证明材料目录

附件 1

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Single multimode fibre for in vivo light-field-encoded endoscopic imaging

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Super-resolution microscopy is typically not applicable to in situ imaging through a narrow channel due to the requirement for complex optics. Although multimode fibres (MMFs) have emerged as a potential platform for cost-effective and precise endoscopic imaging, they suffer from extreme sensitivity to bending and other external conditions. Here we demonstrate imaging through a single thin MMF for in vivo light-field encoded imaging with subcellular resolution. We refer to the technique as spatial-frequency tracking adaptive beacon light-field-encoded (STABLE) endoscopy. Spatial-frequency beacon tracking provides up to 1 kHz disorder tracking frequency, thus ensuring stable imaging through long-haul MMFs under fibre bending and various operating conditions. The full-vector modulation and fluorescence emission difference are combined to enhance the imaging signal-to-noise ratio and achieve a subdiffraction resolution of 250 nm. We integrate STABLE in a white-light endoscope and demonstrate cross-scale imaging in a bronchus model and in vivo imaging in mice models. The high-resolution and resilience to observation in a minimally invasive manner paves the way to the expansion of MMF in endoscopy to the study of disease mechanisms in biomedical sciences and clinical studies.

One of the ultimate dreams of endoscopists would be real-time high-resolution endoscopy that combines in vivo imaging and therapeutic intervention, resulting in an endoscopic diagnosis that matches an in vitro pathological diagnosis[1,2]. Considerable progress has recently been made in endoscopy. Endocytoscopy, confocal laser endomicroscopy and other techniques have been developed to enable in vivo cellular imaging[3–8]. Meanwhile, super-resolution microscopy enables spatial resolution at much smaller scales than the subcellular level, leading to breakthroughs in the fields of biology and life sciences[9–13]. However, super-resolution microscopy often requires cumbersome optics and is thus challenging to implement in a narrow channel. In fact, one critical missing ability is to conduct robust in vivo nano-endoscopy, which is yet to be satisfactorily established. One promising strategy is to employ thin multimode fibres (MMFs) as minimally invasive probes using wavefront shaping. The mode density of MMFs is 2–3 orders of magnitude higher than those of traditional endoscopes of the same diameter[14–30], but this technology has two critical limitations: the operational inflexibility due to the strong transmission dependence

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News & Views

Multimode fiber imaging: a novel and fast-developing field

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Multimode fibers (MMFs) are low-cost, mode-division multiplexing waveguide mediums that can support the propagation of thousands of spatial modes within an ultra-compact footprint (~100 μm) [1]. Despite these advantages, the spatial degree of freedom in MMFs is often not fully utilized due to mode coupling [2]. With the advancement in wavefront shaping technology and computational power, MMF imaging has become a subject of great scientific and technological interest because of its unique properties, such as minimally invasive, high resolution, and high modulation ability [3–15]. We will present the latest significant developments in MMFs imaging technologies and provide views on their future.

When light is launched into the MMF, it excites independent transmission modes, each of which has different propagation velocities and experiences distinct polarization mixing [2]. Those features lead to scattering and randomization of the light propagation vectors in MMF similar to in the scattering medium. Therefore, an experimental transmission matrix (TM) calibration is typically required [5]. This process can be described as

$$\psi_{out}(x,y) = T\psi_{in}(x,y), \quad (1)$$

where x and y represent the two-dimensional spatial factors at the two ends of the fiber. The TM T is obtained by the linear mapping between the input light-field ψ_{in} and the output light-field ψ_{out}. In classical MMF imaging, a series of scan points are generated and swept across the specimen (Fig. 1a). The image is reconstructed from the reflection or fluorescent signals of samples. The above process is the most utilized process to obtain MMF imaging [5–7]. Here we focus on MMF imaging based on TM approach.

By employing MMFs, Vasquez-Lopez et al. [6] achieved minimally invasive subcellular optical imaging and neural information measurement in living mice's deep brain. A 50 μm core diameter fiber probe was used to achieve fluorescence imaging of subcellular neuronal structures, dendrites, and synaptic specialization in the deep brain region with a resolution of nearly 1.35 μm (Fig. 1b). Ca^{2+} responses were simultaneously obtained under auditory stimuli throughout the experiment. Imaging with MMFs reduced the volume of brain tissue damage by more than 100 times compared to conventional imaging with graded-index (GRIN) lens [6]. During the same time, Turtaev et al. [7] achieved 3.5 frames/s high-fidelity MMF *in vivo* imaging. Recently, Silveira et al. [8] propose a novel probe of MMF. This probe allows to image samples on the side of the fiber and not on its distal facet which allows for less tissue damage [8]. Those studies represent breakthroughs in minimally invasive high-resolution *in vivo* imaging. Three-dimensional (3D) microscopic imaging provides more complete structure information of cells than planar imaging methods and the potential for improved diagnostic accuracy of disease. Wen et al. [9] designed a compact 3D MMF imaging system (Fig. 1c), which uses a digital micromirror device to shape the wavefront of light to correct misalignment and achieve diffraction-limited imaging at different depths in the sample. In order to capture the real-time activity of cells, a higher sampling rate is needed. The TM-based MMF imaging techniques rely on sequential hologram pattern projection. Thus the bottleneck of existing scanning schemes is the speed of the spatial light modulator (up to 22 kHz). By using mode-coupling characteristics in MMFs, Amitonova et al. [10] used compressive sampling instead of point-by-point sampling (Fig. 1d). And then they combine sparse constraints and compressed sensing reconstruction to achieve imaging speed 20 times faster than the Nyquist-Shannon limit with a simple experimental setup [10].

To effectively introduce MMFs endoscope into clinical diagnosis and keyhole surgery, the imaging system not only requires high spatial resolution and frame rate, but also needs to extend working distance and field of vision. Leite et al. [11] first demonstrated the MMF far-field imaging based on the 17,000 modes modulation. By modulating the light-field energy on the corresponding spatial-frequency region, the power uniformity of far-field focal points and the signal-to-noise ratio of imaging can be improved more than twofold. The MMF imaging is capable of video-level imaging of macroscopic objects at distances from 20 to 400 mm.

In addition, if 3D information can be extracted from the image, the clinicians can obtain the depth changes in the surgical field of vision more intuitively. During the operation, the injury of blood vessels and nerves can be minimized, and the probability of surgical complications can be reduced. Most recently, a breakthrough was published in *Science* (Fig. 1e) [12]. Stellinga et al. [12] provide 3D information about the scene by MMFs. Different from previous studies, this scheme extends the laser source from continuous-wave to pulse-wave (pulse duration is ~700 ps). The image was

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Optics Letters

Fast volumetric fluorescence imaging with multimode fibers

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In this Letter, we propose a compact multimode fiber endoscope which employs wavefront shaping with a digital micromirror device (DMD). An automated single calibration step allows us to correct for optical misalignment, and the method achieves accurate focusing at various depths in the sample through rapid switching of holographic patterns by the DMD. The speed of calibration is one or two orders of magnitude faster than existing methods. The method, single calibration multimode fiber imaging (SCMFI), is compared with existing methods, and its performance is validated. We show a near diffraction limited focusing capability at imaging depths up to 110 μm with near constant lateral resolutions of 1.4 μm. Finally, we demonstrate the method for the imaging of small fluorescent beads embedded in a 3D matrix. The results indicate excellent power penetration and focusing performance. Combined with the high speed of SCMFI, this paves the way for volumetric tissue endoscopy at depth.

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The optical endoscope is a key technology for the diagnosis of disease and for guidance of surgical procedures. A multimode fiber can be used as a minimally invasive endoscope, as it possesses a larger mode capacity, a higher efficiency of light collection, and a much reduced cost compared to endoscopes using fiber bundles [1,2]. However, a limitation of using multimode fibers for image transmission is that mode dispersion causes the image to be transmitted in the form of speckle patterns at the output end of the imaging fiber [2]. With the rapid development of wavefront shaping technology that prevents optical aberrations introduced by tissue scattering in recent years, the interest in the subject has increased dramatically [3–12]. Mode dispersion can be compensated for by measuring the transmission matrix (TM) which, as a wavefront shaping approach, represents the linear relationship between the fiber input field and fiber output field. Various imaging methods based on multimode fibers have been reported which make use of the TM approach, including confocal [8,13], light sheet [14], wide-field [4] and two-photon [9] imaging modalities.

The technology has attractive features for volumetric imaging. The imaging focus can be adjusted without movement of mechanical components and without requirement for a focusing element on the tip of the fiber [15]. This reduces the complexity and size of the endoscope and thus the risk of trauma. However, several problems prevail that prevent widespread application. Currently, multimode fiber endoscope requires extensive calibration prior to imaging. To realize an axially adjustable focus, multiple calibration steps must be executed at different axial distances behind the multimode fiber, as shown in approach 1, Fig. 1(a). Most fiber endoscope applications require placing the fiber within tissue involving bending and temperature changes. This results in a change in mode of the multimode fiber and requires recalibration [see Fig. 1(b)]. Although the time for a single calibration is usually no more than a few minutes [15,16], the entire calibration time for volumetric imaging can easily reach tens of minutes [as shown in Fig. 1(c)]. The time-consuming calibration process is a bottleneck for some practical applications. In contrast, an appropriate quadratic phase term can be added to the incident wavefront prior to launch into the fiber. This achieves axially adjustable focusing requiring only a single calibration step and greatly reduces acquisition and processing times. However, for good quality and control of the axially adjustable focus, one requires a precise alignment of the spatial frequencies of the incident optical field and those of the fiber. Misalignment deteriorates the quality of imaging, particularly at depth. By converting the transformation matrix into the representation of propagation-invariant modes, misalignment can be perfectly eliminated [6]. However, the method requires the addition of an external reference arm, which will cause interferometric stability problems and increase the complexity of the system [5].

Here we introduce a step multimode fiber endoscope that can be rapidly focused for imaging at different depths and requires only a single calibration step for volumetric imaging. We have

Optics Letters

Spatially variant deblur and image enhancement in a single multimode fiber imaged by deep learning

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A single multimode fiber has been applied in minimally invasive endoscopy with wavefront shaping for biological research such as brain imaging. Most of the fibers, such as step-index and graded-index multimode fibers, give rise to spatially variant blur due to limits on the numerical aperture and collection efficiency. Routines to solve this problem are based on iterative algorithms, which are often slow and computer-intense. We developed a method to synthesize datasets for driving a deep learning network to deblur and denoise the spatially variant degraded image. This approach is fast (5 ms), up to three orders of magnitude faster than the iterative way. Furthermore, our method can be applied to different types of fiber endoscopy, and two types of fiber are tested here. The performance is verified on fluorescence beads and three kinds of biological tissue sections in the experiment, demonstrating effectiveness in image enhancement.

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Multimode optical fibers (MMF) have emerged as a prominent imaging tool inside a narrow channel. Compared with microprobes such as fiber bundles and gradient-index (GRIN) lenses in micro-endoscopes, the MMF has huge inbuilt advantages due to its ultra-thin diameter and capability of tomography [1–3]. Therefore, this tool is particularly appropriate for *in vivo* deep imaging when minimal invasiveness and miniature damage are required, including deep brain imaging. However, the nature of the fiber scrambles the incident light wavefront and leads to mode chaos, making the output beam have seemingly random speckle patterns [4]. The development of wavefront shaping makes it possible to unscramble the chaos through a spatial light modulator or digital micromirror (DMD) [5]. Modulation of light forms a diffraction-limited focus in a 2D or even 3D scan of the specimen at the distal end of the fiber [6].

Most MMFs or well-designed fiber probes have a limitation on the numerical aperture (NA). The effective NA of the fiber is degraded both at large axial distances from the output fiber facet and at a large radial axis from the center of the core [7]. The degradation leads to variant spatially focuses and nonuniform blur images [8]. In addition, photon detectors like the photomultiplier tube (PMT) or avalanche photodiode inevitably bring about Poisson noise and Gaussian noise in collecting signals. These noises could further degrade the image quality and block the way to perform the algorithm for restoration.

Recently, some amended deconvolution methods have been proposed to deal with the spatially variant blur [8–10]. However, they are still time-consuming and computationally intensive, limiting the way to further application. Deep learning deconvolution methods have newly become an effective tool for image restoration at a fast speed, showing a considerable improvement over the iterative algorithms [11]. In addition, data-driven deep-learning-based methods have the potential to map the variant point spread functions (PSFs) and perform nonlinear deconvolution. There are also many pieces of research about applying deep learning in a single MMF [12,13], but most of them focus on unscrambling the intrinsic mode chaos of MMFs instead of deblurring or denoising images in a fiber.

In this work, we propose a deep-learning-based approach for spatially variant deblur in fiber imaging at a fast speed. Depending on the recorded PSFs, a simple method is devised to synthesize the space-variant blurred image dataset, which drives the neural network into the optimal position. Furthermore, we build a new model which is capable of deconvolution and denoising at the same time. The trained model offers an increase in speed up to two or three orders of magnitude compared with iterative methods. The performance of this method was assessed in the context of two types of the most normally used MMFs, indicating the potential for universal applications.

Optics Letters

Phase imaging through a single multimode fiber

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Phase imaging techniques are pivotal for achieving high-contrast visualization of unstained biological specimens *in vitro*, which is typically not applicable in narrow spaces. Recently, multimode fiber (MMF) has shown promise in enabling high-resolution *in vivo* endoscopy in biological research. Herein, we introduce a novel, to the best of our knowledge, phase imaging microscopy technique employing a single multimode fiber, showcasing remarkable capabilities in high-contrast imaging and quantitative shape reconstruction through frequency-domain modulation. Our method, validated through comparisons with reflection and phase-contrast results, demonstrates exceptional ability in imaging diverse samples, including microspheres, semiconductor chips, and oral epithelial cells. Notably, the quantitative reconstruction of surface shape achieves a sensitivity of less than 100 nm, enabling the extraction of three-dimensional information from single focal plane images. Moreover, our technique excels in contrast enhancement and defocused background suppression, presenting a promising avenue for minimally invasive, high-contrast, label-free *in vivo* phase imaging.

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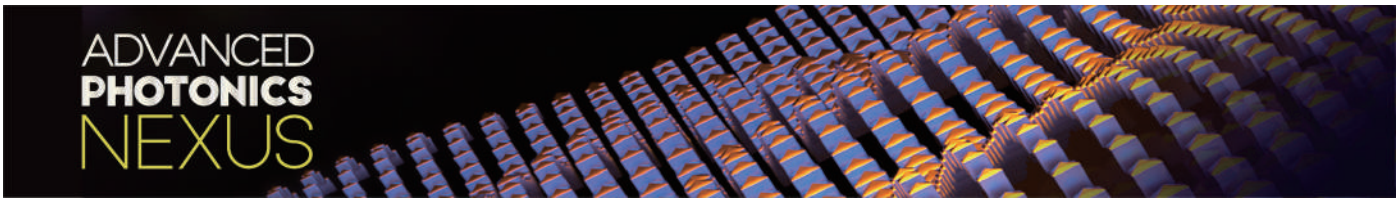
Phase imaging techniques are widely used in biomedical research because they provide high-contrast images of samples, especially when they are nearly transparent [1–3]. These techniques commonly convert phase differences into intensity differences which enables label-free optical imaging of biological specimens *in vitro*, such as differential phase contrast (DPC), differential interference contrast (DIC), and transport of intensity equation (TIE) [4]. Phase imaging techniques have important applications in observing cell structure and activity [5], blood screening [6], and disease analysis [7]. Currently, most phase retrieval microscopies are based on rigid and bulky microscopes that are difficult to meet the requirements of *in vivo* application. Although some studies have used optical fiber bundles for replacement [8,9], there are still problems such as iterative computation, comparative invasiveness, and high costs [10,11]. With the property of high information capacity, single multimode fiber (MMF) has been used as a minimally invasive endoscope in gastrointestinal tract imaging and deep-brain *in vivo* observation [12,13]. The linear relationship between the input optical field and output speckle can be described with the transmission matrix (TM) [14]. Despite the mode scrambling inside multimode fibers leading to chaos in signal transmission, the light propagating through fibers remains deterministic and can be controlled by wavefront shaping (WFS) [15]. With it, one may organize the light propagated through the MMFs to form foci to scan the target pixel by pixel. The recent development of MMF imaging has enabled *in vivo* stable imaging under fiber bending and various operating conditions [13] and deblurred volumetric imaging [16,17] at high speed [18]. The imaging techniques through the MMF can provide the sample's microstructure, most of which are based on specific fluorescent markers. It is a challenge to obtain high-resolution images of samples inside the lumen of the body without labeling.

As mentioned above, label-free phase imaging can display the refractive index changes of objects and provide information that would be unobservable in conventional microscopy. Phase imaging combined with the MMF is significant for biological research and *in vivo* imaging. The oblique back-illumination microscopy [1] enables *in vivo* phase imaging compatible with conventional optical microscopes and fiber bundles; however, it is unsuitable for MMFs. There is research on MMF phase imaging in optical coherence microscopy to reduce phase noise [19] and computational reconstruction [20]. The imaging speed of the computational reconstruction method is limited by computational complexity rather than hardware, as is the case with WFS methods. Due to current computational complexity and hardware performance, the speed is approximately tens of seconds. The most used metrology is WFS methods in MMF imaging. However, there is no program based on wavefront shaping to modulate a single MMF into a phase imaging microscope.

In this Letter, we demonstrate an approach for phase imaging microscopy using a single MMF. We built an experimental system for phase-contrast imaging, leveraging frequency-domain coded wavefront modulation. Asymmetric illumination is achieved by selectively switching the MMF output aperture to capture a pair of intensity images. The phase-gradient distribution of the target is derived through difference calculation using the provided images. The three-dimensional distribution of the surface can be quantitatively reconstructed by obtaining the phase-gradient distribution in mutually perpendicular directions

Research Article



Efficient reference-less transmission matrix retrieval for a multimode fiber using fast Fourier transform

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Abstract. Imaging through multimode fiber (MMF) provides high-resolution imaging through a fiber with cross section down to tens of micrometers. It requires interferometry to measure the full transmission matrix (TM), leading to the drawbacks of complicated experimental setup and phase instability. Reference-less TM retrieval is a promising robust solution that avoids interferometry, since it recovers the TM from intensity-only measurements. However, the long computational time and failure of 3D focusing still limit its application in MMF imaging. We propose an efficient reference-less TM retrieval method by developing a nonlinear optimization algorithm based on fast Fourier transform (FFT). Furthermore, we develop an algorithm to correct the phase offset error of retrieved TM using defocused intensity images and hence achieve 3D focusing. The proposed method is validated by both simulations and experiments. The FFT-based TM retrieval algorithm achieves orders of magnitude of speedup in computational time and recovers 2286 × 8192 TM of a 0.22 NA and 50 μm diameter MMF with 112.9 s by a computer of 32 CPU cores. With the advantages of efficiency and correction of phase offset, our method paves the way for the application of reference-less TM retrieval in not only MMF imaging but also broader applications requiring TM calibration.

Keywords: transmission matrix retrieval; multimode fiber; imaging through scattering.

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1 Introduction

Imaging through multimode fibers (MMFs) of tens to hundreds of micrometers enables high-resolution imaging by a hair-thin instrument. It provides minimally invasive high-resolution imaging for locations deep inside living organisms[1] without traumatic tissue slices.[2] Its broad applications include *in vivo* endoscopes,[3–5] optical tweezers over cellular area,[6,7] and remote time-of-flight 3D depth sensing.[8]

MMF imaging is achieved by exploiting the property of transmission matrix (TM). With the TM, one can collect the feedback signal after rapidly scanning foci on the sample[5,9] or directly inverse the scattering process.[10,11] However, the calibration of TM requires measuring the transmitted complex fields after sending probing incident complex fields. With both amplitude and phase, the complex fields cannot be measured directly by a camera. Conventionally, external reference methods[12–14] build a complicated experimental setup to interferometrically measure the transmitted complex field with an external reference beam. These methods suffer from phase instability of the reference beam, easily caused by mechanical variation and thermal drift. The internal reference methods[9,15,16] set parts of the modulation modes as an internal reference. It reduces the number of effective modulation modes and uses speckle reference, which contains dark reference points.[1,16] Its retrieved TM has the phase offset error, excluding applications that require 3D focusing.[6] Therefore, it is desirable to develop a simple and stable method to measure the full TM in MMF imaging.

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附件 2

专利证明材料

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专利号：ZL 2018 1 1589195.2

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发 明 人：马耀光;文仲;杨青;刘旭

专 利 号：ZL 2018 1 1589999.2

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专利权人：浙江大学

地 址：310013 浙江省杭州市西湖区余杭塘路866号

授权公告日：2020年11月03日　　授权公告号：CN 109683342 B

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局

2020年11月03日

其他事项参见续页

证书号第5665537号

发明专利证书

发明名称：一种基于频率域追踪的多模光纤稳定成像方法及装置

发明人：杨青;文仲;董振宇;邓启林;刘旭

专利号：ZL 2022 1 0067529.X

专利申请日：2022年01月20日

专利权人：浙江大学

地址：310013 浙江省杭州市西湖区浙大路38号

授权公告日：2022年12月27日　　授权公告号：CN 114563879 B

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局长
申长雨

国家知识产权局
2022年12月27日

其他事项参见续页

国 家 知 识 产 权 局

100013

北京市东城区北三环东路 36 号 2 号楼 C 座 20 层 2001 房间 北京志霖恒远知识产权代理有限公司
奚丽萍(18058806640)

发文日：

2023 年 12 月 22 日

申请号：202210130711.5　　**发文序号：**2023122201390850

申请人：之江实验室

发明创造名称：一种全矢量调制的单光纤高信噪比三维成像方法及装置

授 予 发 明 专 利 权 通 知 书

1.根据专利法第 39 条及实施细则第 54 条的规定，上述发明专利申请经实质审查，没有发现驳回理由，现作出授予专利权的通知。

申请人收到本通知书后，还应当依照办理登记手续通知书的内容办理登记手续。

申请人按期办理登记手续后，国家知识产权局将作出授予专利权的决定，颁发发明专利证书，并予以登记和公告。

期满未办理登记手续的，视为放弃取得专利权的权利。

法律、行政法规规定相应技术的实施应当办理批准、登记等手续的，应依照其规定办理。

2.授予专利权的上述发明专利申请是以下列申请文件为基础的：

☐原始申请文件。☐分案申请递交日提交的文件。☒下列申请文件：

申请日提交的摘要附图、说明书摘要、说明书第 1-39 段、说明书附图； 2023 年 11 月 17 日提交的权利要求第 1-9 项。

3.授予专利权的上述发明专利申请的名称：

☒未变更。

☐由_____变更为上述名称。

4. ☐申请人于_____年_____月_____日提交专利号为_____的“放弃专利权声明”，经审查：

☐进入放弃专利权的程序。

☐未进入放弃专利权的程序。理由是：申请人声明放弃的专利与本发明专利申请不属于相同的发明创造。

5. ☐审查员依职权对申请文件修改如下：

6. ☐申请人在申请日后补交了实验数据，该数据未包含在授权公告文本中。

注：在本通知书发出后收到的申请人主动修改的申请文件，不予考虑。

国家知识产权局 专利审查业务章 1101081359134

审查员：赵芳　　审查部门：专利审查协作河南中心

联系电话：0371-87791984

证书号第5599782号

发明专利证书

发明名称：一种基于色散超表面的光纤束多方位三维共聚焦成像装置及方法

发 明 人：杨青;董震宇;文仲;徐璟罡;马耀光;王立强;刘旭

专 利 号：ZL 2021 1 0108456.X

专利申请日：2021年01月27日

专利权人：之江实验室;浙江大学

地 址：310023 浙江省杭州市余杭区文一西路1818号

授权公告日：2022年11月22日　　授权公告号：CN 112666698 B

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局

2022年11月22日

其他事项参见续页

证书号第5791638号

发明专利证书

发 明 名 称：一种基于光场调控的传像束大视场三维成像装置及其方法

发 明 人：杨青;李全智;文仲

专 利 号：ZL 2022 1 0624432.4

专利申请日：2022年06月02日

专 利 权 人：浙江大学

地 址：310058 浙江省杭州市西湖区余杭塘路866号

授权公告日：2023年03月17日　　授权公告号：CN 114967104 B

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专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长
申长雨

国家知识产权局
2023年03月17日

其他事项参见续页

附件 3

项目证明材料

国家自然科学基金资助项目批准通知

（包干制项目）

文仲　先生/女士：

根据《国家自然科学基金条例》、相关项目管理办法规定和专家评审意见，国家自然科学基金委员会（以下简称自然科学基金委）决定资助您申请的项目。项目批准号：62405278，项目名称：基于矢量光场自适应调控的多模光纤原位深穿透层析成像研究，资助经费：30.00万元，项目起止年月：2025年01月至 2027年 12月，有关项目的评审意见及修改意见附后。

请您尽快登录科学基金网络信息系统（https://grants.nsfc.gov.cn），**认真阅读《国家自然科学基金资助项目计划书填报说明》并按要求填写《国家自然科学基金资助项目计划书》（以下简称计划书）**。对于有修改意见的项目，请您按修改意见及时调整计划书相关内容；如您对修改意见有异议，须在电子版计划书报送截止日期前向相关科学处提出。

请您将电子版计划书通过科学基金网络信息系统（https://grants.nsfc.gov.cn）提交，由依托单位审核后提交至自然科学基金委。自然科学基金委审核未通过者，将退回的电子版计划书修改后再行提交；审核通过者，打印纸质版计划书（一式两份，双面打印）并在项目负责人承诺栏签字，由依托单位在承诺栏加盖依托单位公章，且将申请书纸质签字盖章页订在其中一份计划书之后，一并报送至自然科学基金委项目材料接收工作组。纸质版计划书应当保证与审核通过的电子版计划书内容一致。**自然科学基金委将对申请书纸质签字盖章页进行审核，对存在问题的，允许依托单位进行一次修改或补齐。**

向自然科学基金委提交电子版计划书、报送纸质版计划书并补交申请书纸质签字盖章页截止时间节点如下：

1. **2024年9月9日16点：**提交电子版计划书的截止时间；

2. **2024年9月16日16点：**提交修改后电子版计划书的截止时间；

3. **2024年9月23日：**报送纸质版计划书（一式两份，其中一份包含申请书纸质签字盖章页）的截止时间。

4. **2024年10月8日：**报送修改后的申请书纸质签字盖章页的截止时间。

请按照以上规定及时提交电子版计划书，并报送纸质版计划书和申请书纸质签字盖章页，逾期不报计划书或申请书纸质签字盖章页且未说明理由的，视为自动放弃接受资助；未按要求修改或逾期提交申请书纸质签字盖章页者，将视情况给予暂缓拨付经费等处理。

附件：项目评审意见及修改意见表

国家自然科学基金委员会

2024年8月23日

浙江省科学技术协会
ZHEJIANG Association for Science and Technology

首页 走进科协 智库 学术 科普 人才 党建 应用

您现在所在的位置：首页> 通知公告

2024-2026年度浙江省科协青年人才托举培养项目人选名单公示

发布时间： 2024-05-31 作者： 来源： 省科协组织人事部

按照《关于做好2024-2026年度浙江省科协青年人才托举培养项目被托举人遴选工作的通知》、《浙江省科协青年人才托举培养项目管理办法（试行）》要求，经各项目实施单位遴选推荐，省科协审核，拟确定王式彬等72名同志入选2024-2026年度浙江省科协青年人才托举培养项目。现予以公示，公示时间为5个工作日。

公示期间，如有不同意见，请以书面形式，实名向浙江省科协机关纪委反映。反映情况须客观真实，以单位名义反映情况的材料需加盖单位公章，以个人名义反映情况的材料应署实名并提供有效的联系方式。

联系电话：0571-85100729

联系地址：杭州市武林广场8号省科协大楼1905室

附件：2024-2026年度浙江省科协青年人才托举培养项目拟入选者名单

浙江省科学技术协会
2024年5月31日

2024-2026年度浙江省科协青年人才托举培养项目拟入选者名单

（72名，按姓氏笔画排序）

序号	姓名	性别	研究领域	工作单位	遴选单位
1	王式彬	男	电催化理论研究	浙江工业大学化学工程学院	浙江工业大学科协
2	王青月	女	化学反应工程	浙江大学衢州研究院	浙江大学衢州研究院科协
3	王国烽	男	能源互联网优化，电力系统需求响应	浙江工业大学信息工程学院	浙江省电机动力学会
4	王泽楠	男	骨与软组织肿瘤免疫代谢	浙江大学医学院附属第二医院	浙江省医学会
5	王娟	女	纳米材料在能源储存与转化中的应用	温州大学化学与材料工程学院	温州大学新材料与产业技术研究院科协
6	车金鑫	男	药学、药物化学	浙江大学药学院	浙江省药学会
7	文仲	男	光学成像	浙江大学极端光学技术与仪器全国重点实验室	浙江省光学学会

中国光学学会2024-2026年度青年人才托举工程项目遴选结果公示

发布时间：2024-11-26　　阅读次数：3651

根据《中国科协办公厅关于开展第十届中国科协青年人才托举工程项目被托举人遴选工作的通知》，按照《中国科协青年人才托举工程实施管理细则（修订）》、《中国光学学会青年人才托举工程项目管理办法》有关要求，拟推荐陈鹏、文仲作为中国科协第十届（2024-2026年度）青年人才托举工程项目候选人。

本届青年人才托举工程项目经广泛征集、资格审查、通讯初评、线上会评，评审实行严格的专家回避制度。现将拟推荐人选和遴选专家予以公示，公示期为2024年11月26日-12月2日。公示期间，如有异议，请书面实名向中国光学学会秘书处反映。

特此公示。

附件1. 拟推荐被托举人信息

附件2.会评遴选专家信息

联 系 人：贾瑞卿

联系电话：010-62103275

联系邮箱：cosoffice@cast.org.cn

地 址：北京市海淀区学院南路86号东201

< 返回上一页　　上一篇：关于申报2025年中国光学...　　下一篇：2024年度中国光学学会科...

附件

第十届中国科协青年人才托举工程立项单位推荐拟入选者名单

（共 987 名，按姓氏笔画排序）

序号	姓名	性别	研究领域	工作单位	遴选单位
1	丁一波	男	载运工具动力学及其控制	西北工业大学	中国科协创新融合学会联合体
2	丁亚丽	女	森林植被与水土保持	北京林业大学	中国水土保持学会
3	丁岩	男	计算机体系结构	湖南大学	中国电子学会
4	丁涛	男	实验地球化学和计算地球化学	中国地质科学院矿产资源研究所	中国地质学会
5	丁婧祎	女	生物与土壤地理学	北京师范大学	中国地理学会
6	丁琳	女	土壤侵蚀与水土保持	中国水利水电科学研究院	中国水土保持学会
7	丁蕾	女	化学电源	天津力神电池股份有限公司	国务院国资委
8	卜俊杰	男	认知障碍与认知干预	安徽医科大学	中国科协生命科学学会联合体
34	尹蕾	女	低维半导体材料	武汉大学	中国科协先进材料学会联合体
35	文仲	男	光学成像、图像分析与处理	浙江大学	中国光学学会
36	文勇亮	男	智能盾构	中铁工程装备集团有限公司	中国机械工程学会
37	文博	男	超精密加工工艺与装备	通用技术集团机床有限公司	国务院国资委
38	文静	女	交叉学科中的人工智能问题	宝山钢铁股份有限公司	国务院国资委
39	文鑫	女	药理学其他科学问题	山东大学	中国科协生命科学学会联合体
40	方仕童	女	机械结构与系统动力学	深圳大学	中国振动工程学会
41	方娟	女	热力学基础与热力学评价	北京科技大学	中国工程热物理学会
42	方涛	男	水声通信	江苏科技大学	中国科协创新融合学会联合体
43	方特	男	机电一体化	广州穗腾数字科技有限公司	中国系统工程学会
44	毛奕婕	女	移动通信	上海科技大学	中国通信学会
45	毛晨峰	男	动脉粥样硬化与动脉硬化	军事科学院军事医学研究院生物工程研究所	中国科协生命科学学会联合体

Light: Science & Applications

科学网 ScienceNet.cn

荣誉证书

2023
中国光学
十大社会影响力事件
Light10

入选事件

在体超分辨成像缓步走来

获奖团队

浙江大学 杨青 刘旭 文仲 王立强

之江实验室 庞陈雷 刘松国

剑桥大学 Clemens F Kaminski

中国科学院长春光学精密机械与物理研究所

2024年1月

中国科学报社

2024年1月

证书

文仲，董震宇，邓启林，庞陈雷，Clemens F. Kaminski，徐晓蓉，严蕙蕙，王立强，刘松国，唐建斌，陈伟，刘旭，杨青

贵课题组发表在**Nature Photonics**上的成果“**Single multimode fibre for in vivo light-field-encoded endoscopic imaging**”入选“2023中国光学十大进展”（基础研究类），特发此证。

评审委员会主任：

中国激光杂志社

2024年4月

中国·光学十大进展

OPTICS AWARD