footprint
- Polarization insensitive operation
- Single mode design (multi-mode possible)
- Fiber optic coupling
- Stability of switching
- Full variable range optical power splitting
- Continuously voltage adjustable output characteristics
- Reliability (no mechanical parts)
- Precision silicon micro-technology
- Wafer level scale manufacturing
- Scalability and integrability with other devices switching

Applications

- Fast, long lifetime monitoring fiber-optic sensor networks (MHz)
- Optical telecommunication networks
- Signal monitoring
- Fiber-to-fiber interconnection
- Signal attenuation
- Laser technology

Bundesministerium für Bildung und Forschung

The development of a polarization independent waveguide has been supported by the German Federal Ministry of Education and Research, as part of the research initiative Wissenschaftliche Vorprojekte (WiVorPro) within the program Photonic Research in Germany, Project. EOF-IOS, Contract No. 13N12442

3 *Estimated transmission in polarization insensitive liquid crystal waveguide*