Light Advanced Manufacturing

Outstanding Papers in 2023

Automated optical inspection of FAST's reflector surface using drones and computer vision

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Automated Optical Inspection of FAST's Reflector Surface using Drones and Computer Vision

The Five-hundred-meter Aperture Spherical radio Telescope (FAST) is the world's largest single-dish radio telescope. Its large reflecting surface achieves unprecedented sensitivity but is prone to damage, such as dents and holes, caused by naturally-occurring falling objects. Hence, the timely and accurate detection of surface defects is crucial for FAST's stable operation. To accelerate the inspection process and increase its accuracy, Jianan Li and Tingfa Xu from China's Beijing Institute of Technology make the first step towards automating the inspection of FAST by integrating deep-learning techniques with drone technology. Equipped with a dedicated plug-in operation for deep detectors, namely cross-fusion, multi-level features are fused point-wise to support the accurate detection of defects of various scales and types. The AI-powered drone-based automated inspection is time-efficient, reliable, and has good accessibility, which guarantees the long-term operation of FAST.

3D-printed facet-attached microlenses for advanced photonic system assembly

Yilin Xu, Pascal Maier, Mareike Trappen, Philipp-Immanuel Dietrich, Matthias Blaicher, Rokas Jutas, Achim Weber, Torben Kind, Colin Dankwart, Jens Stephan, Andreas Steffan, Amin Abbasi, Padraic Morrissey, Kamil Gradkowski, Brian Kelly, Peter O'Brien, Wolfgang Freude, Christian Koos

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Multi-photon lithography: 3D-Printed microlenses enable scalable photonic system assembly

3D-printed facet-attached microlenses (FaML) can improve the scalability of the assembly of photonic integrated circuits (PIC). Currently, the assembly of PIC relies on complex and expensive active alignment techniques. FaML can be printed onto the facets of optical components using multi-photon lithography, offering the possibility to collimate the emitted beams to a comparatively large diameter that is independent of the specific device, thereby relaxing both axial and lateral alignment tolerances. The FaML concept allows for passive assembly using industry-standard machine vision or simple mechanical stops. Experiments show the versatility of the concept in creating pluggable fiber-chip interfaces, in combining PIC with discrete micro-optical elements, and in coupling light with ultra-low back-reflection. Based on these results, the authors believe that FaML may offer an attractive path towards novel PIC-based system architectures.

Iterative projection meets sparsity regularization: towards practical single-shot quantitative phase imaging with in-line holography

Yunhui Gao, Liangcai Cao

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Compressive holography: Seeing transparent samples with a snap shot

Holography provides access to the phase of an optical field that contains various sources of information. Yet recovering the accurate phase remains a challenging task for holography due to the existence of the twin-image artifacts. Liangcai Cao from China's Tsinghua University and colleagues now report development of a compressive holographic reconstruction framework that enables the quantitative analysis of optical phase from a single shot. It utilizes physical knowledge and the sparsity nature of the real-world samples to eliminate the twin image and achieve high imaging fidelity. The team conducted holographic reconstruction of various optically transparent samples, demonstrating its potential applications in surface metrology and biomedical imaging.

Metasurfaces designed by a bidirectional deep neural network and iterative algorithm for generating quantitative field distributions

Yang Zhu, Xiaofei Zang, Haoxiang Chi, Yiwen Zhou, Yiming Zhu, Songlin Zhuang

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Deep learning for designing flat devices with quantitative functionalities

A metasurface-based device with quantitative wavefront-modulation functionalities can enable practical applications such as high-accuracy sensing and detecting. The current metasurface design assisted by deep learning is mainly restricted to generating qualitative field distributions. Xiaofei Zang and Yiming Zhu from China's University of shanghai for science and technology and colleagues now propose an approach that is realized by combining a tandem neural network and an iterative algorithm, for the reverse design of metasurfaces enabling quantitative field distributions. As proof-of-principle examples, metalenses predicted via the designed network architecture that possess multiple focal points with identical/orthogonal polarization states, as well as accurate intensity ratios, have been demonstrated. The unique design strategy will promote machine learning in further designing ultracompact devices with high-accuracy and quantitative functionalities.

Ultra-compact lithium niobate photonic chip for high-capacity and energy-efficient wavelength-division-multiplexing transmitters

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Lithium Niobate Photonic Chip: High-capacity and Energy-efficient Wavelength-division-multiplexing Transmitters

Ultra-fast modulation and wavelength-division-multiplexing are key points to expand capacity in optical interconnects. Modulators on lithium-niobate-on-insulator (LNOI) platform are able to achieve high-speed and low-loss electro-optic modulation. However, it is still challenging to realize on-chip multi-channel optical transmitter due to the anisotropy of LN and the large footprints. Daoxin Dai's group from Zhejiang University in China now report an ultracompact LNOI photonic chip, comprising four optical modulators based on ultracompact 2×2 Fabry-Perot cavities and a four-channel WDM filter based on multimode waveguide gratings. The design avoids any waveguide bends in the key regions, resulting in small size, design flexibility, and scalability. The fabricated chip exhibits high-performance in both excess loss and data transmissions, showing great potential for further realization of ultrahigh-capacity and energy-efficient WDM optical interconnects and optical computing on LNOI.

Hybrid integration of 2D materials for on-chip nonlinear photonics

Vincent Pelgrin, Hoon Hahn Yoon, Eric Cassan, Zhipei Sun

Light: Advanced Manufacturing. 2023, **4**(3) : 311-333. doi: 10.37188/lam.2023.014

Hybrid integration of 2D materials for on-chip nonlinear photonics

In the past decade, the field of micro and nanotechnologies has undergone significant changes due to the emerging demand for high-performance on-chip integrated devices and the advent of quantum computing. Although on-chip optical devices have been identified as a promising platform, several limitations still need to be addressed to facilitate integrated photonics' next technological evolution. The integration of disruptive new nanomaterials, particularly 2D materials, with the integrated optics approach, is a promising solution to unlock the full potential of the next generation of on-chip devices. The unique electronic, optical, and mechanical properties of 2D materials can enable the development of ultra-compact and efficient photonic components, such as modulators and detectors, and new functionalities. The integration of 2D materials with integrated optics is a promising avenue for revolutionizing the field of on-chip devices, paving the way for significant technological advances.

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Perovskite light-emitting diodes toward commercial full-colour displays: progress and key technical obstacles

Changjiu Sun, Yuanzhi Jiang, Keyu Wei, Mingjian Yuan

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Perovskite light-emitting diodes toward commercial full-colour displays

Metal-halide perovskite light-emitting diodes (PeLEDs) possess wide colour gamut, high luminescence efficiency, and low-cost synthesis, making them a promising photonic source for next-generation display applications. Mingjian Yuan from China's Nankai University and colleagues review the primary technical bottlenecks of PeLEDs for commercial display applications. They focus on large-area PeLED preparation, patterning strategies, and flexible PeLED devices. They review the technical approaches for achieving these targets and highlight the current challenges for these perovskite materials and PeLED devices to meet the requirements of the next-generation high-colour-purity full-colour display market.

Quantitative phase imaging (QPI) through random diffusers using a diffractive optical network

Yuhang Li, Yi Luo, Deniz Mengu, Bijie Bai, Aydogan Ozcan

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All-optical quantitative phase imaging through random diffusers using diffractive networks

Quantitative phase imaging (QPI) is a label-free computational technique frequently used for imaging cells and tissue samples. Modern QPI systems heavily rely on digital processing and face challenges when diffusive media obstruct the optical path. A team led by Aydogan Ozcan at the University of California, Los Angeles (UCLA), reported a new approach to perform QPI through random unknown phase diffusers using a diffractive optical network. This diffractive network, optimized through deep learning, consists of a set of spatially-engineered diffractive surfaces designed to transform the phase information of input samples positioned behind random diffusers into intensity variations that quantitatively represent the object's phase information at the output. The team anticipates the potential integration of QPI diffractive networks onto the active area of image sensor-arrays, converting an existing optical microscope into a diffractive QPI microscope that performs all-optical phase recovery and image reconstruction on a chip.

Large viewing angle holographic 3D display system based on maximum diffraction modulation

Di Wang, Nan-Nan Li, Yi-Long Li, Yi-Wei Zheng, Zhong-Quan Nie, Zhao-Song Li, Fan Chu, Qiong-Hua Wang

Light: Advanced Manufacturing. 2023, **4**(3) : 195-205. doi: 10.37188/lam.2023.018

A novel holographic 3D display system with large viewing angle

Holographic 3D display is widely considered a promising candidate for the ultimate 3D display solution. However, the viewing angle of holographic 3D display is far from meeting the viewing needs by resorting to the existing strategies. Qiong-Hua Wang from Beihang University of China and colleagues now report a novel large viewing angle holographic 3D display system that enables a viewing angle of 73.4°. The core idea of the proposed system is to consider the maximum diffraction angle of SLM as the limited diffraction modulation range of each image point and implement a self-engineered liquid crystal grating. The proposed system has huge application potential in fields such as education, culture, and entertainment and is expected to promote the applications of holographic 3D display.

Fabry–Perot-based phase demodulation of heterodyne light-induced thermoelastic spectroscopy

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Fabry–Perot-based phase demodulation of heterodyne light-induced thermoelastic spectroscopy

Fabry–Perot (F–P)-based phase demodulation of heterodyne light-induced thermoelastic spectroscopy (H-LITES) was demonstrated for the first time in this study. The vibration of a quartz tuning fork (QTF) was detected using the F–P interference principle instead of an electrical signal through the piezoelectric effect of the QTF in traditional LITES to avoid thermal noise. Given that an Fabry–Perot interferometer (FPI) is vulnerable to disturbances, a phase demodulation method that has been demonstrated theoretically and experimentally to be an effective solution for instability was used in H-LITES. The sensitivity of the F–P phase demodulation method based on the H-LITES sensor was not associated with the wavelength or power of the probe laser. Thus, stabilising the quadrature working point (Q-point) was no longer necessary. This new method of phase demodulation is structurally simple and was found to be resistant to interference from light sources and the surroundings using the LITES technique.