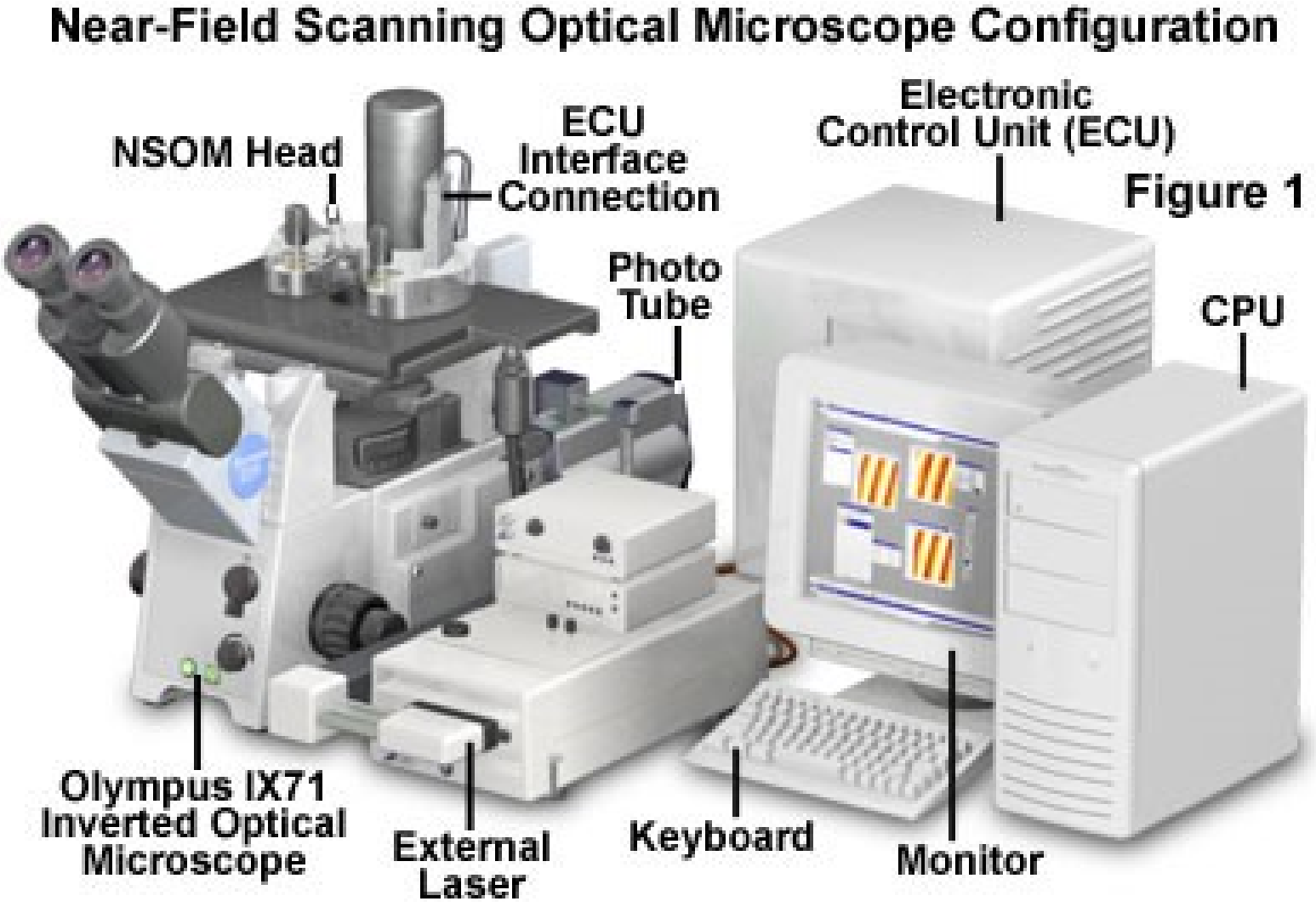
无标记超分辨显微成像技术

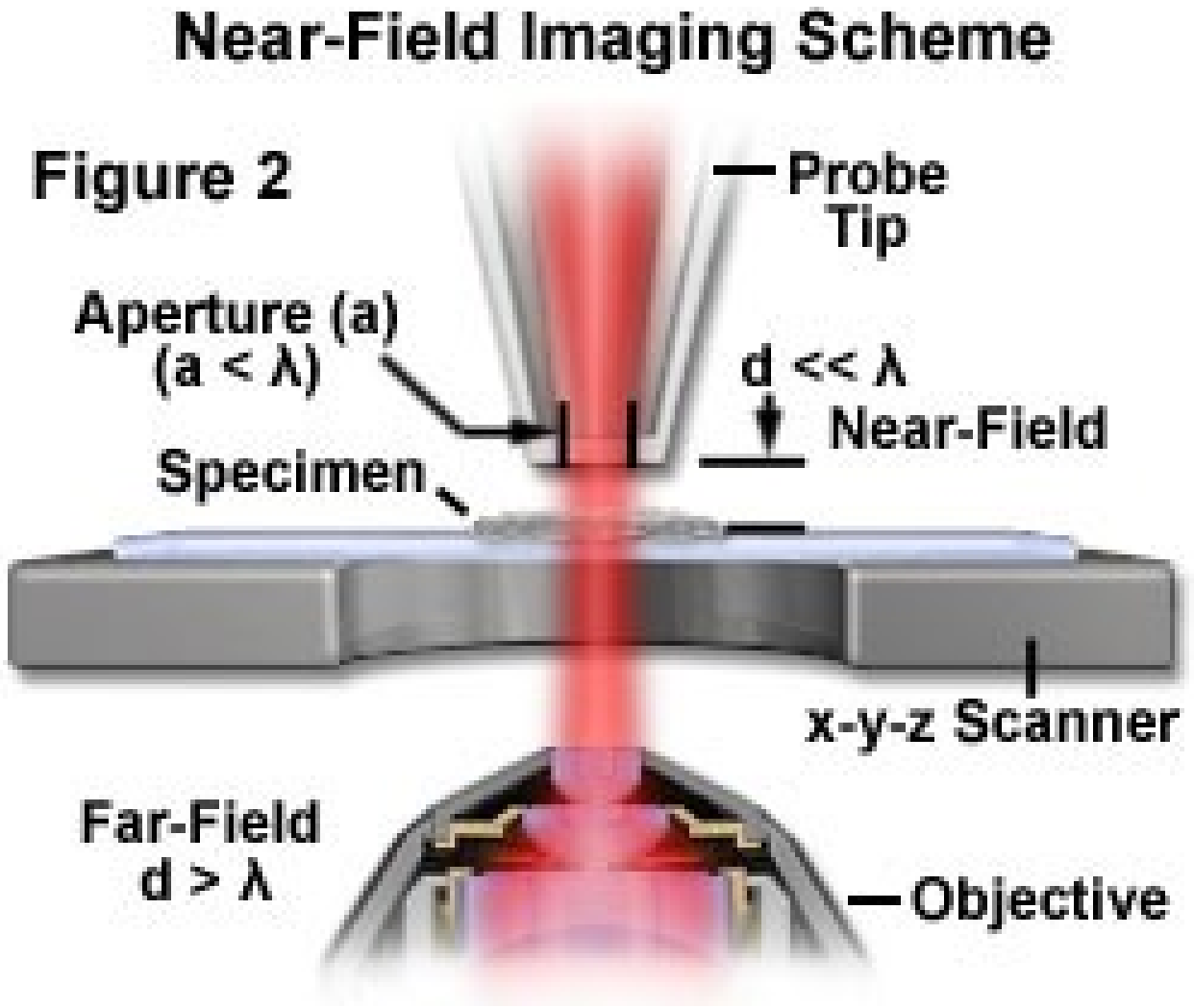
叶燃

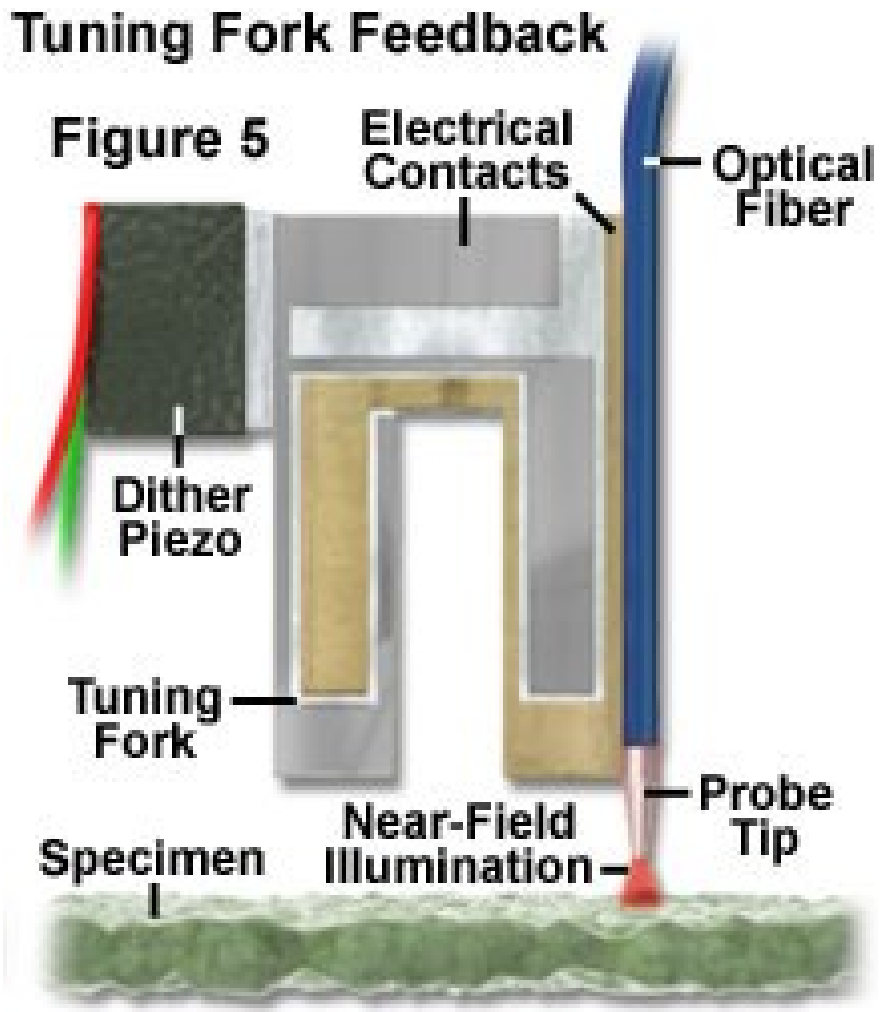
2021年11月30日

近场扫描光学显微镜 (NSOM / SNOM)



近场扫描光学显微镜 (NSOM / SNOM)





Near-Field Scanning Demonstration

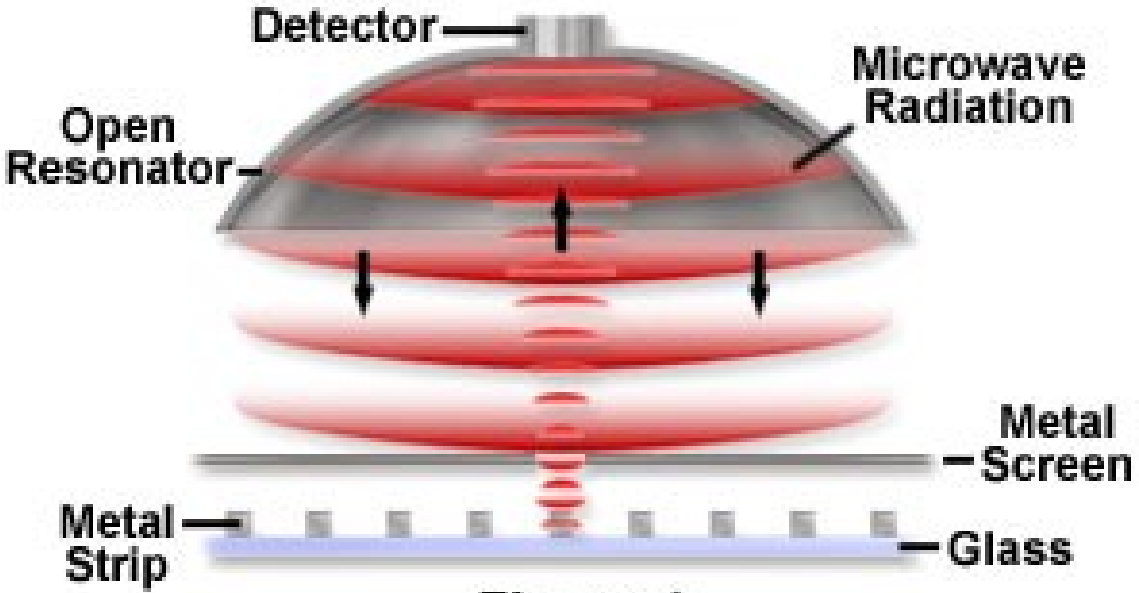


Figure 4

Bent Probe Optical Feedback

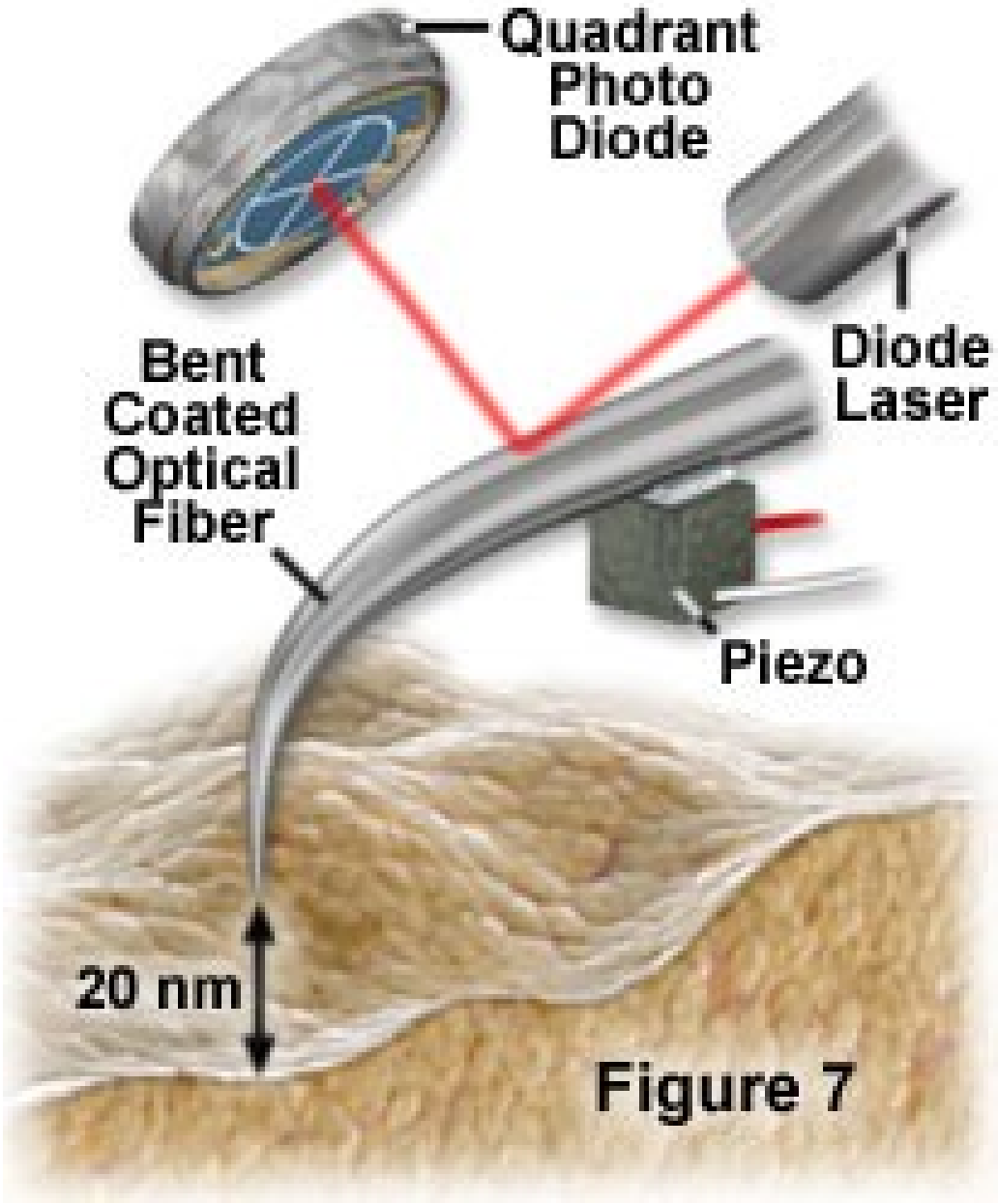
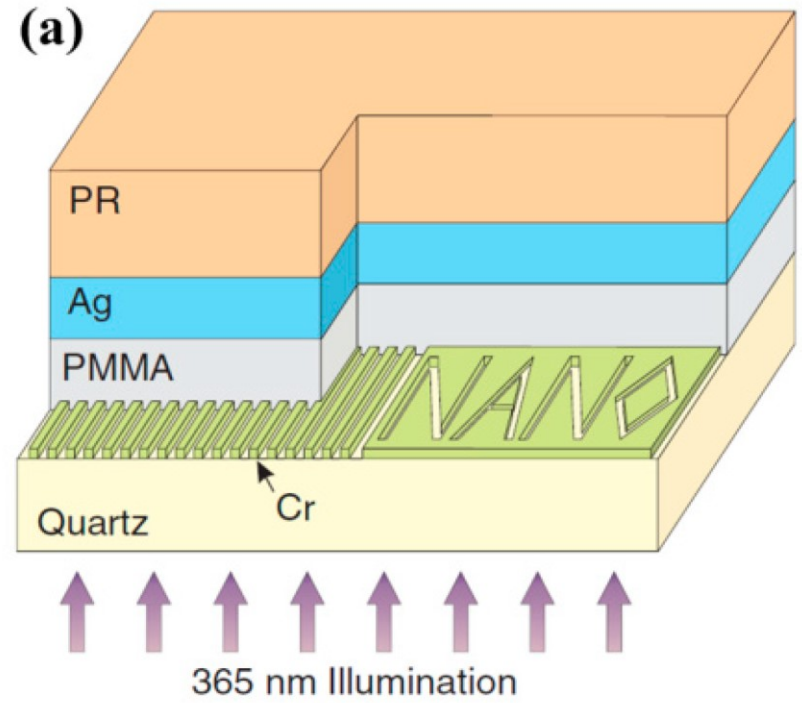


Figure 7

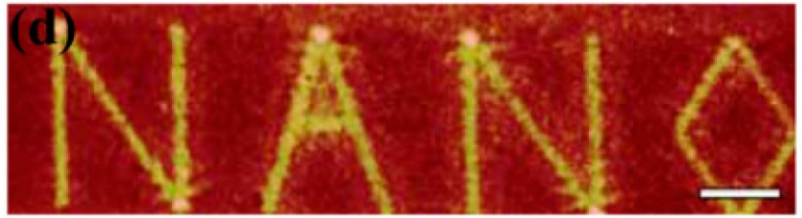
超透镜

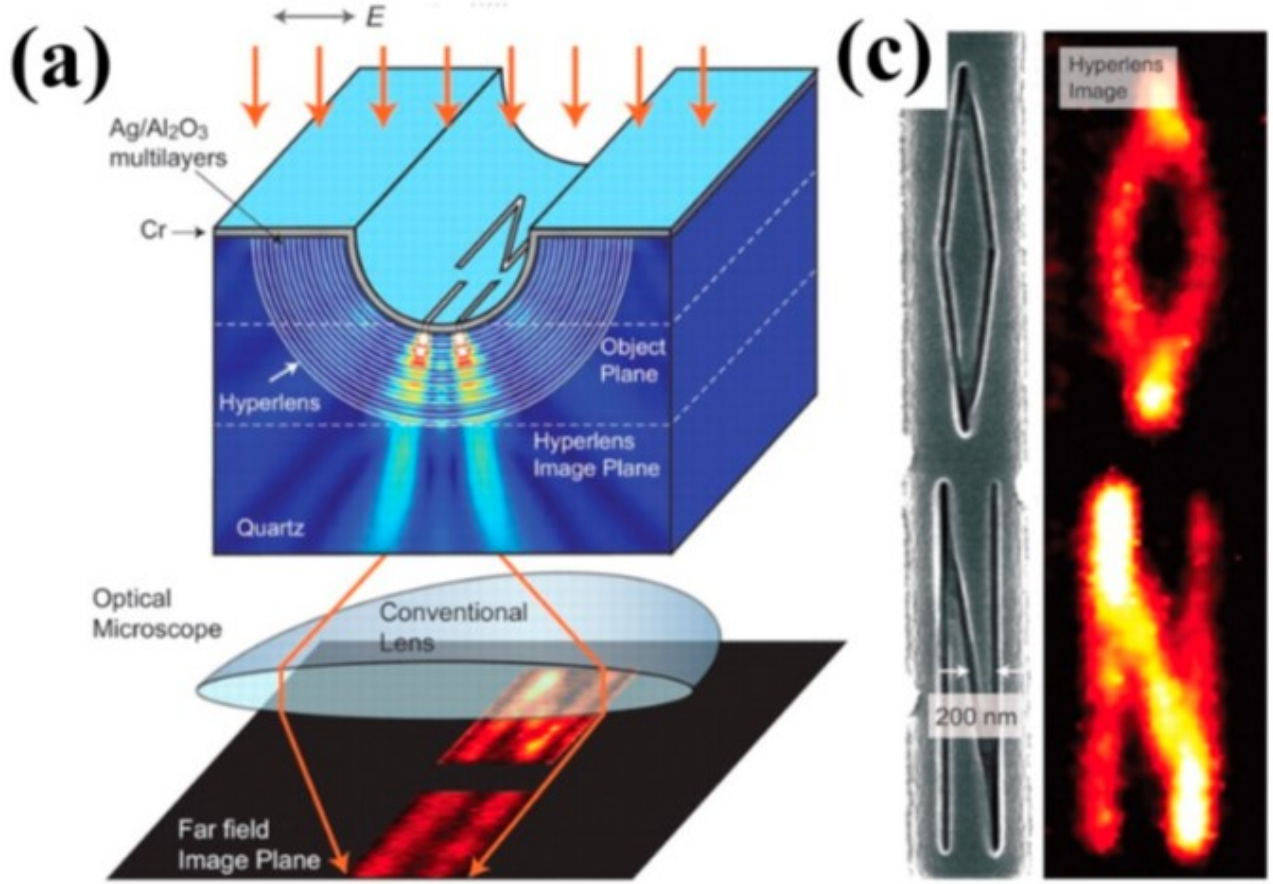
SUPERLENS/HYPERLENS

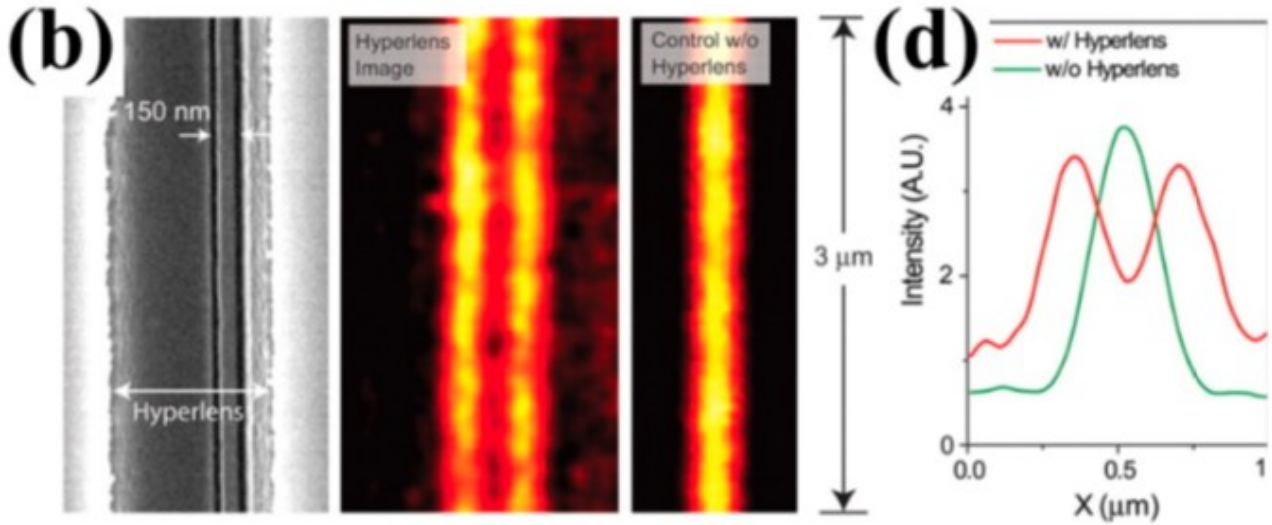

(a)
PR
Ag
PMMA
Quartz
Cr
365 nm Illumination

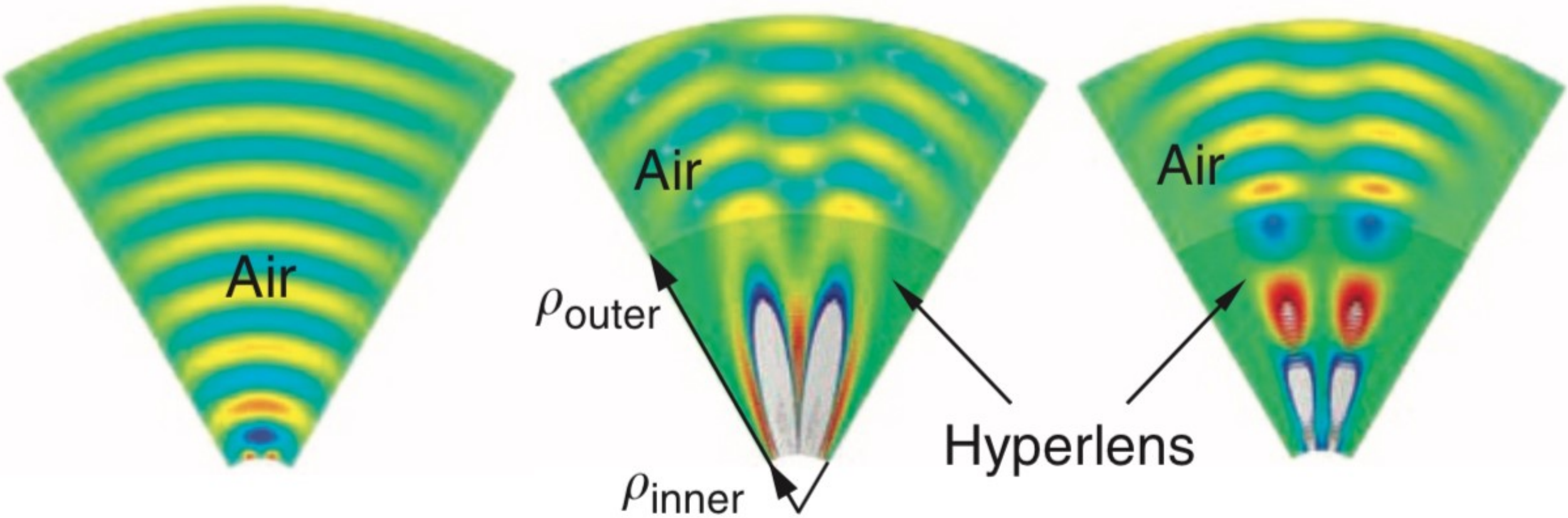

(b)

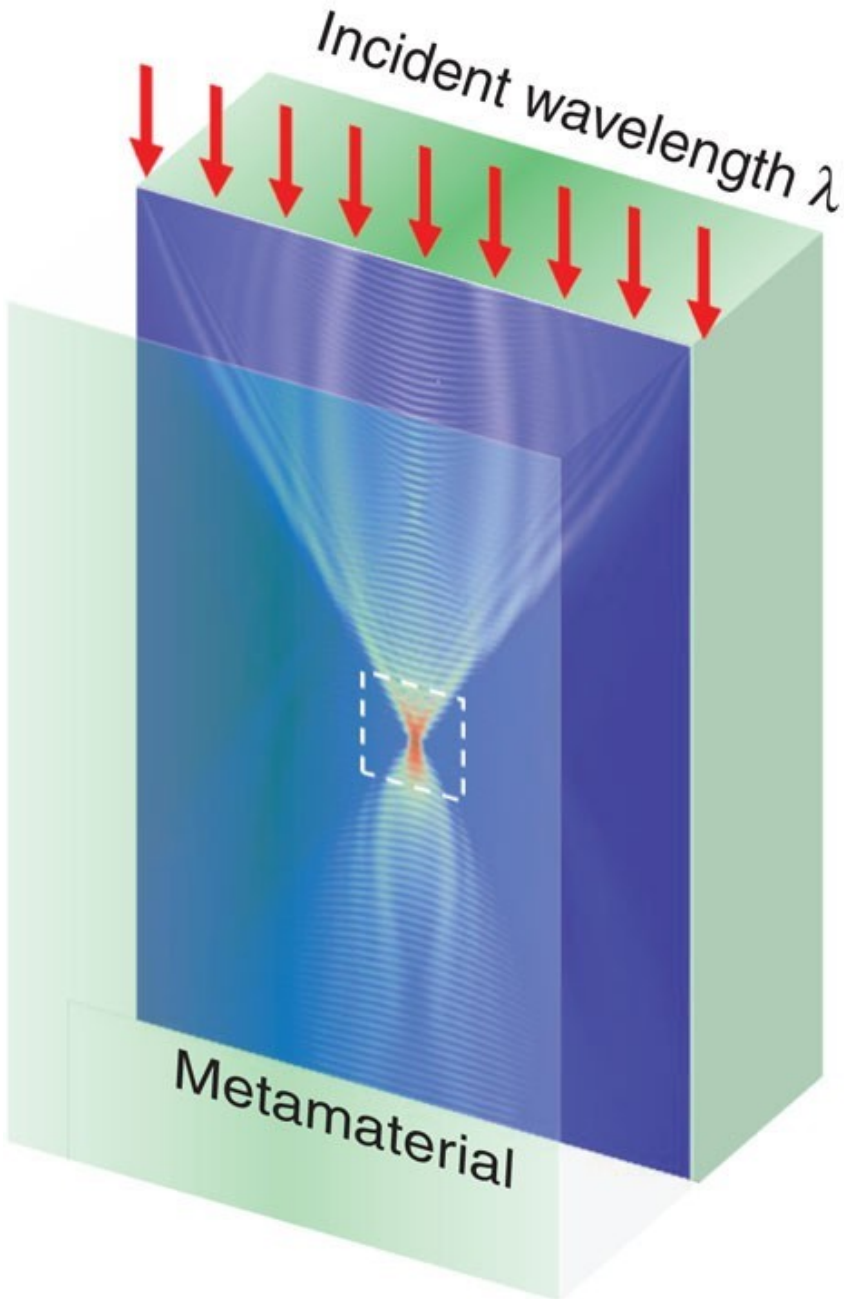

(c)

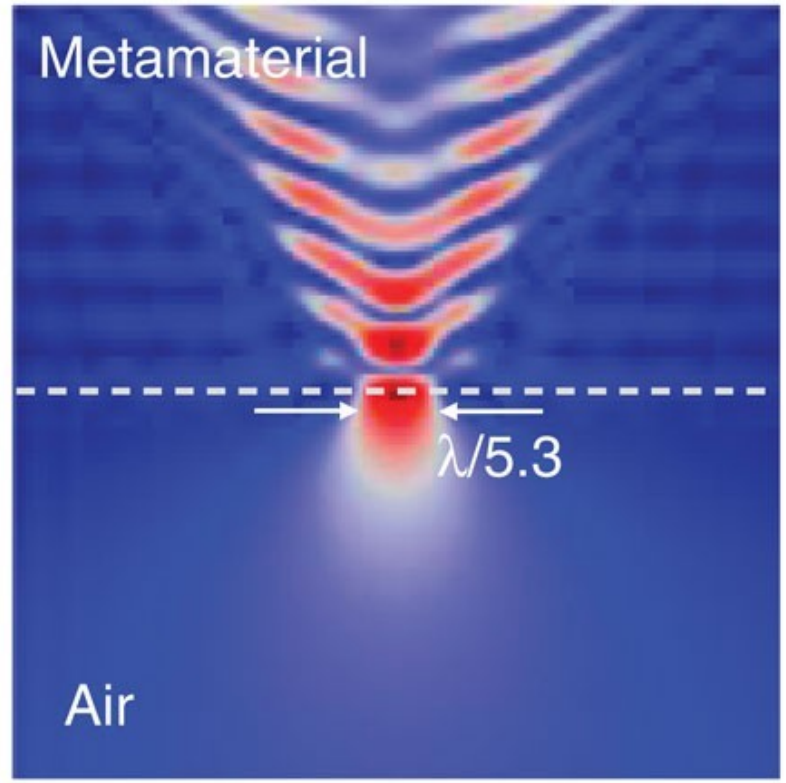

(d)

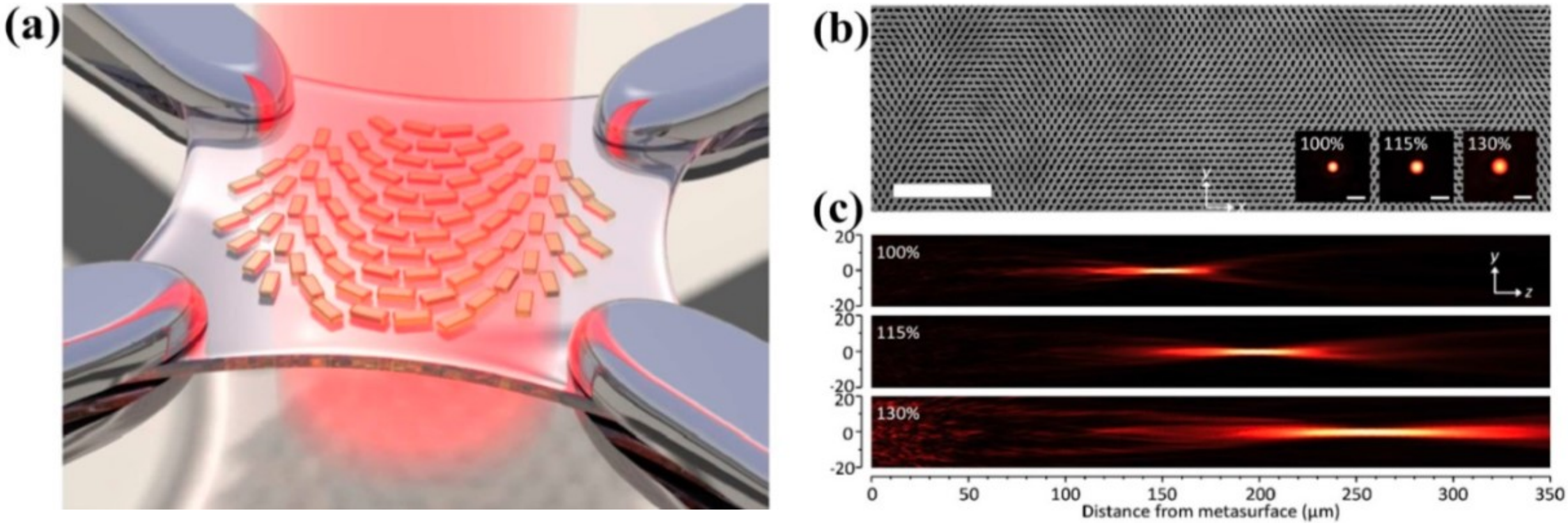

(a)
E
Ag/Al2O3 multilayers
Cr
Hyperlens
Object Plane
Hyperlens Image Plane
Quartz
Optical Microscope
Conventional Lens
Far field Image Plane
(c)
Hyperlens Image
200 nm


(b)
150 nm
Hyperlens
Hyperlens Image
Control w/o Hyperlens
3 μm
(d)
w/ Hyperlens
w/o Hyperlens
Intensity (A.U.)
X (μm)


Air
Air
Air
ρ_{outer}
ρ_{inner}
Hyperlens


Incident wavelength λ
Metamaterial


Metamaterial
λ/5.3
Air


(a)
(b)
100%
115%
130%
(c)
100%
115%
130%
20
0
-20
0
50
100
150
200
250
300
350
Distance from metasurface (μm)

微球超分辨成像

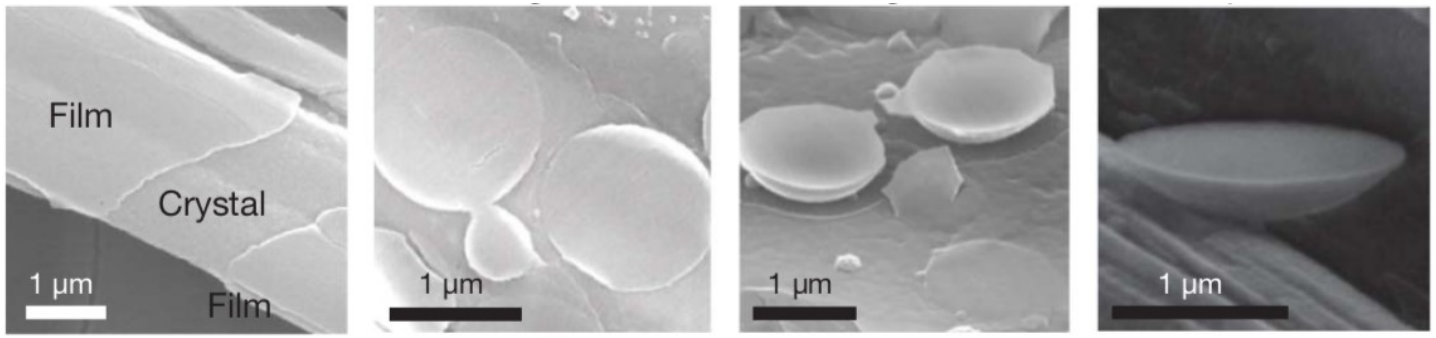
MICROSPHERE-ASSISTED MICROSCOPY

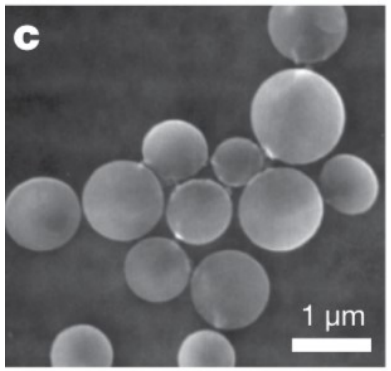
nature Vol 460|23 July 2009|doi:10.1038/nature08173

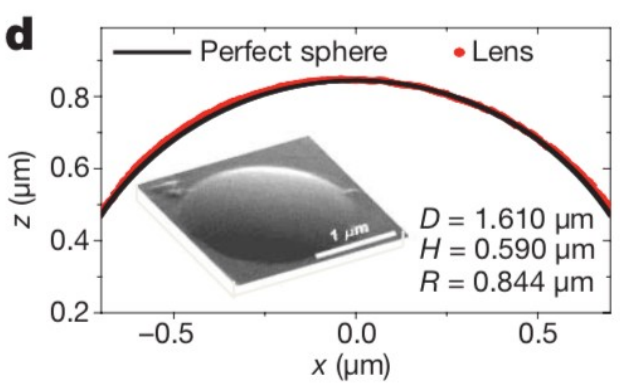
LETTERS

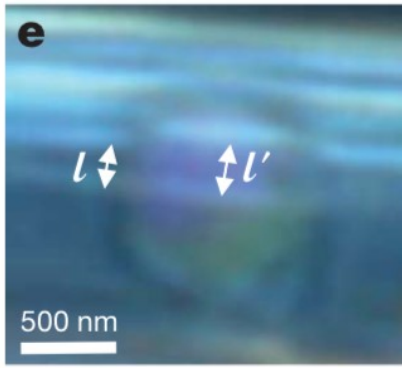
Near-field focusing and magnification through self-assembled nanoscale spherical lenses

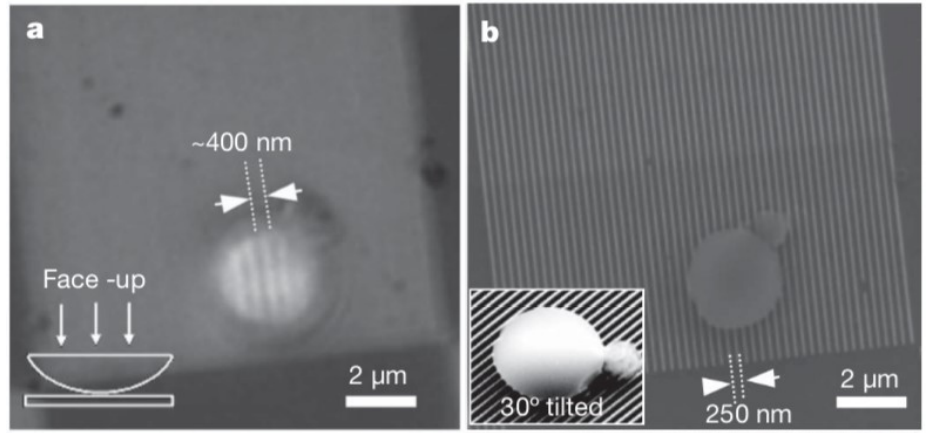
Ju Young Lee[1]*, Byung Hee Hong[1,2]*, Woo Youn Kim[1], Seung Kyu Min[1], Yukyung Kim[1], Mikhail V. Jouravlev[1], Ranojoy Bose[3], Keun Soo Kim[2], In-Chul Hwang[1], Laura J. Kaufman[4], Chee Wei Wong[3], Philip Kim[5] & Kwang S. Kim[1]

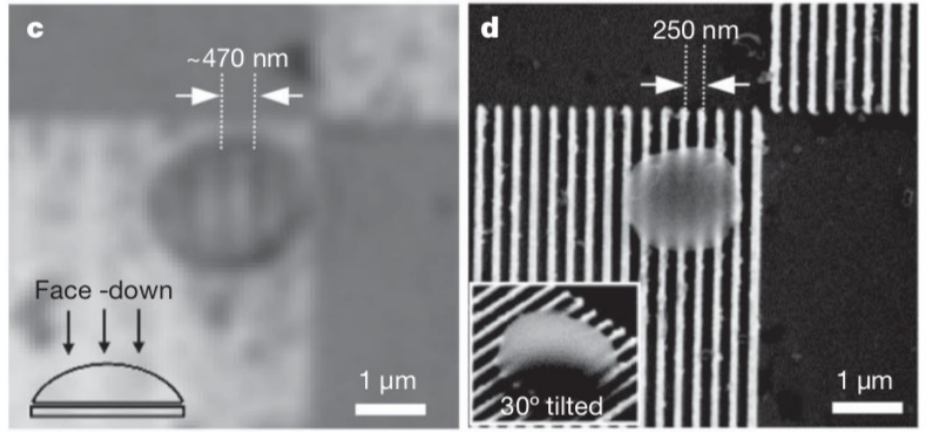


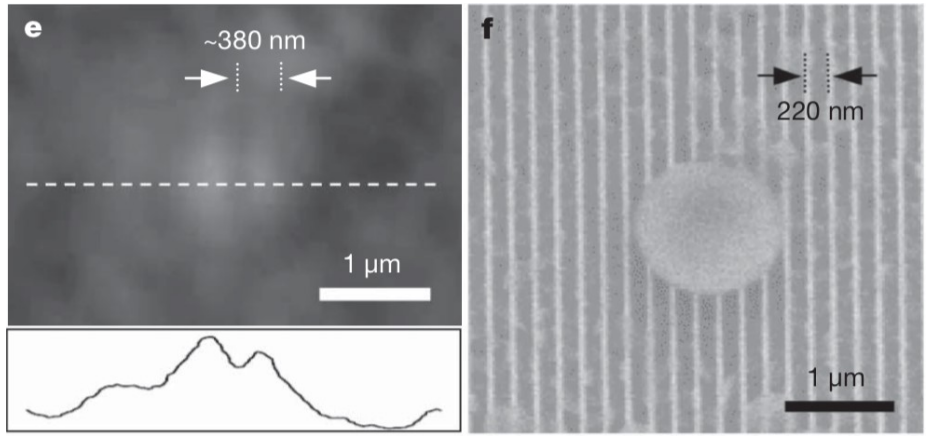












nature COMMUNICATIONS

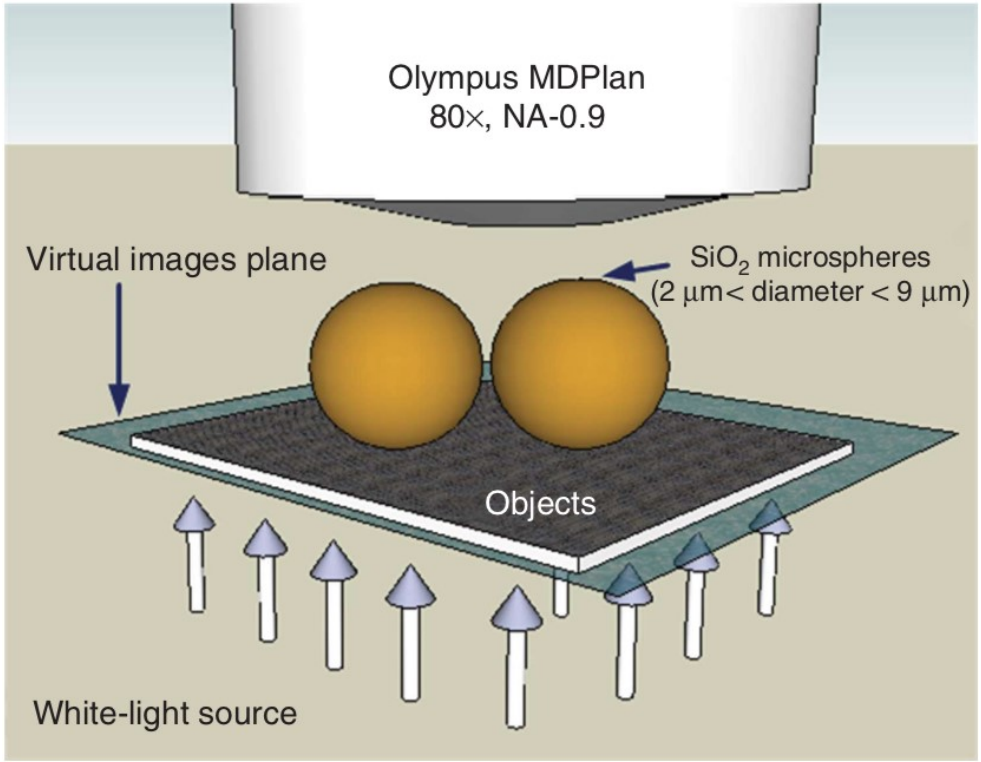
ARTICLE

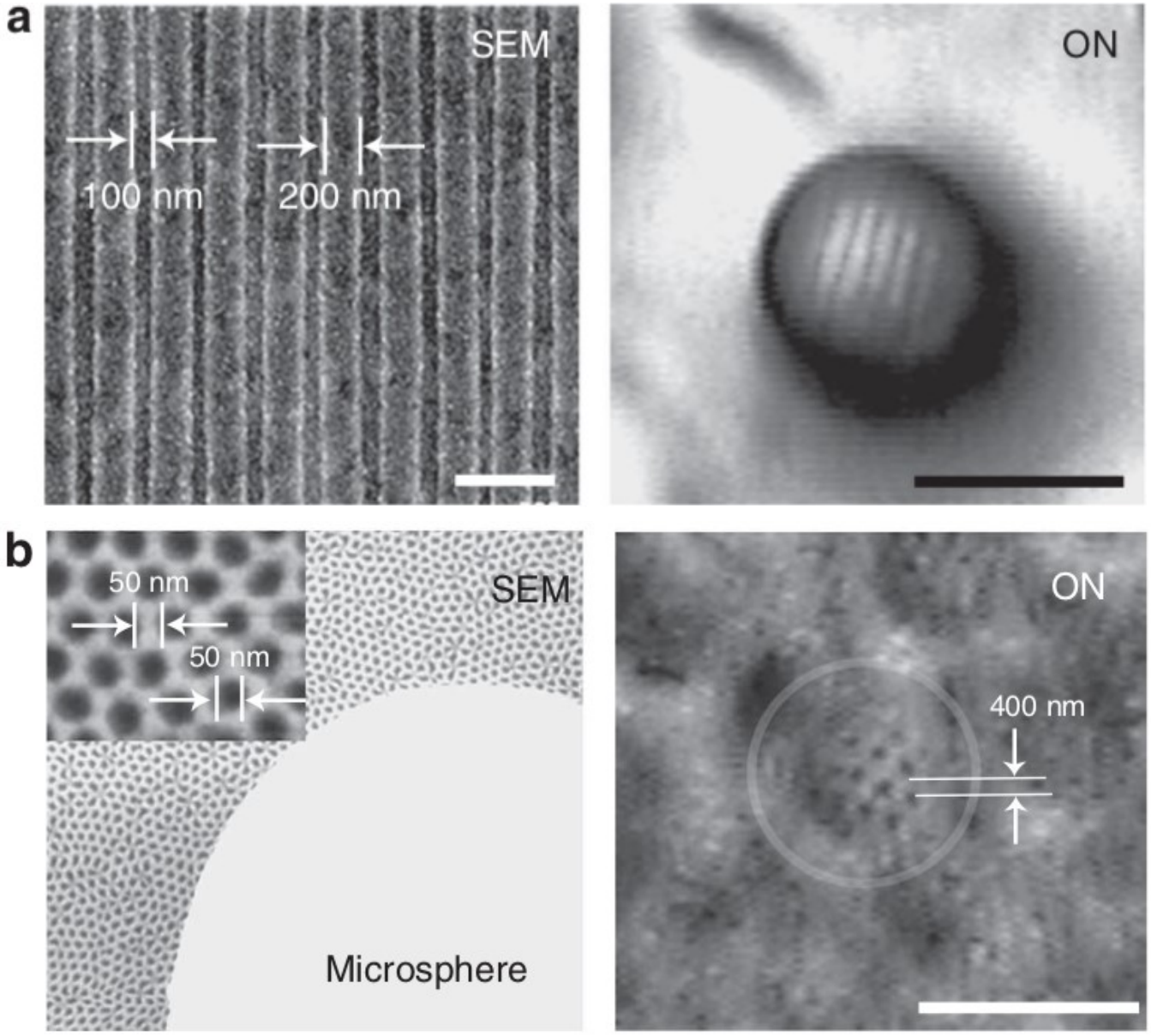
Received 16 Aug 2010 | Accepted 26 Jan 2011 | Published 1 Mar 2011

DOI: 10.1038/ncomms1211

Optical virtual imaging at 50 nm lateral resolution with a white-light nanoscope

Zengbo Wang[1], Wei Guo[1,2], Lin Li[1], Boris Luk'yanchuk[3], Ashfaq Khan[1], Zhu Liu[2], Zaichun Chen[3,4] & Minghui Hong[3,4]





APPLIED PHYSICS LETTERS **104**, 061117 (2014)

Advantages of microsphere-assisted super-resolution imaging technique over solid immersion lens and confocal microscopies

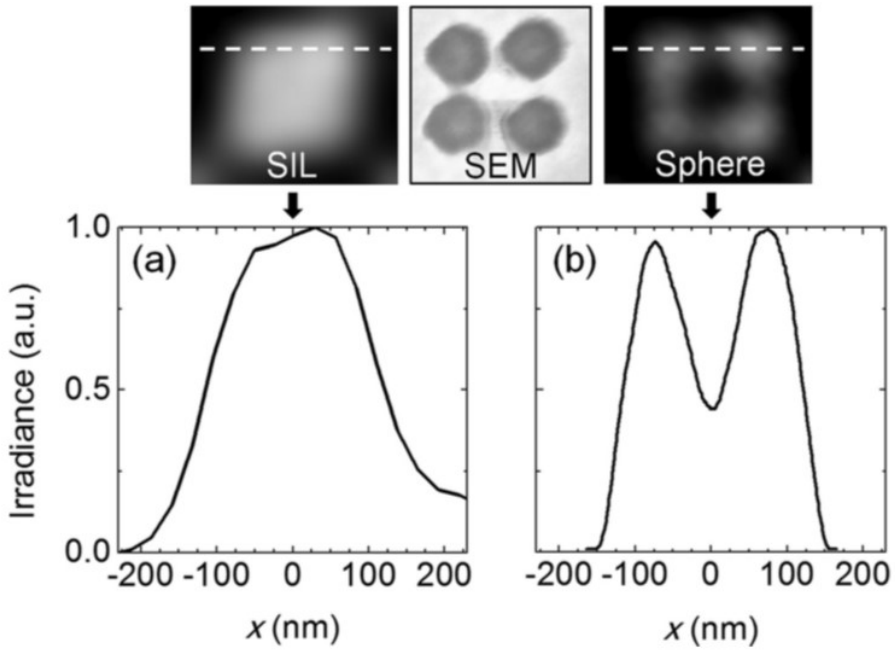
Arash Darafsheh,[1,a),b)] Nicholaos I. Limberopoulos,[2] John S. Derov,[2] Dennis E. Walker, Jr.,[2] and Vasily N. Astratov[1,2,c)]

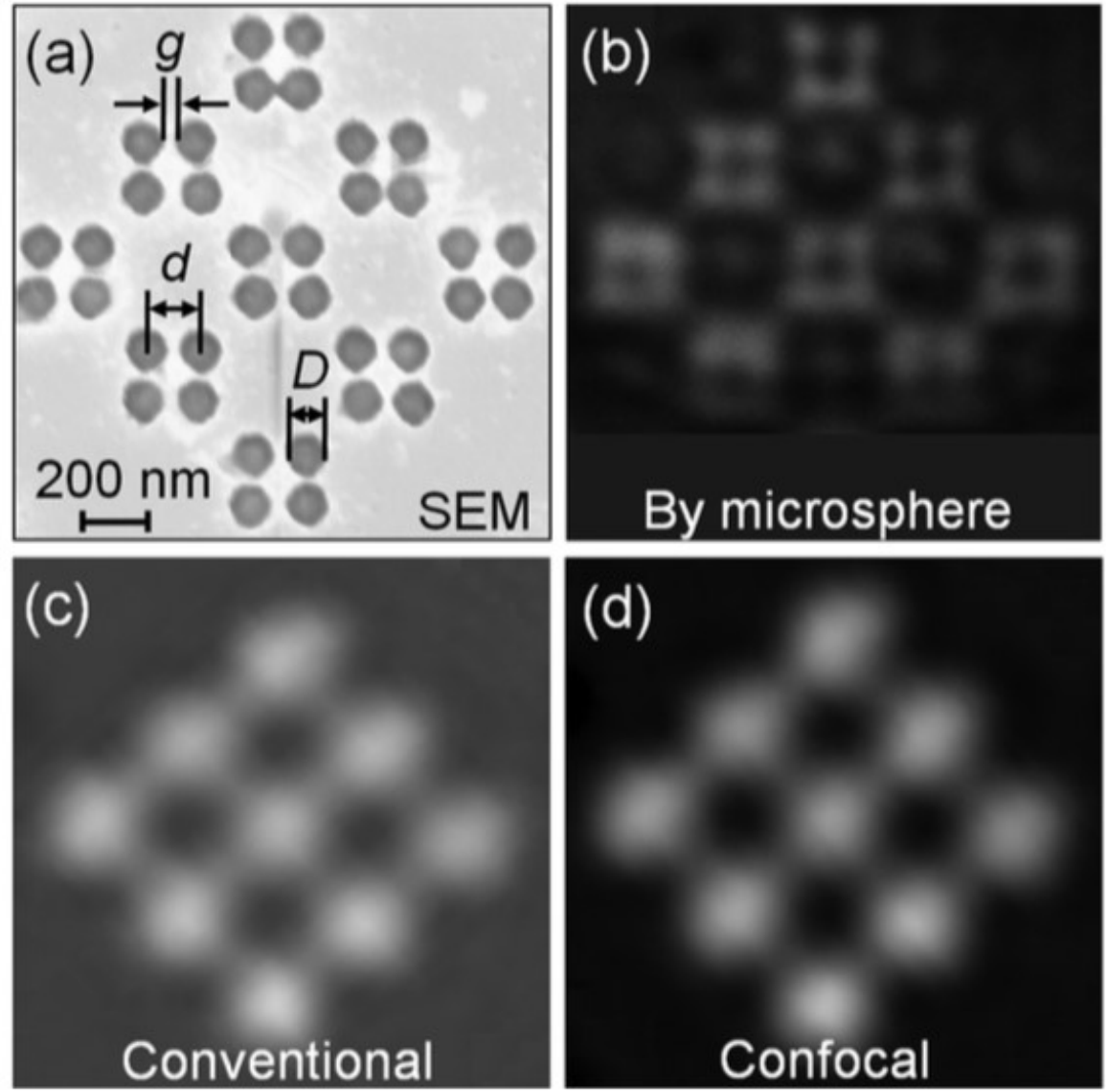
[1]*Department of Physics and Optical Science, Center for Optoelectronics and Optical Communications, University of North Carolina at Charlotte, Charlotte, North Carolina 28223-0001, USA*

[2]*Air Force Research Laboratory, Sensors Directorate, Wright Patterson AFB, Ohio 45433, USA*

(Received 28 October 2013; accepted 27 January 2014; published online 14 February 2014)

We demonstrate a series of advantages of microsphere-assisted imaging over confocal and solid immersion lens microscopies including intrinsic flexibility, better resolution, higher magnification, and longer working distances. We discerned minimal feature sizes of ~50-60 nm in nanoplasmonic arrays at the illumination wavelength $\lambda = 405$ nm. It is demonstrated that liquid-immersed, high-index ($n \sim 1.9$-2.1) spheres provide a superior image quality compared to that obtained by spheres with the same index contrast in an air environment. We estimate that using transparent microspheres at deep UV wavelengths of ~200 nm might make possible imaging of various nanostructures with extraordinary high ~30 nm resolution. © *2014 AIP Publishing LLC*.
[http://dx.doi.org/10.1063/1.4864760]





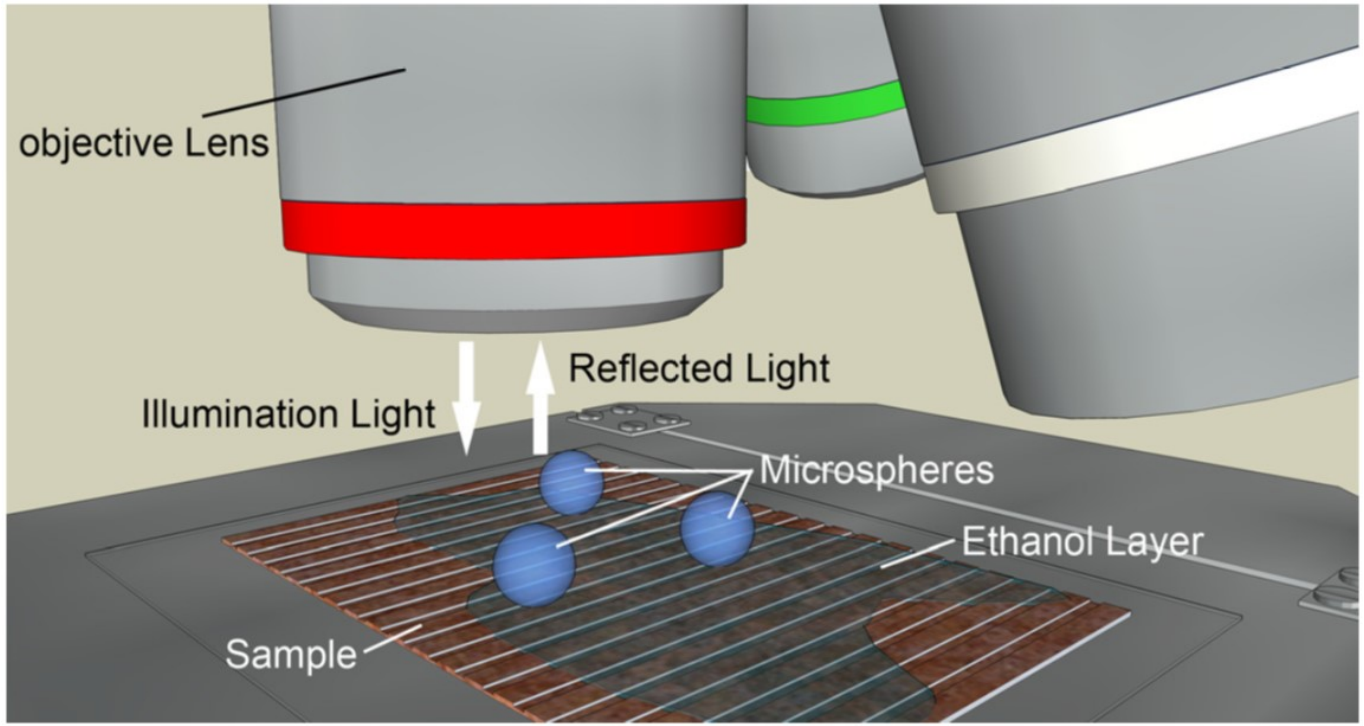
APPLIED PHYSICS LETTERS **99**, 203102 (2011)

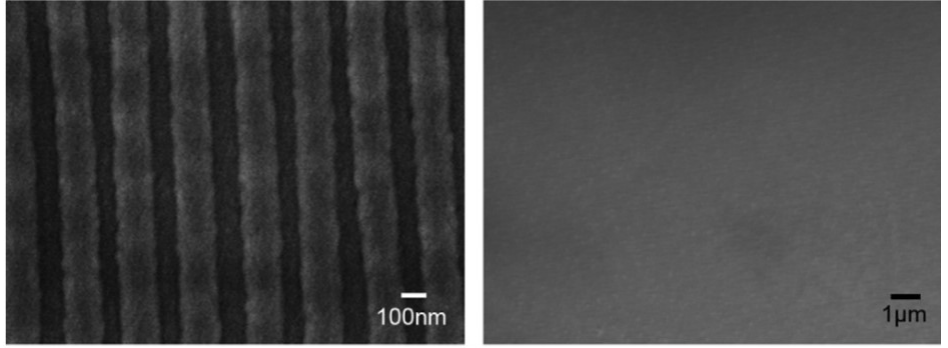
Microsphere based microscope with optical super-resolution capability

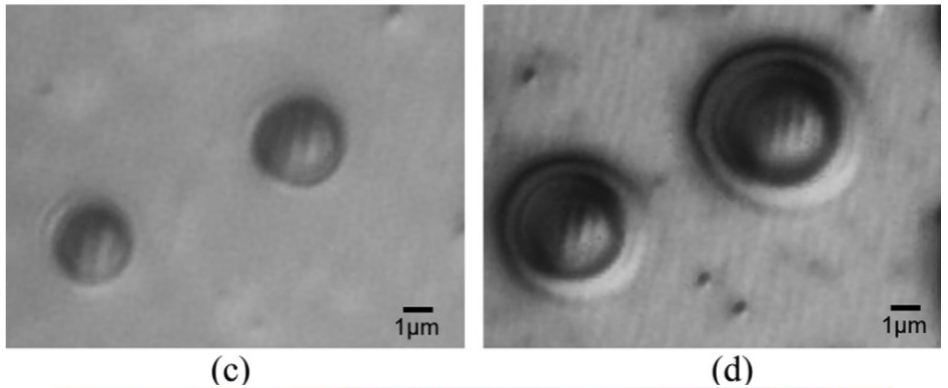
Xiang Hao, Cuifang Kuang, Xu Liu,[a)] Haijun Zhang, and Yanghui Li
Department of Optical Engineering, State Key Laboratory of Modern Optical Instrumentation, Zhejiang University, Hangzhou 310027, China

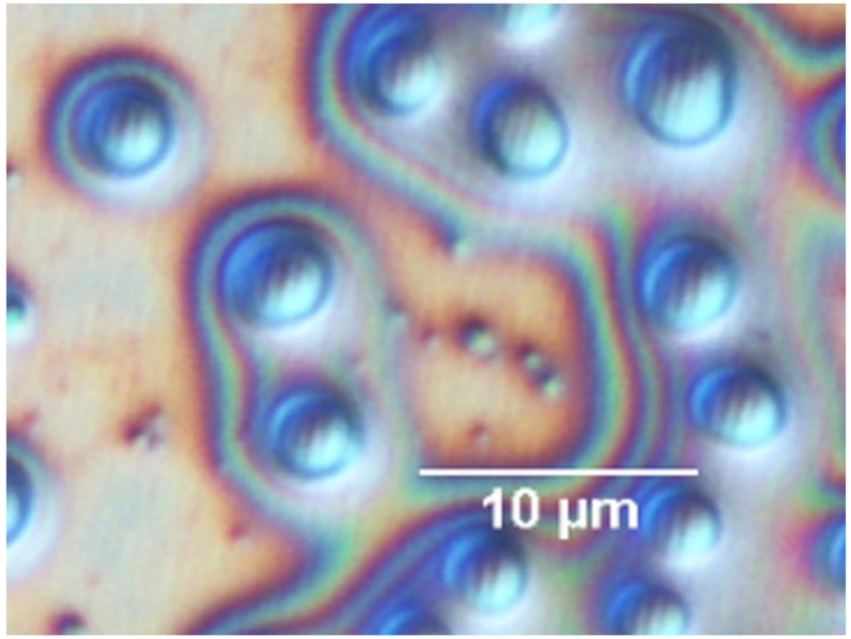
(Received 16 June 2011; accepted 21 October 2011; published online 14 November 2011)

We experimentally demonstrated that the microsphere can discern the details of the object whose sizes are below the conventional diffractive limit and such super-resolution capability can be reinforced if semi-immersing the corresponding microspheres in liquid droplet, producing a sharper contrast and a comparatively smaller magnification factor. The microsphere is considered as a channel that connects the near-field evanescent wave and the transmission one in far field. A conjecture based on this is proposed to explain the mechanism of super-resolution and the corresponding phenomenon. © *2011 American Institute of Physics*. [doi:10.1063/1.3662010]









Experimental far-field imaging properties of a ~5-μm diameter spherical lens

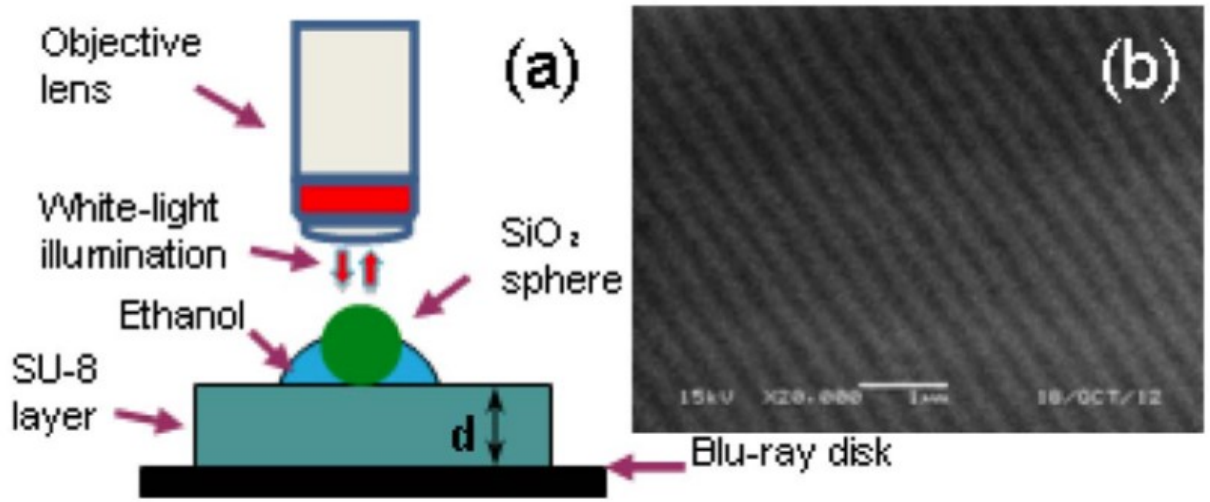
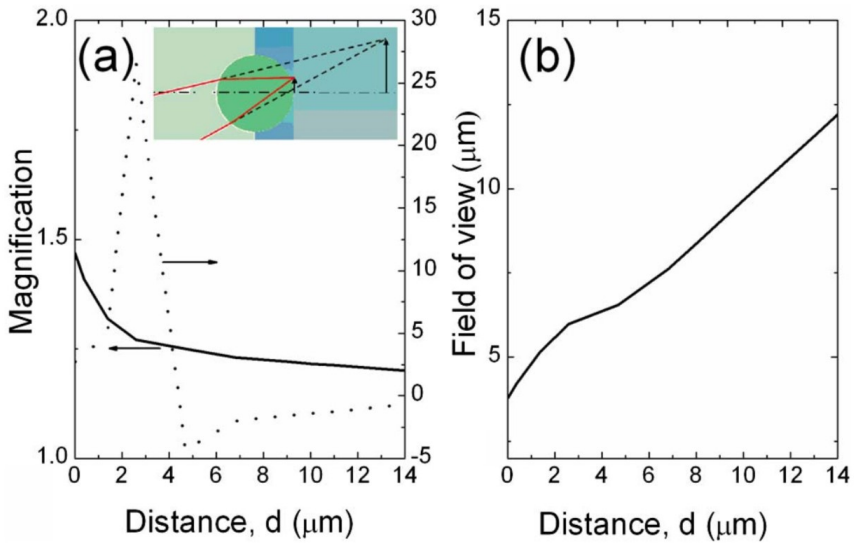
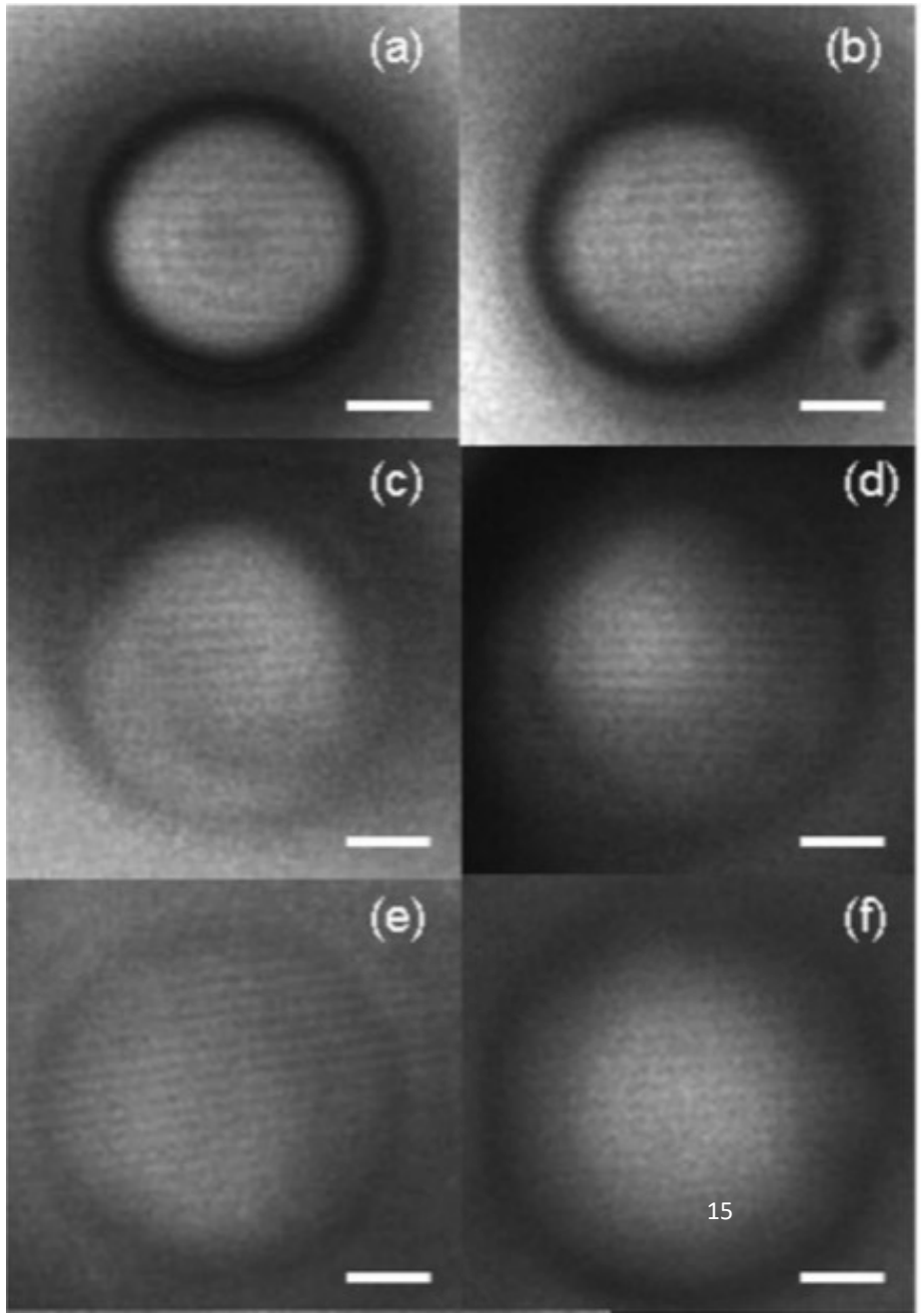


Fig. 1. (a) Schematic of the experimental setup and (b) SEM image of a blank blu-ray disc studied in this Letter.





IOP PUBLISHING NANOTECHNOLOGY

Nanotechnology **23** (2012) 285708 (9pp) doi:10.1088/0957-4484/23/28/285708

Wavelength-scale lens microscopy via thermal reshaping of colloidal particles

Alexandru Vlad, Isabelle Huynen and Sorin Melinte

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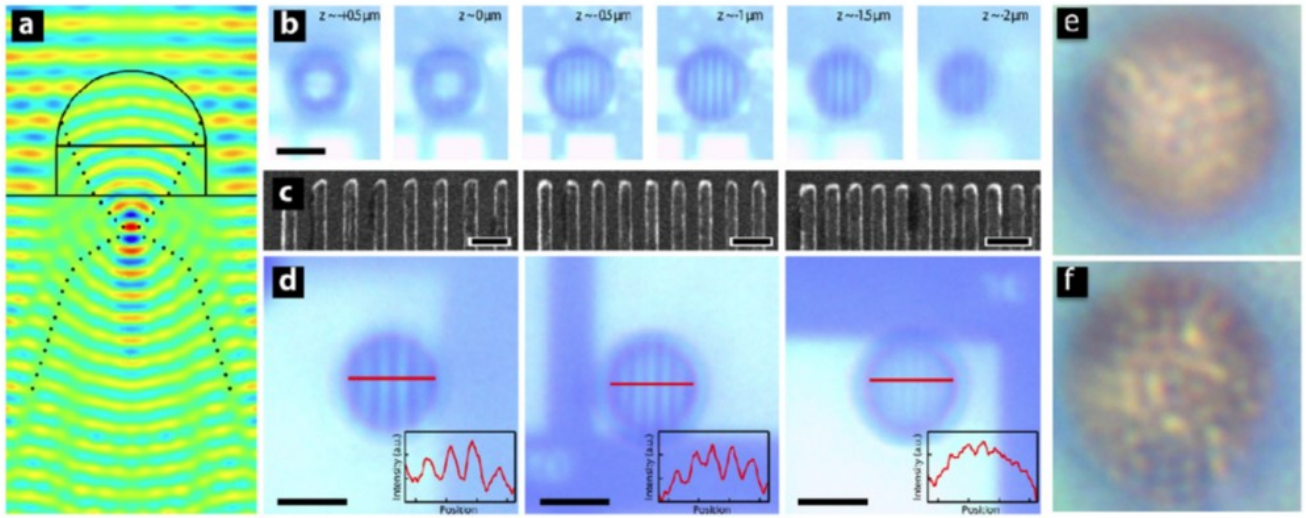
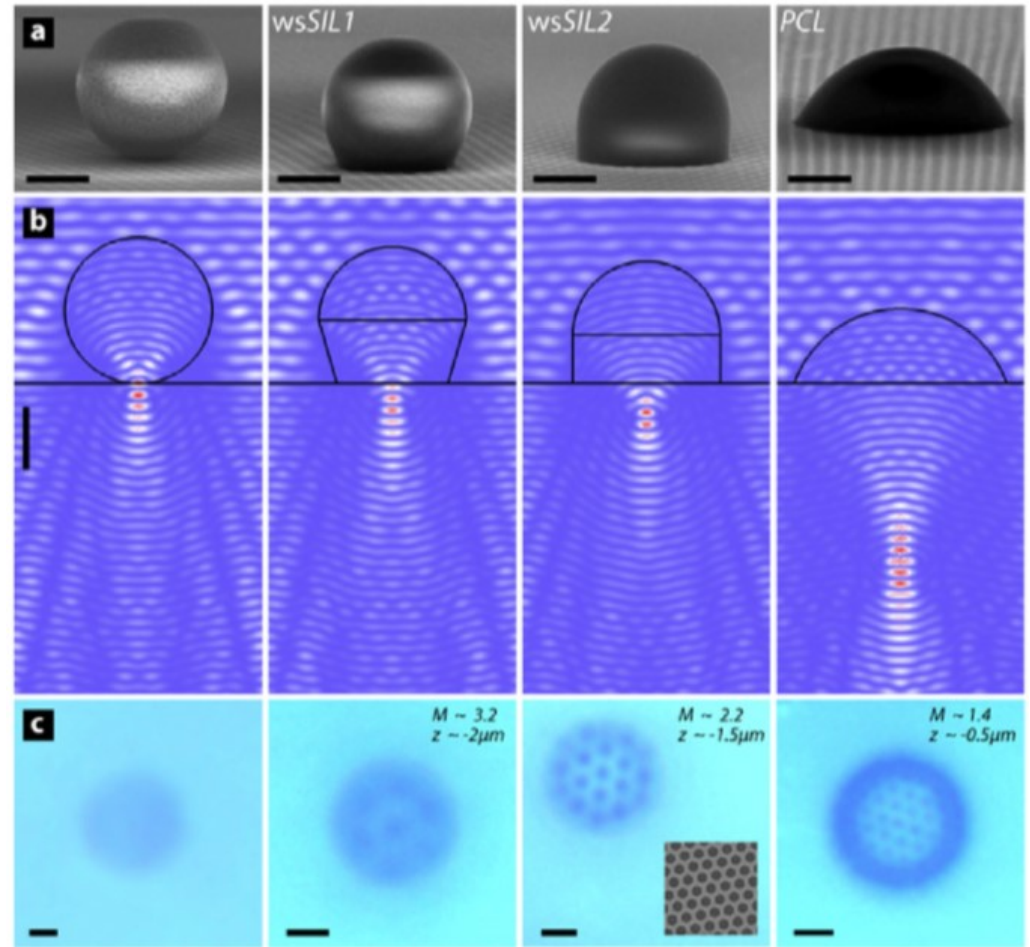


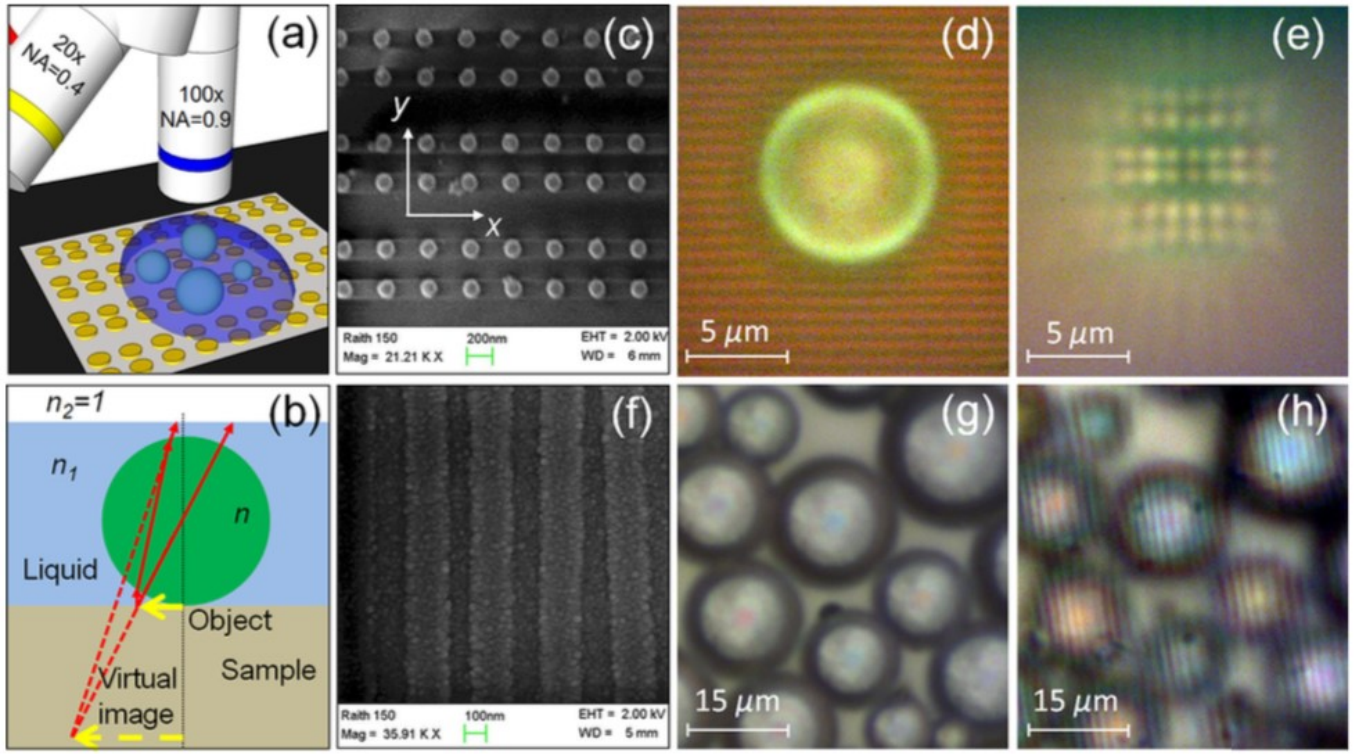
Figure 4. Optical properties of 2.4 μm ws*SIL*2s. (a) Simulated plot of the light propagation (electric field) through the lens. The dotted black curve is a guide to the eye and delimits the optical beam trajectory through the lens. Row (b): the curvilinear wavefront normal is confirmed experimentally, as the first magnified image appears spontaneously upon gradually changing the imaged plane. Scale bar: 2 μm. Row (c): SEM snapshots of the linear arrays used to test the imaging. The lines are ~90 nm wide with various spacings. Scale bars: 200 nm. Row (d): magnified optical images of line patterns with 240, 210 and 180 nm periods. Insets: intensity profiles in the optical microscopy images, showing the pincushion distortion and the decreasing step-edge intensity ratio for size shrinkage. Scale bars: 2 μm. ((e), (f)) Evidence for higher resolution imaging by resolving 170 nm point objects.



APPLIED PHYSICS LETTERS **101**, 141128 (2012)

Optical super-resolution by high-index liquid-immersed microspheres

Arash Darafsheh,[1,a)] Gary F. Walsh,[2,3] Luca Dal Negro,[2] and Vasily N. Astratov[1,b)]
[1]*Department of Physics and Optical Science, Center for Optoelectronics and Optical Communications, University of North Carolina at Charlotte, Charlotte, North Carolina 28223-0001, USA*
[2]*Department of Electrical and Computer Engineering & Photonic Center, Boston University, 8 Saint Mary's Street, Boston, Massachusetts 02215, USA*
[3]*U.S. Army NSRDEC, Nanomaterials Science Team, Kansas Street, Natick, Massachusetts 01760, USA*



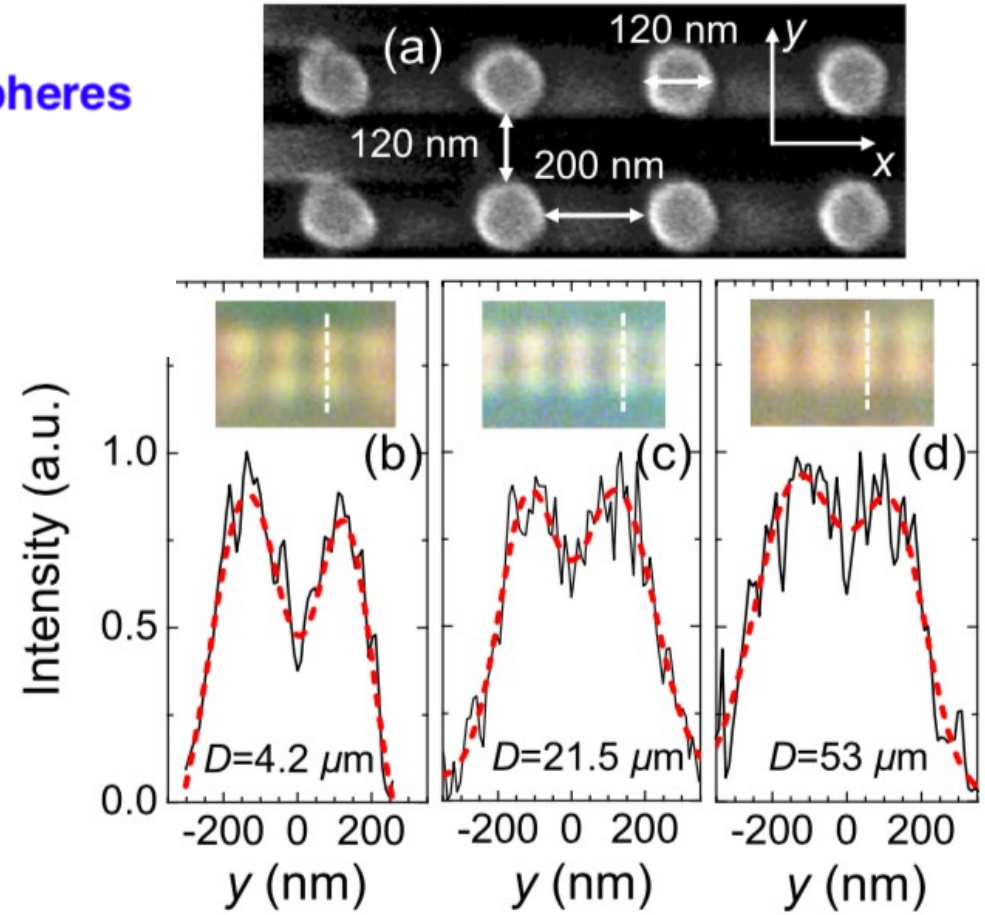


FIG. 3. (a) SEM image of an array of gold NPDs formed by 120 nm nanoparticles with 120 nm separations and resolving power of BTG microspheres with $n \sim 1.9$ and different diameters D: (b) $-4.2\,\mu$m, (c) $-21.5\,\mu$m, and (c) $-53\,\mu$m. Insets show the optical microscope images obtained in (b)–(d) cases corresponding to SEM image in (a).

RAPID RESEARCH LETTER

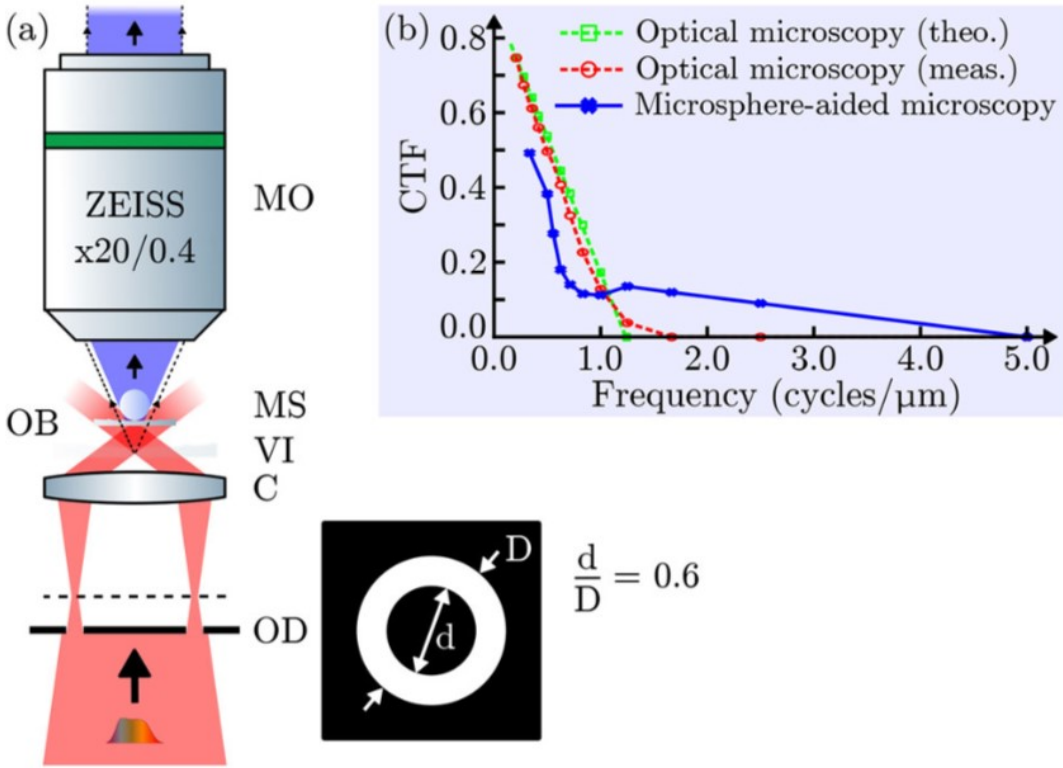
Green Photonics

Phys. Status Solidi RRL **2019**, *13*, 1800445

www.pss-rapid.com

Transmission Microsphere-Assisted Dark-Field Microscopy

Stephane Perrin, Hongyu Li, Keshia Badu, Thomas Comparon, Giorgio Quaranta, Nadia Messaddeq, Nicolas Lemercier, Paul Montgomery, Jean-Luc Vonesch, and Sylvain Lecler*



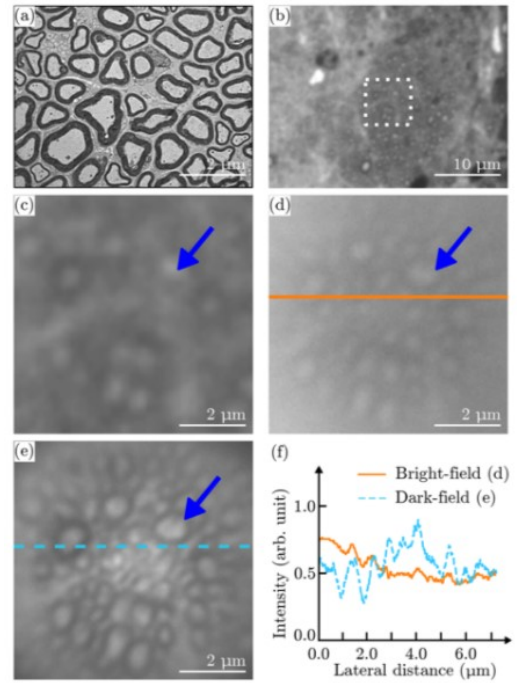


Figure 3. Dark-field super-resolution microscopy for the imaging of mouse brain cells. Direct images of myelinated nerve fibers using (a) transmission electron microscopy, (b) bright-field conventional microscopy, (c) zoom-in view of (b), (d) bright-field nanoscopy, and (e) dark-field nanoscopy. Arrows help for location. f) Intensity profiles of (d) and (e) along the transverse axis.

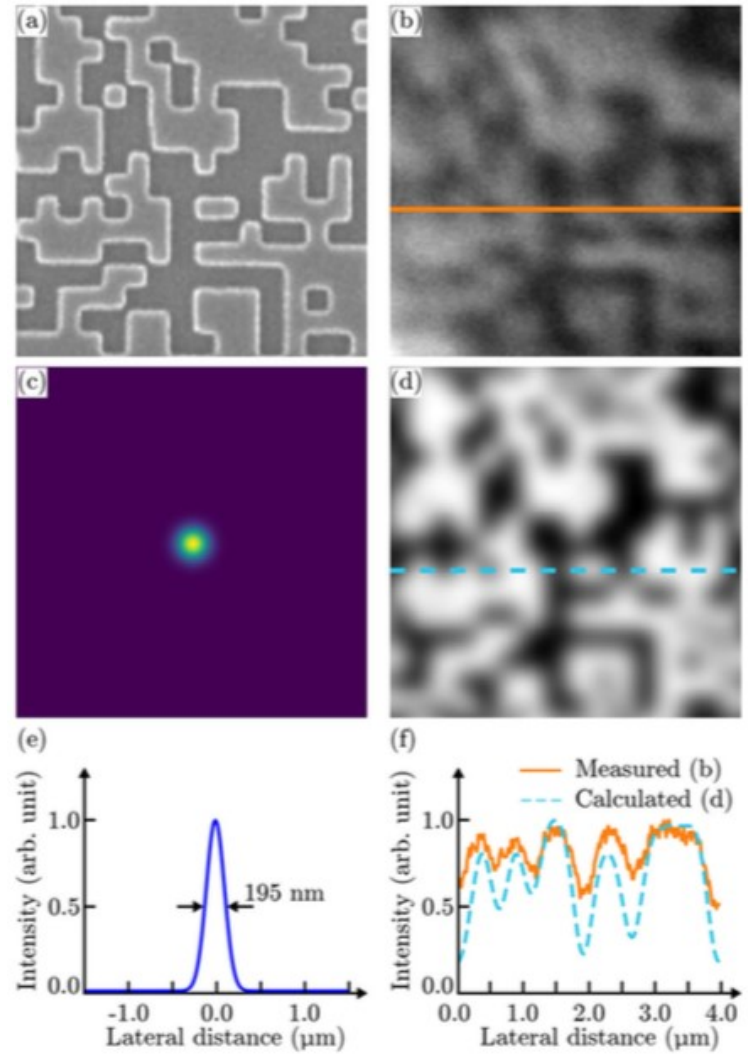


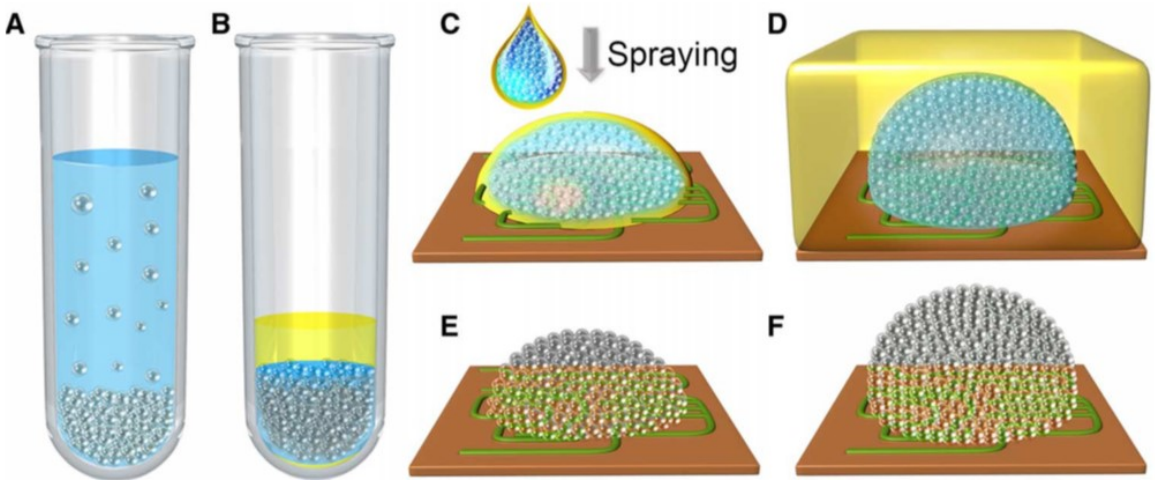
Figure 2. Dark-field super-resolution microscopy for the imaging of transparent 250 nm of side squares. Direct images of the glass nanoimprint squares using (a) SEM and (b) microsphere-assisted microscopy. The soda-lime microsphere diameter is 25 µm. c) Estimated 2D point spread function (PSF) of the microsphere-based nanoscope using a Gaussian approximation. d) Calculated image of the sample using the 2D convolution of the object model and PSF. e) Intensity profile of PSF. f) Intensity distribution of (b) and (d) along the transverse axis.

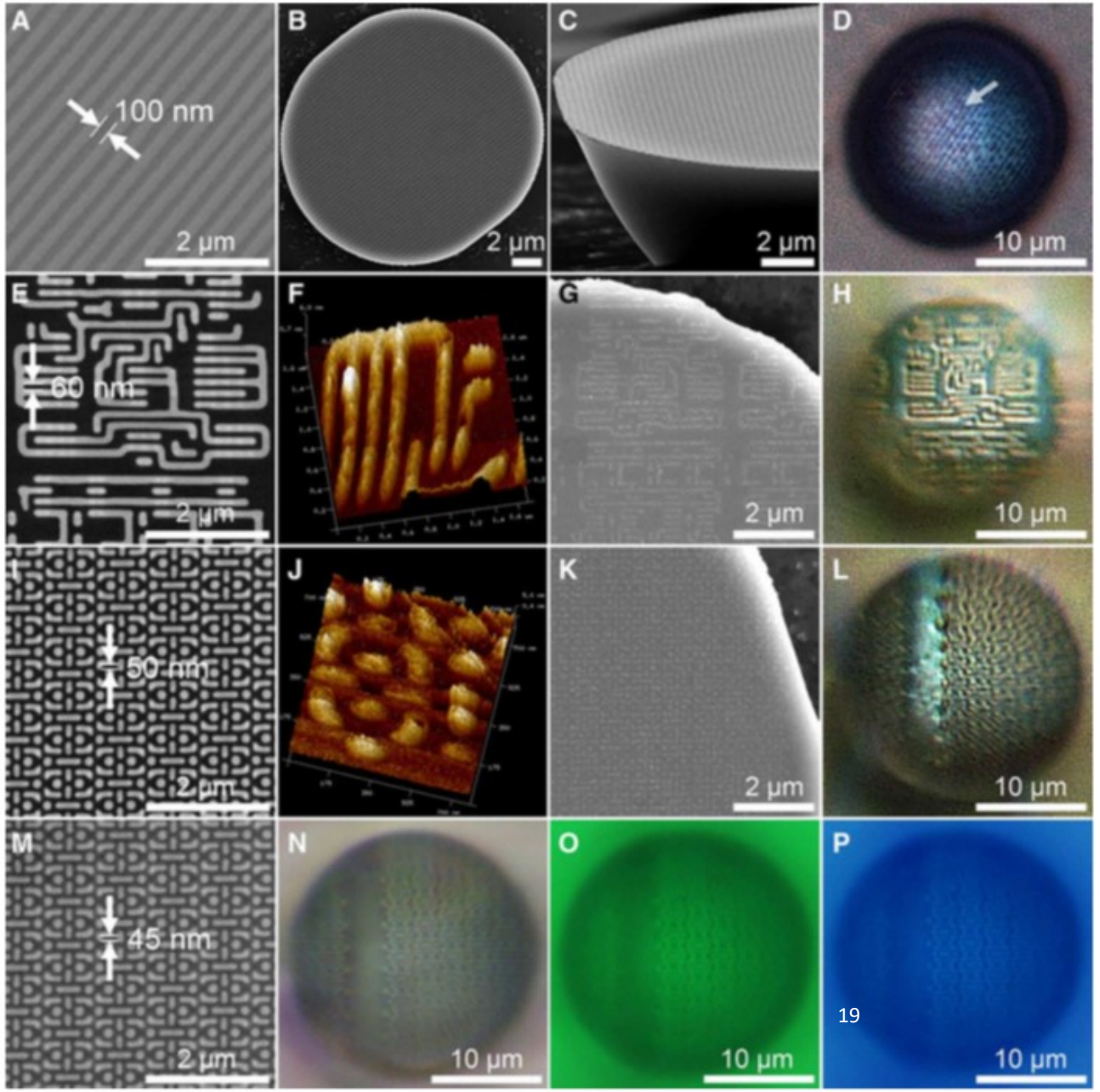
RESEARCH ARTICLE

MATERIALS SCIENCE Fan *et al.* Sci. Adv. 2016;2:e1600901

Three-dimensional all-dielectric metamaterial solid immersion lens for subwavelength imaging at visible frequencies

Wen Fan,[1] Bing Yan,[2] Zengbo Wang,[2]* Limin Wu[1]*





PHOTONICS Research

Subwavelength imaging and detection using adjustable and movable droplet microlenses

Xixi Chen,[1] Tianli Wu,[1] Zhiyong Gong,[1] Yuchao Li,[1,2] Yao Zhang,[1,3] and Baojun Li[1]

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[2]e-mail: liyuchao@jnu.edu.cn
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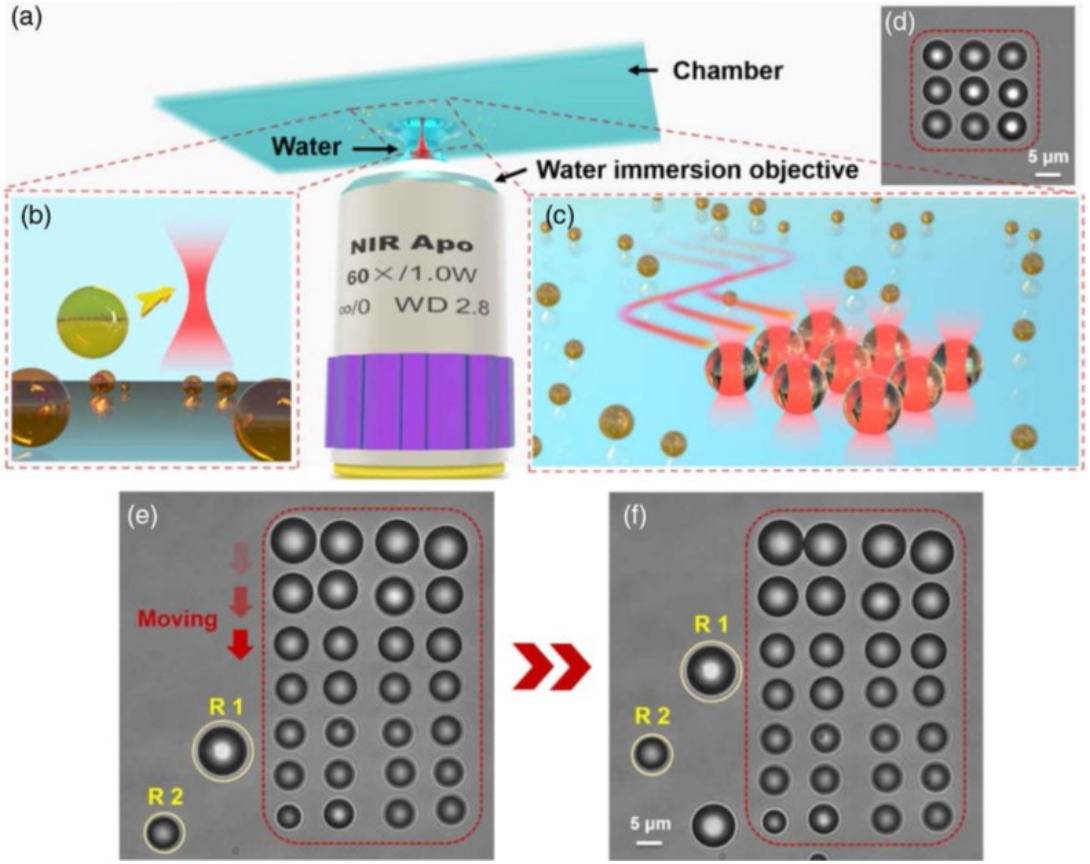

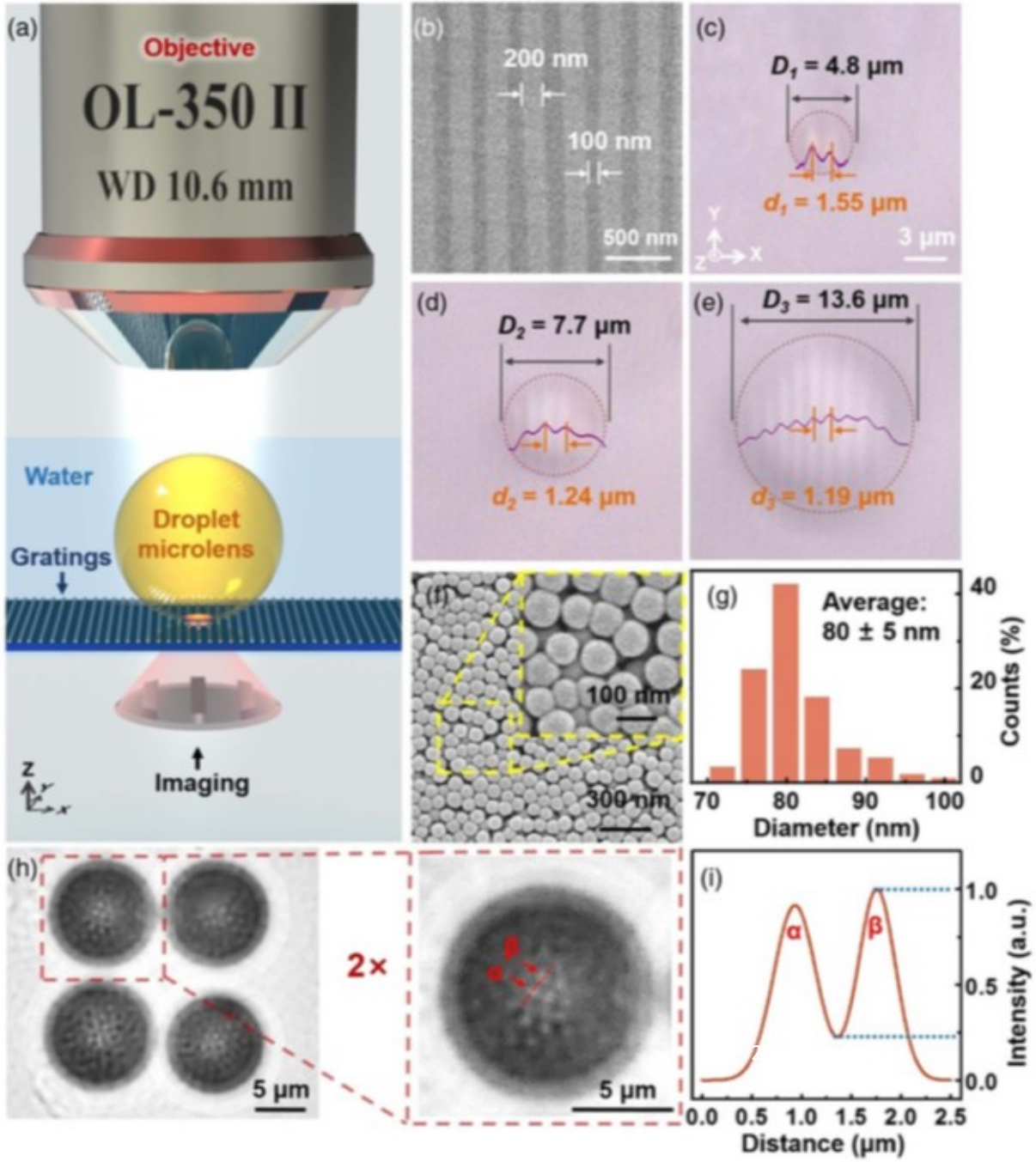

NANO LETTERS

Letter

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Spider Silk: Mother Nature's Bio-Superlens

James N. Monks,[†] Bing Yan,[†] Nicholas Hawkins,[‡] Fritz Vollrath,[‡] and Zengbo Wang*[,†]

[†]School of Electronic Engineering, Bangor University, LL57 1UT, Bangor, United Kingdom

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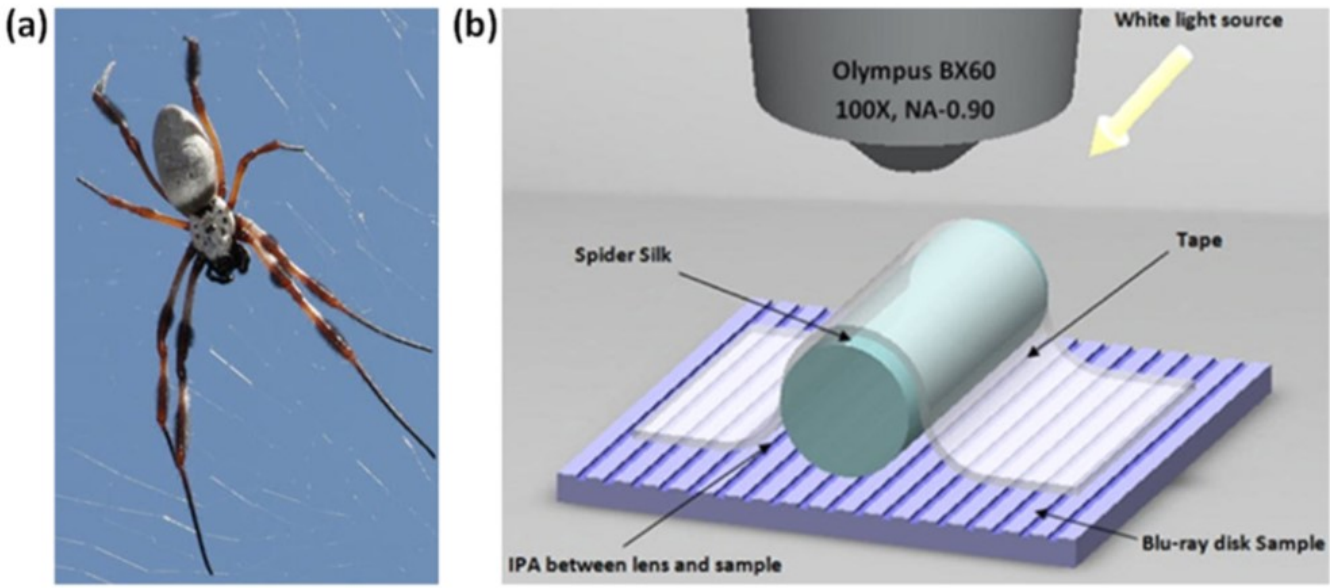

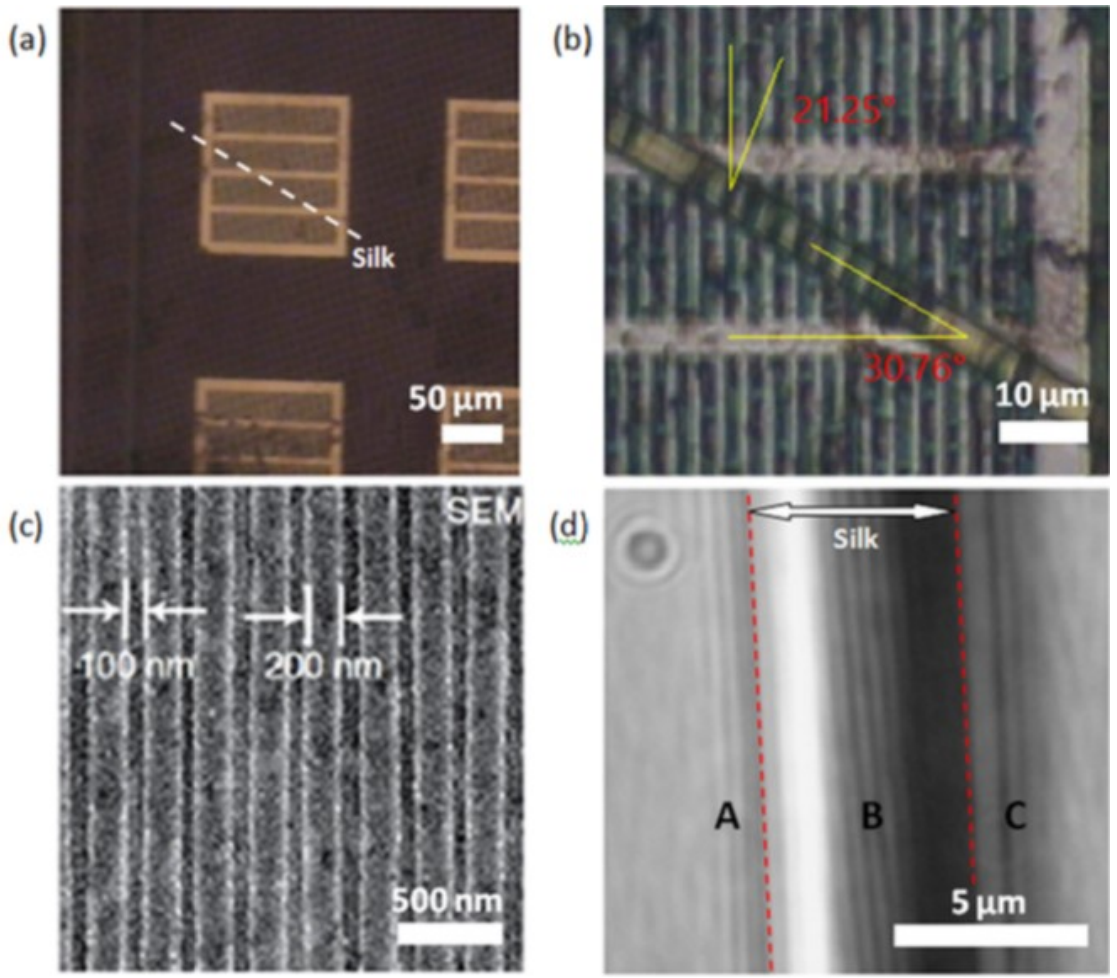

January 1, 2015 / Vol. 40, No. 1 / OPTICS LETTERS

Optical super-resolution imaging by high-index microspheres embedded in elastomers

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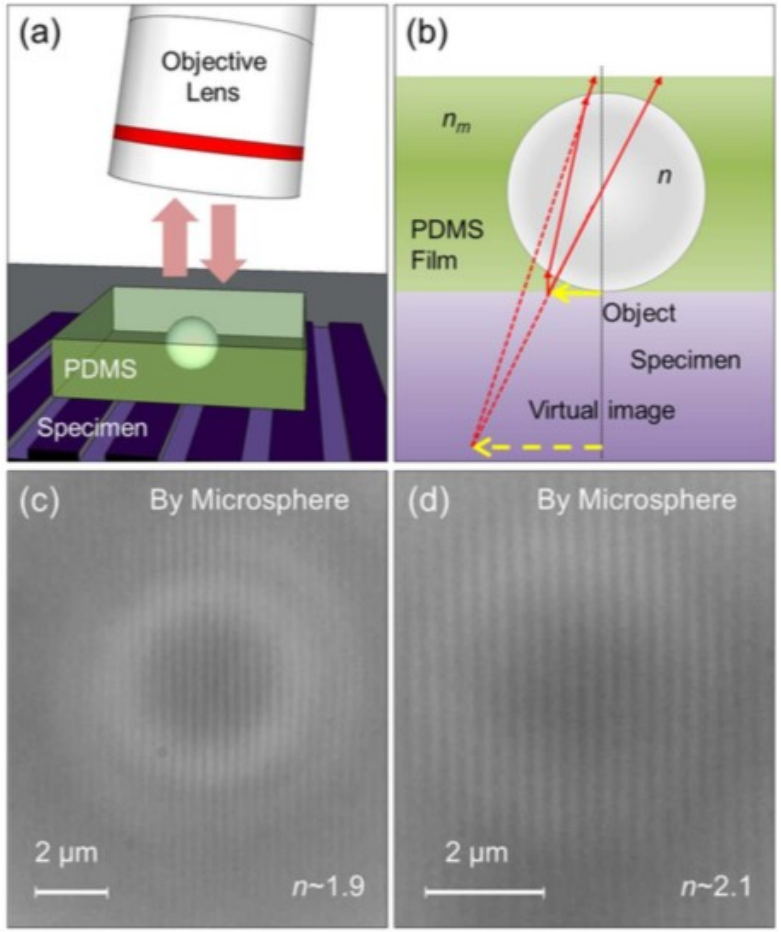

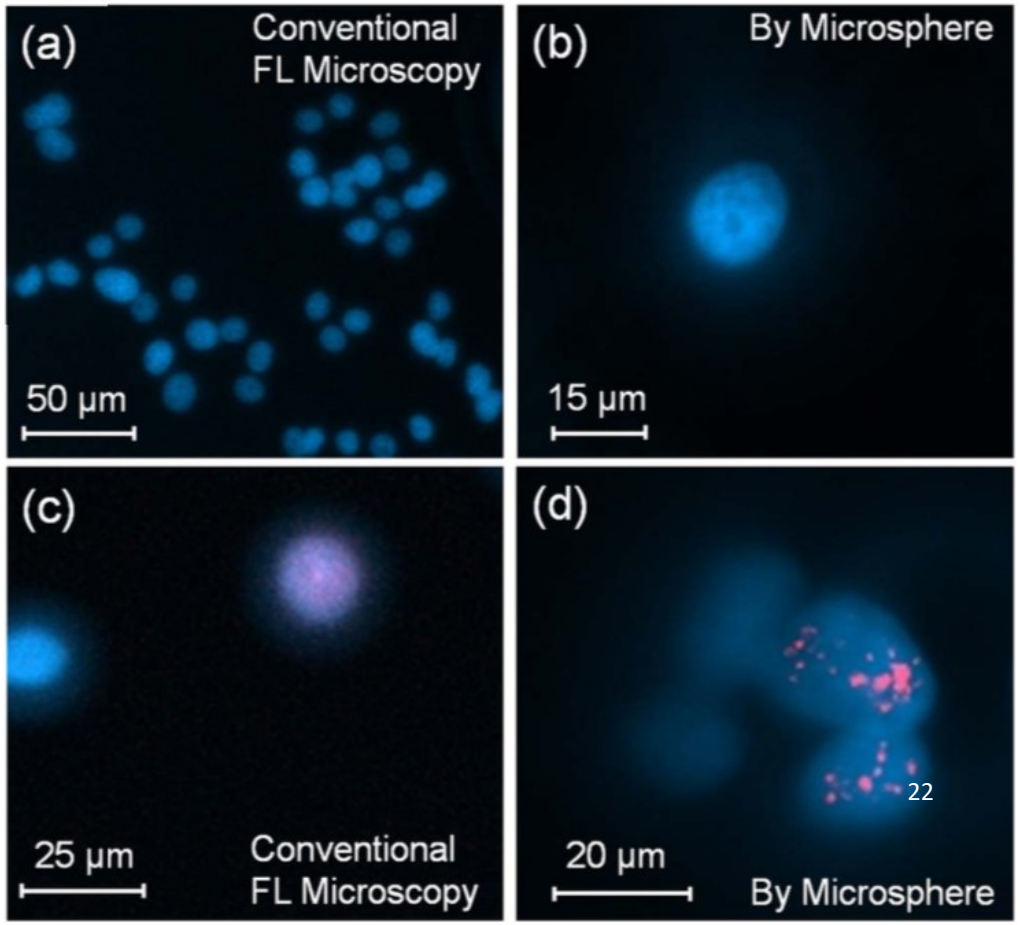

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Microsphere-Coupled Scanning Laser Confocal Nanoscope for Sub-Diffraction-Limited Imaging at 25 nm Lateral Resolution in the Visible Spectrum

Yinzhou Yan,[†,‡] Lin Li,[†,*] Chao Feng,[‡] Wei Guo,[†] Seoungjun Lee,[†] and Minghui Hong[§]

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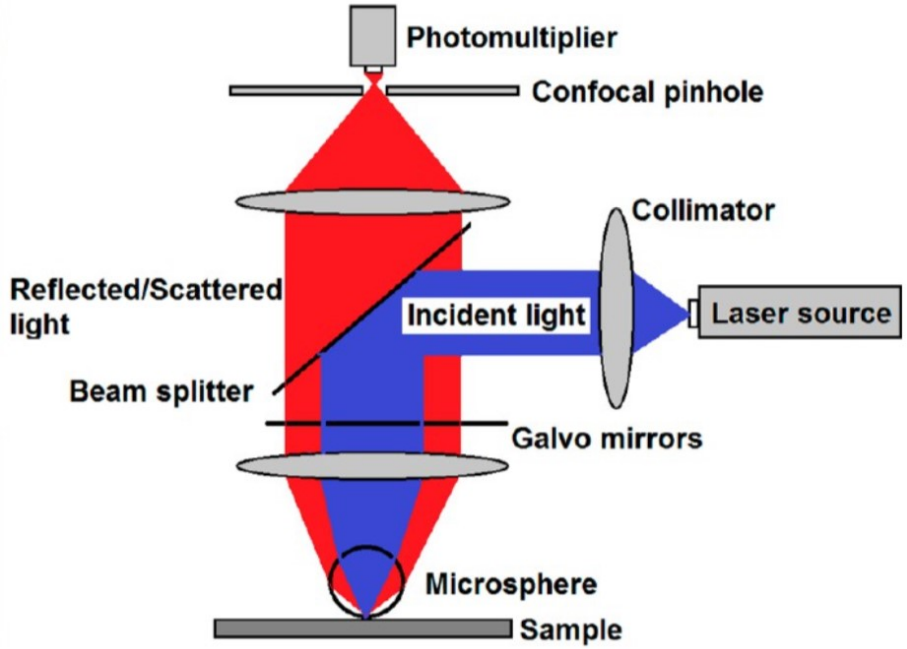

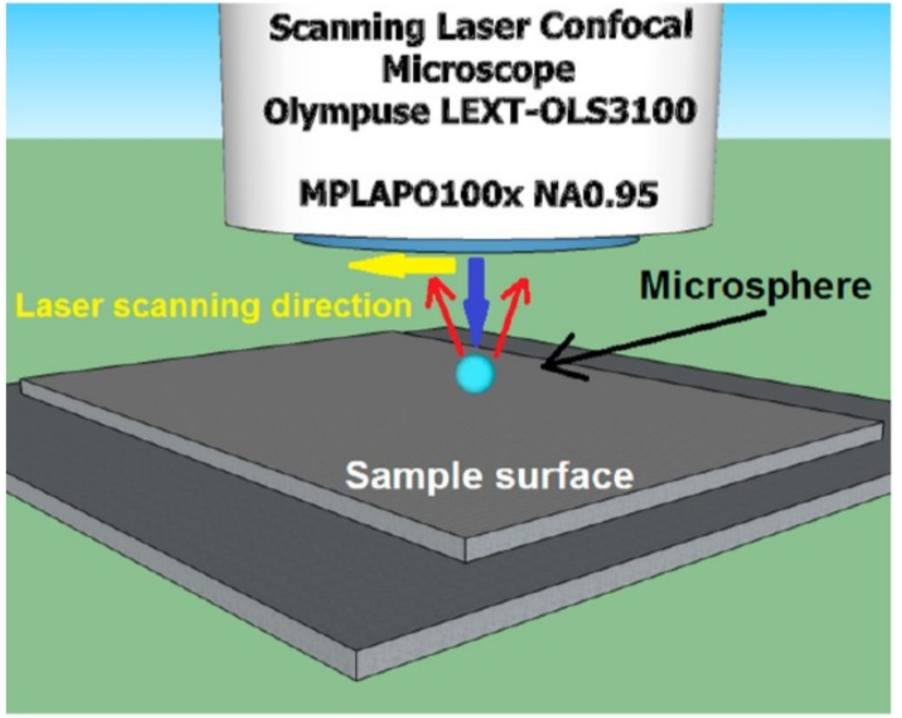

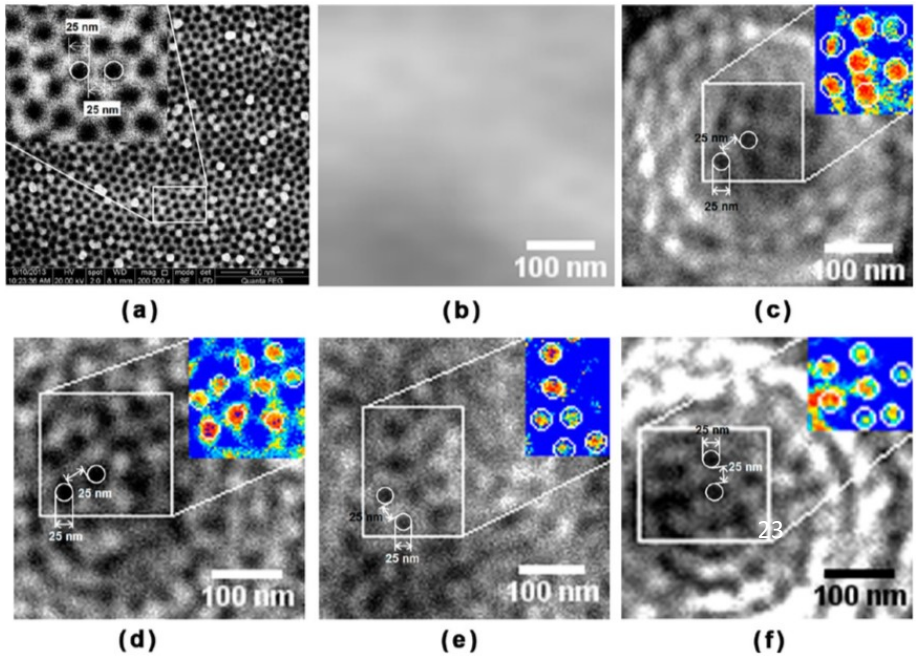

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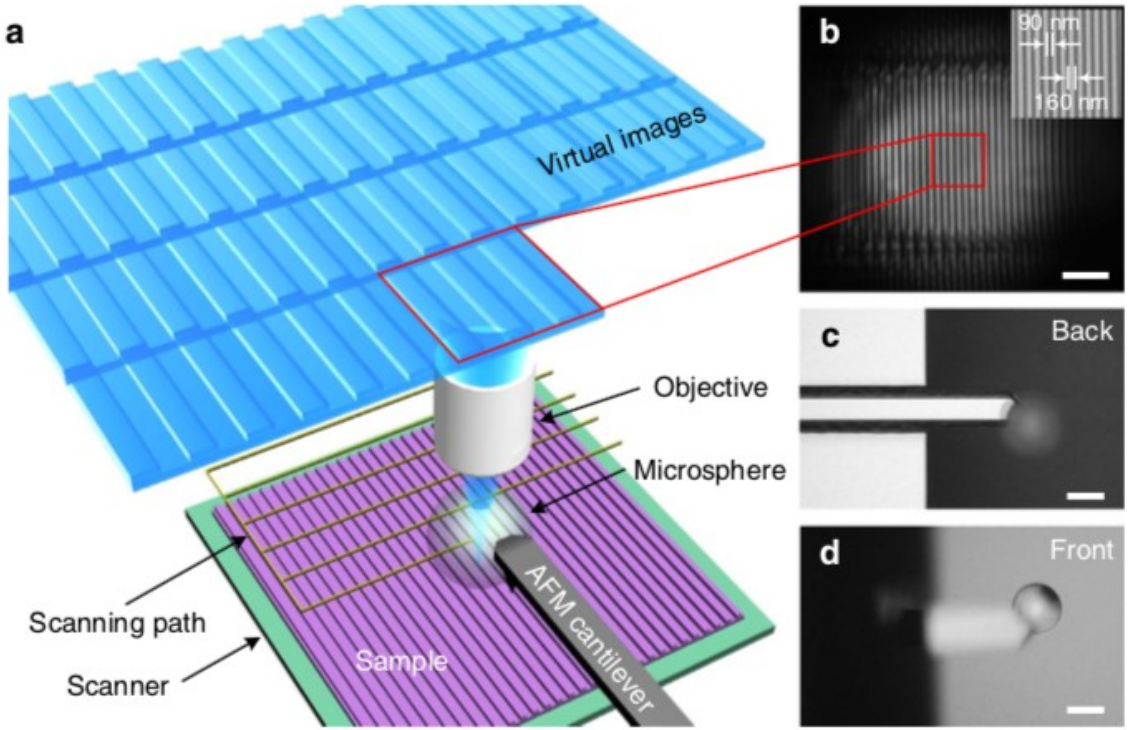
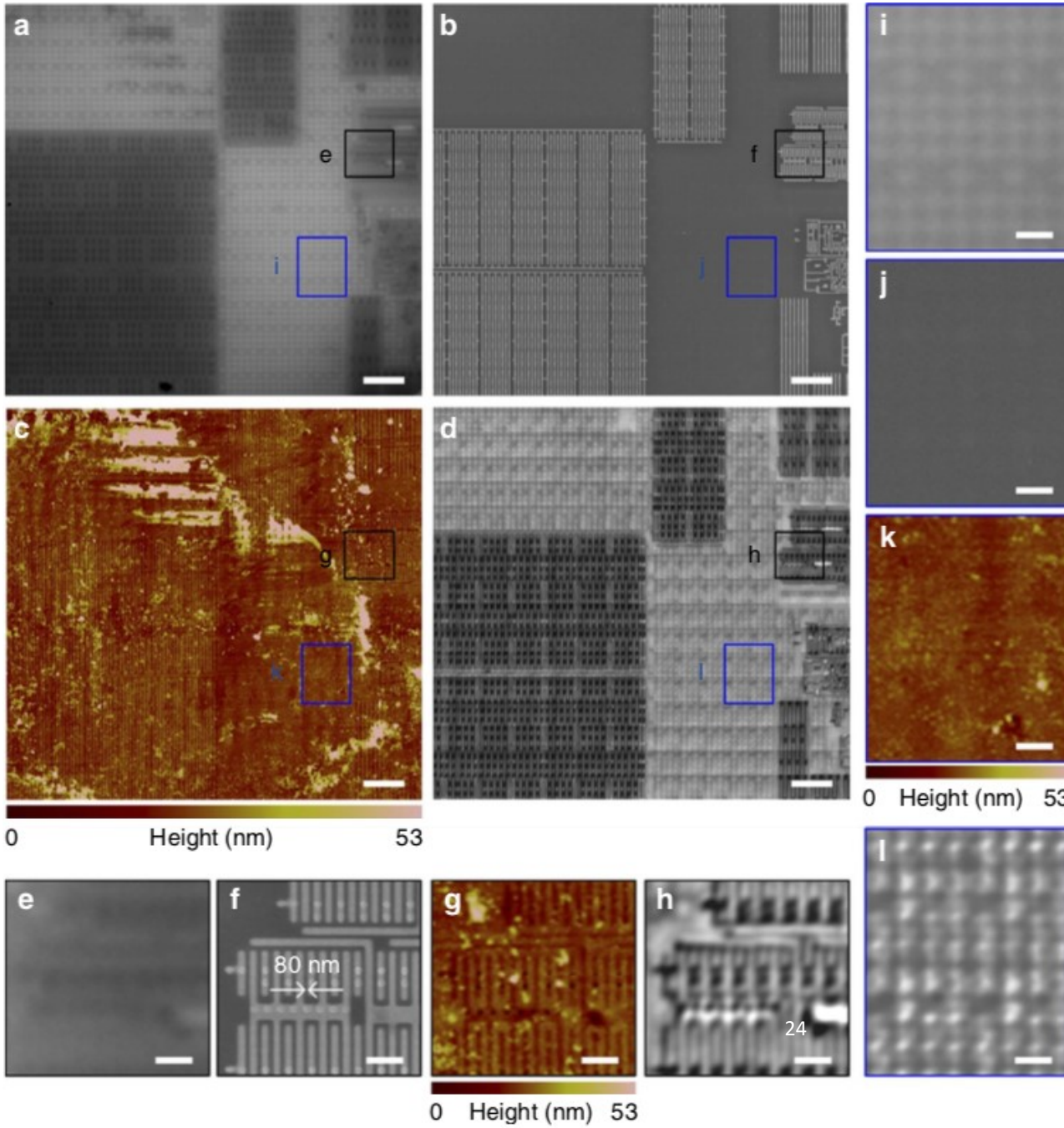
Scanning superlens microscopy for non-invasive large field-of-view visible light nanoscale imaging

Feifei Wang[1,2], Lianqing Liu[1], Haibo Yu[1], Yangdong Wen[1,2], Peng Yu[1], Zhu Liu[1], Yuechao Wang[1] & Wen Jung Li[1,3]





Research Article | Vol. 25, No. 13 | 26 Jun 2017 | OPTICS EXPRESS 15079

Optics EXPRESS

Microsphere-based super-resolution scanning optical microscope

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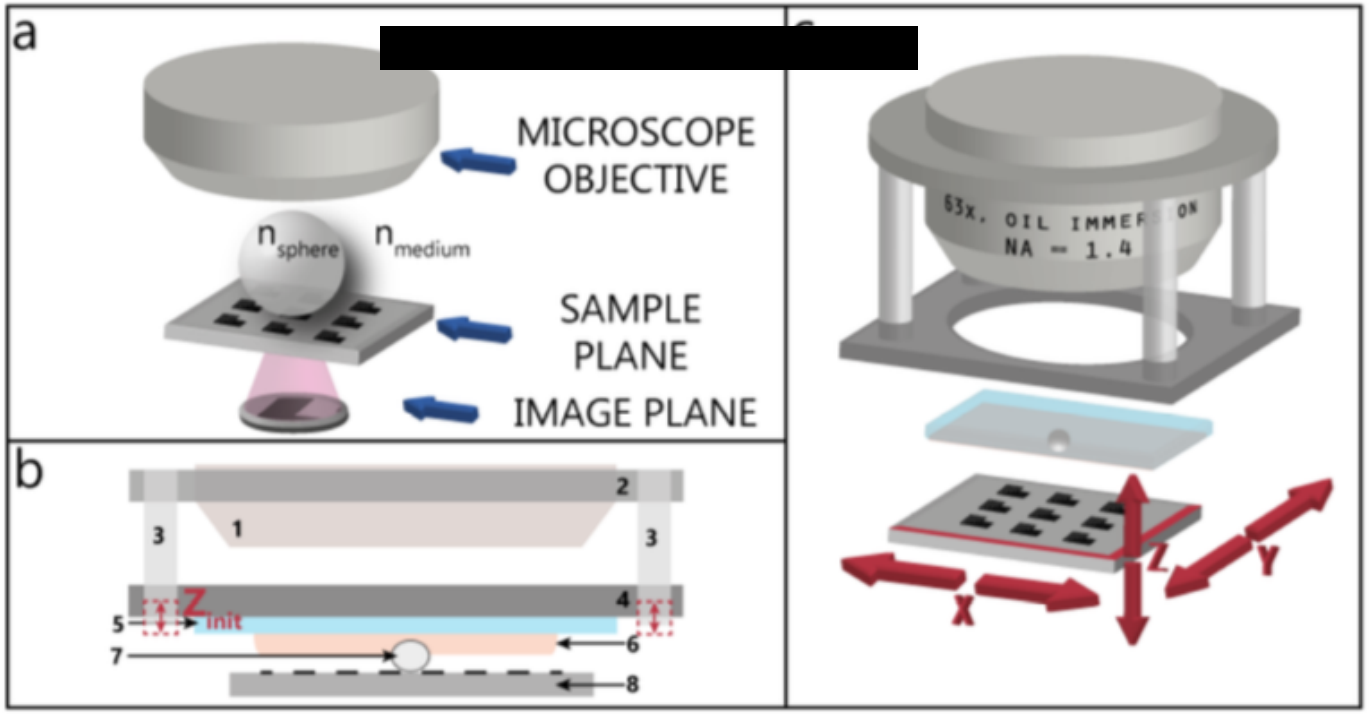

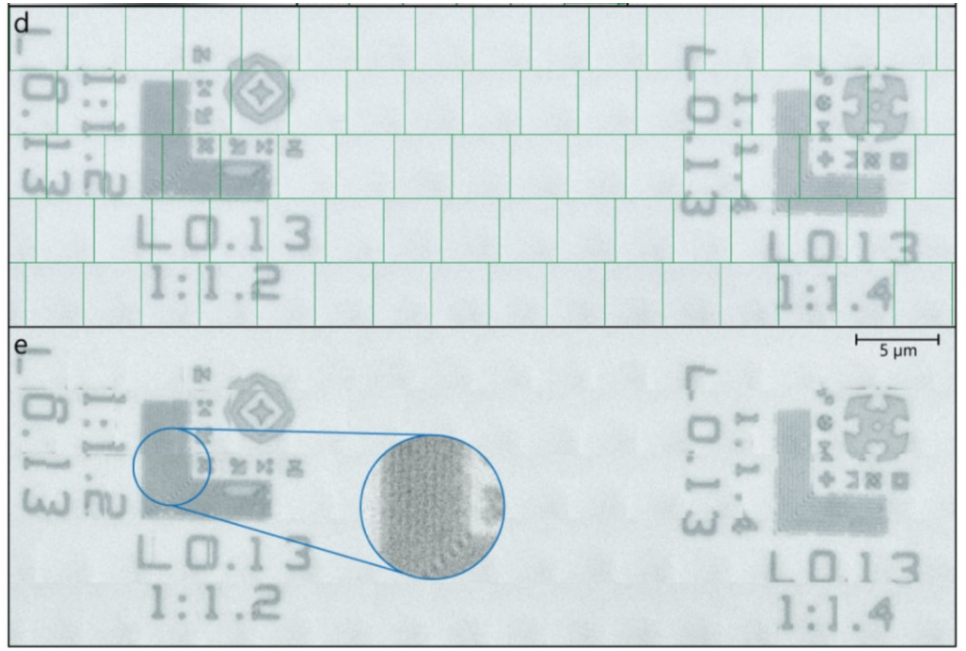

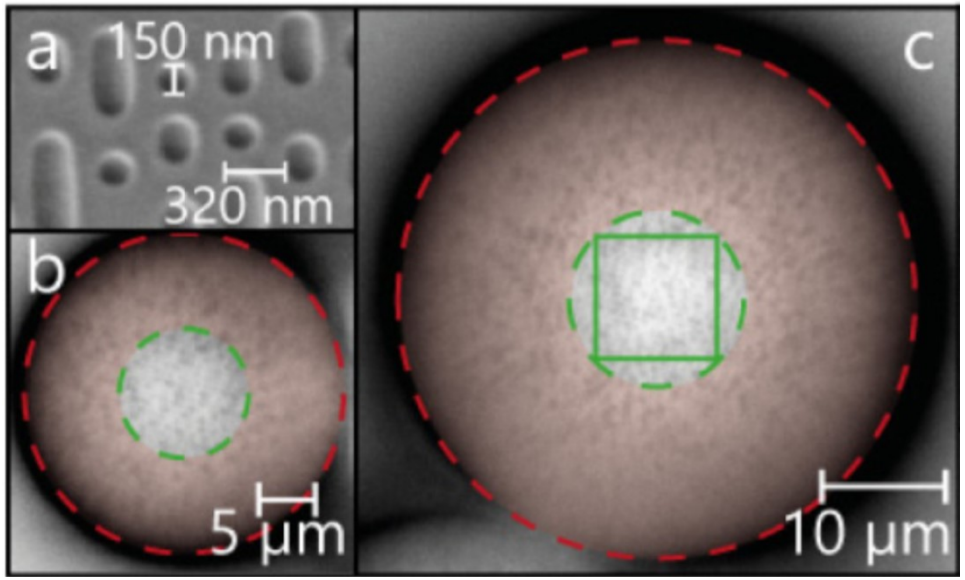

Letter Vol. 45, No. 11 / 1 June 2020 / Optics Letters 2981

Optics Letters

Enhanced high-quality super-resolution imaging in air using microsphere lens groups

Hao Luo,[1,2,3] Haibo Yu,[1,2,5] Yangdong Wen,[1,2,3] Tianyao Zhang,[1,2,3] Pan Li,[1,2,3] Feifei Wang,[4] and Lianqing Liu[1,2,6]

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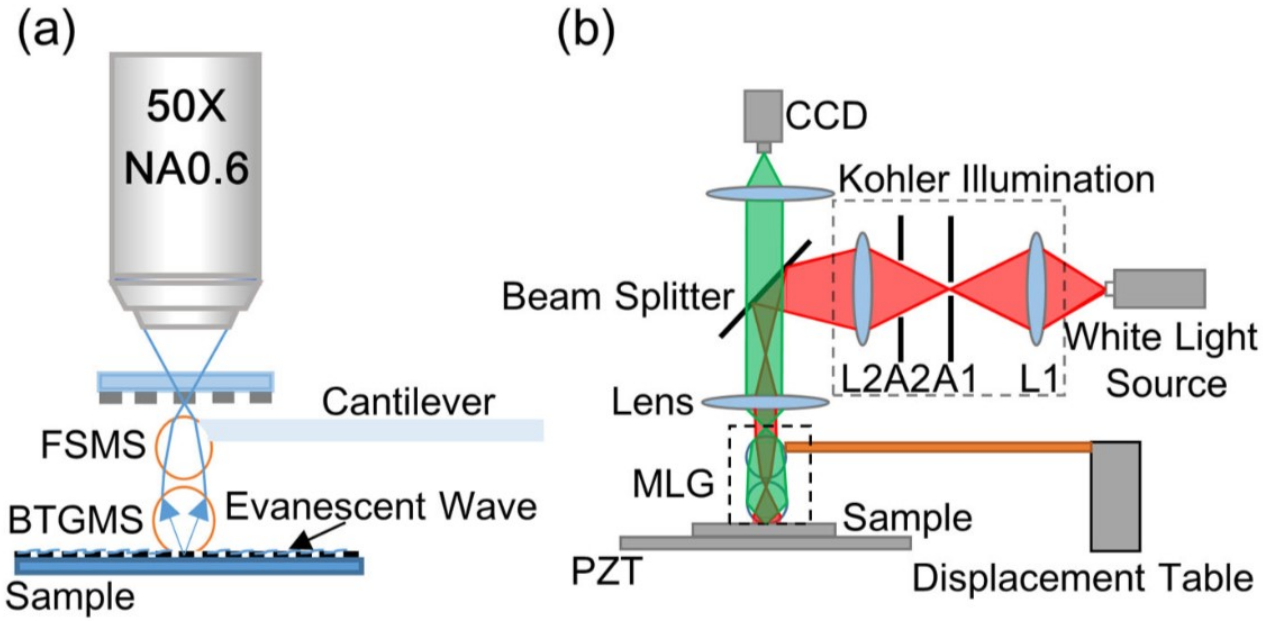

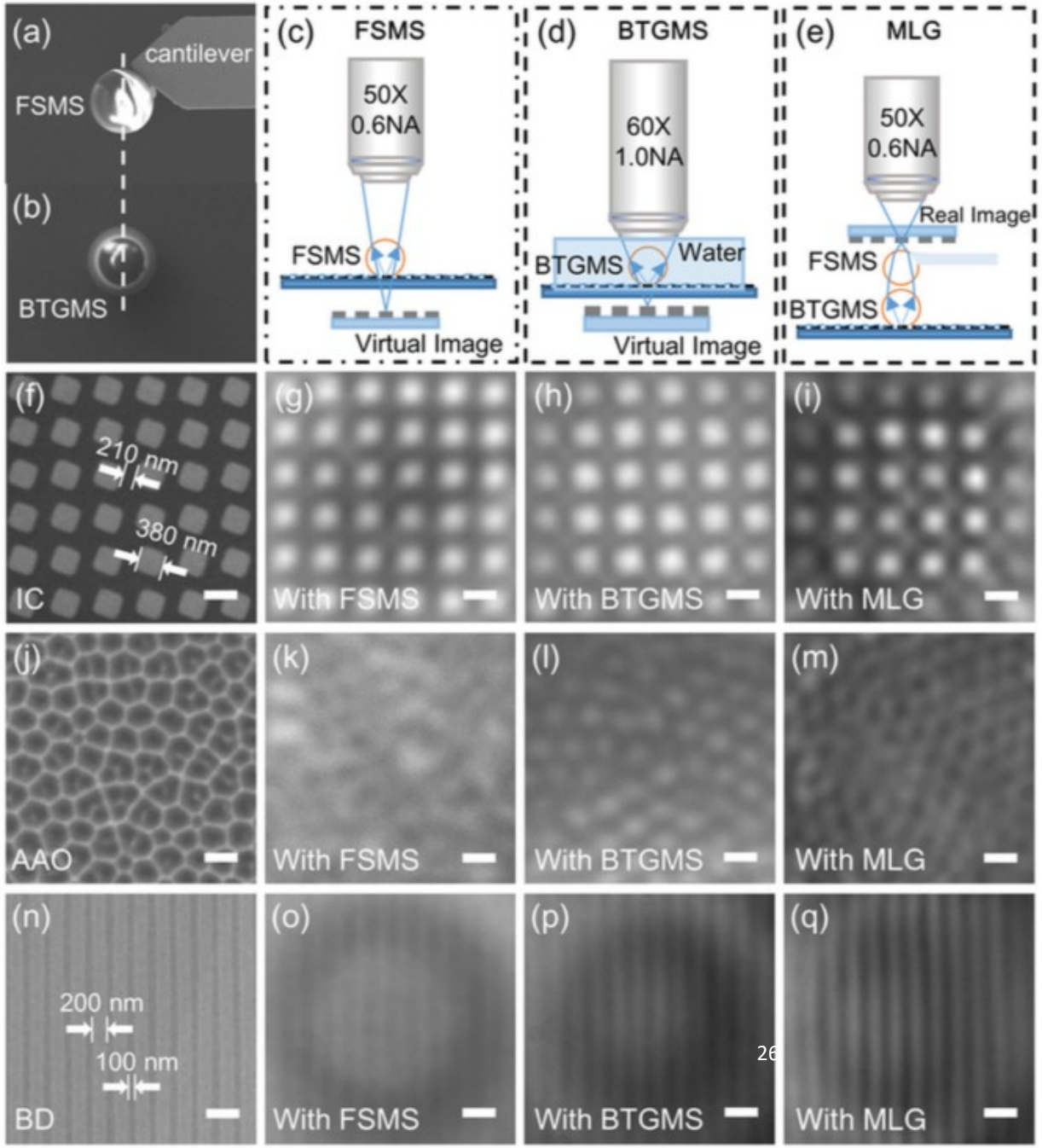

Research Article | Vol. 29, No. 15 / 19 July 2021 / Optics Express 23073
Optics EXPRESS

Optical nano-imaging via microsphere compound lenses working in non-contact mode

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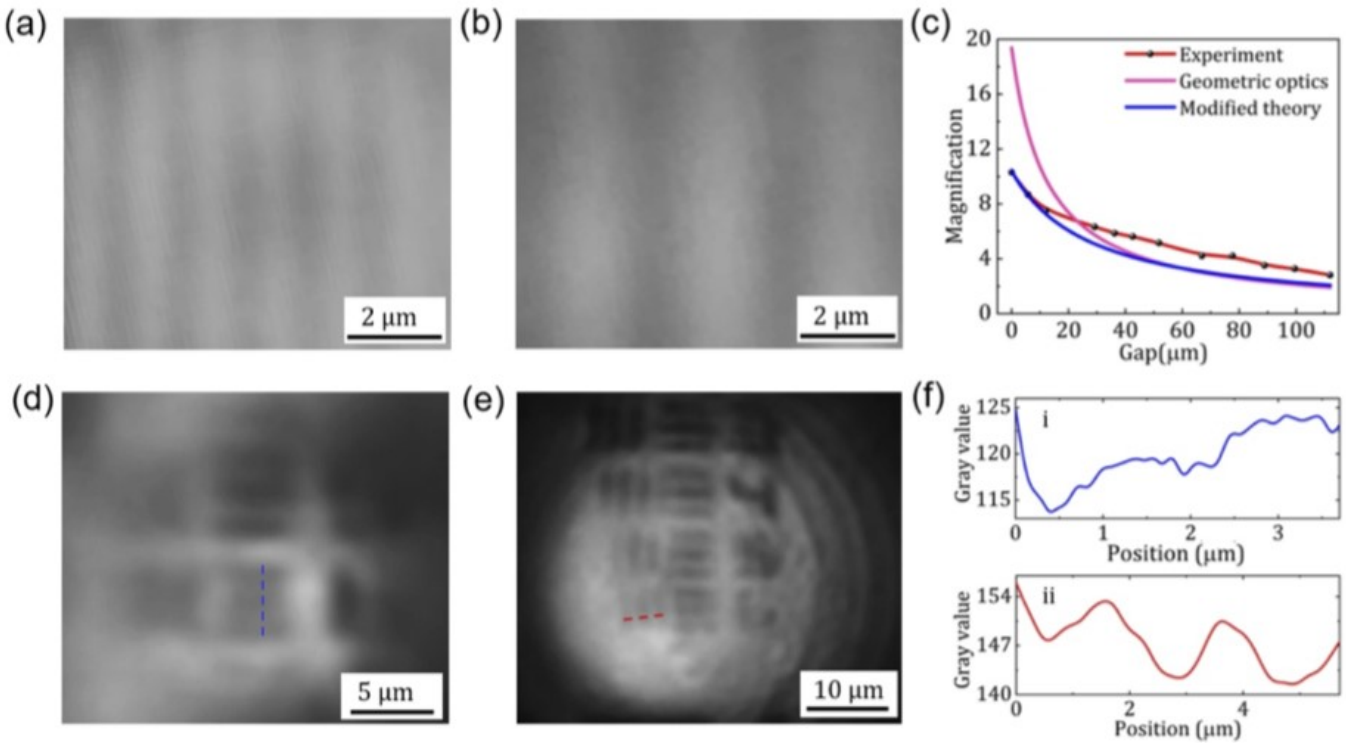


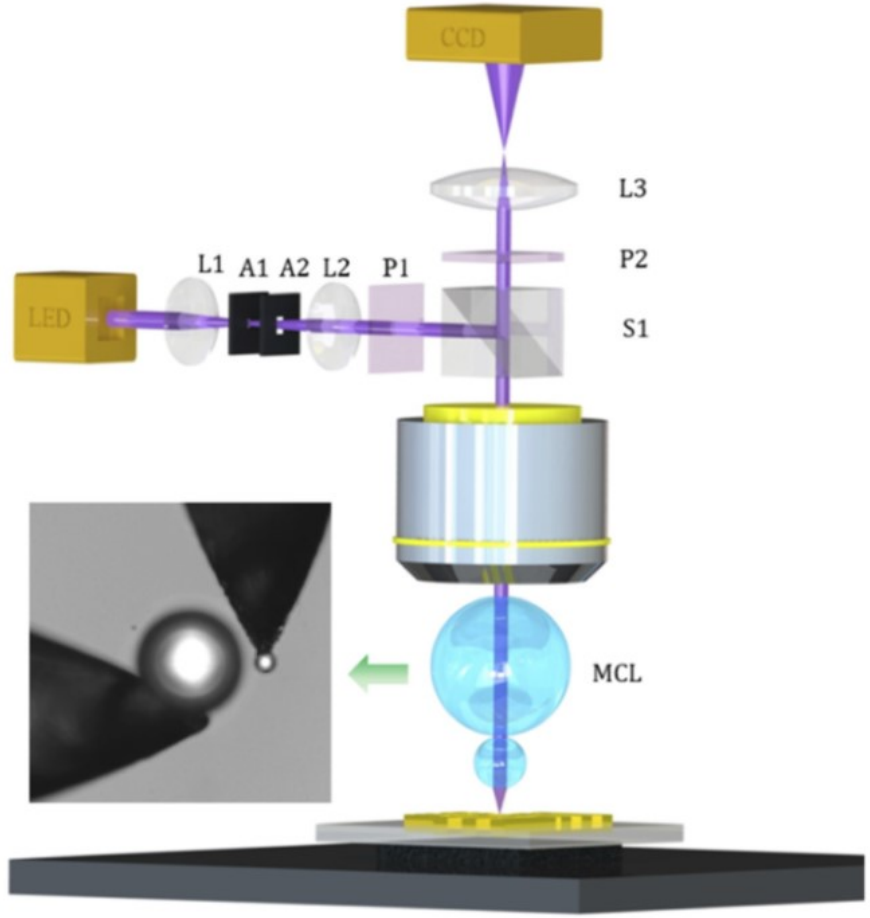


Fig. 4. Blu-ray disc imaged by (a) a single 23 μm silica microsphere with a 20× objective and (b) an MCL consisting of 23 μm (bottom) and 102 μm (upper) silica microspheres with a 20× objective; (c) Magnification of MCL consisting of 23 μm (bottom) and 110 μm (upper) silica microspheres versus the gap between two microspheres. The red line with dots is experimental results. The blue and pink lines are calculated with effective refractive index and refractive index of silica; High-resolution target "HIGHRES-1" imaged by (d) a single 23 μm silica microsphere with 10× objective and (e) an MCL consisting of 23 μm (bottom) and 100 μm silica microspheres (upper) with 10× objective; (f) The gray value profile along the blue and red dash lines in (d) and (e).

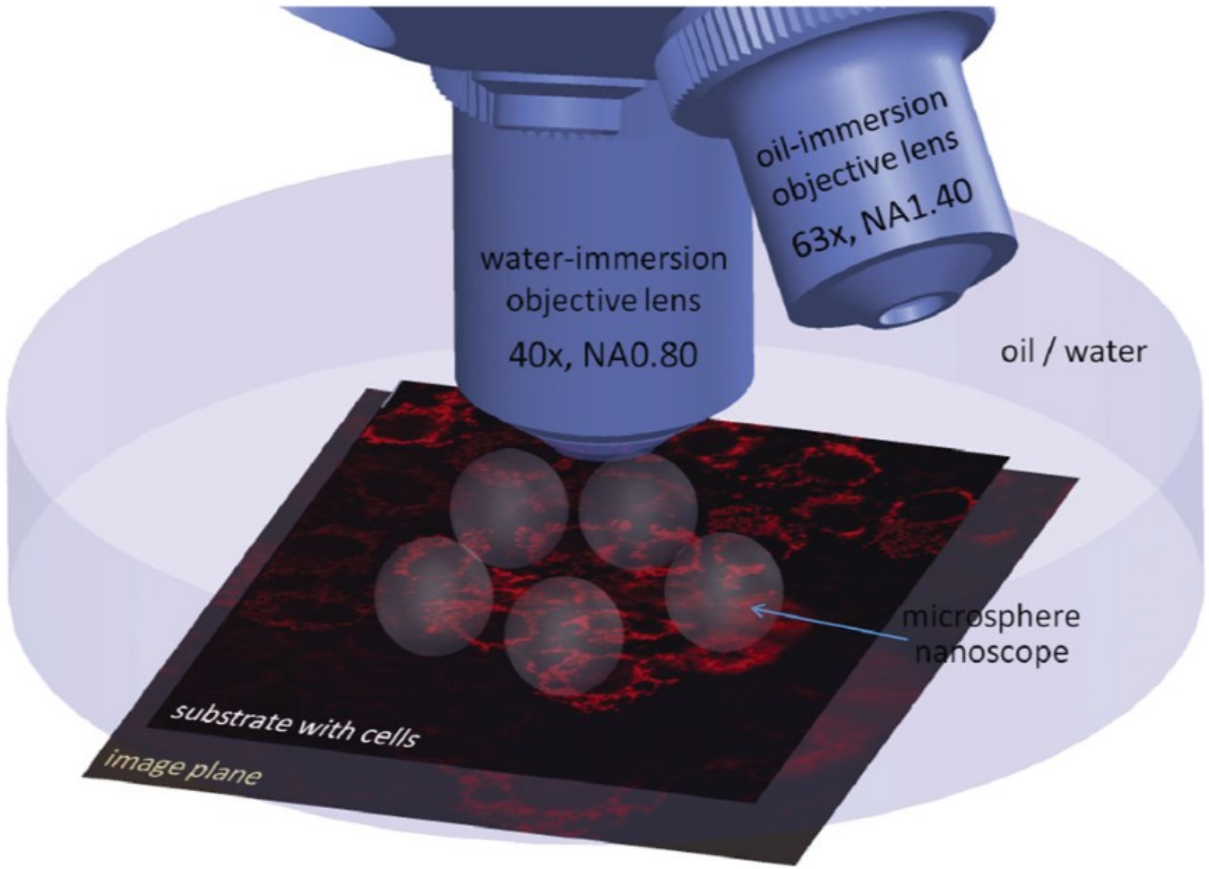
communications

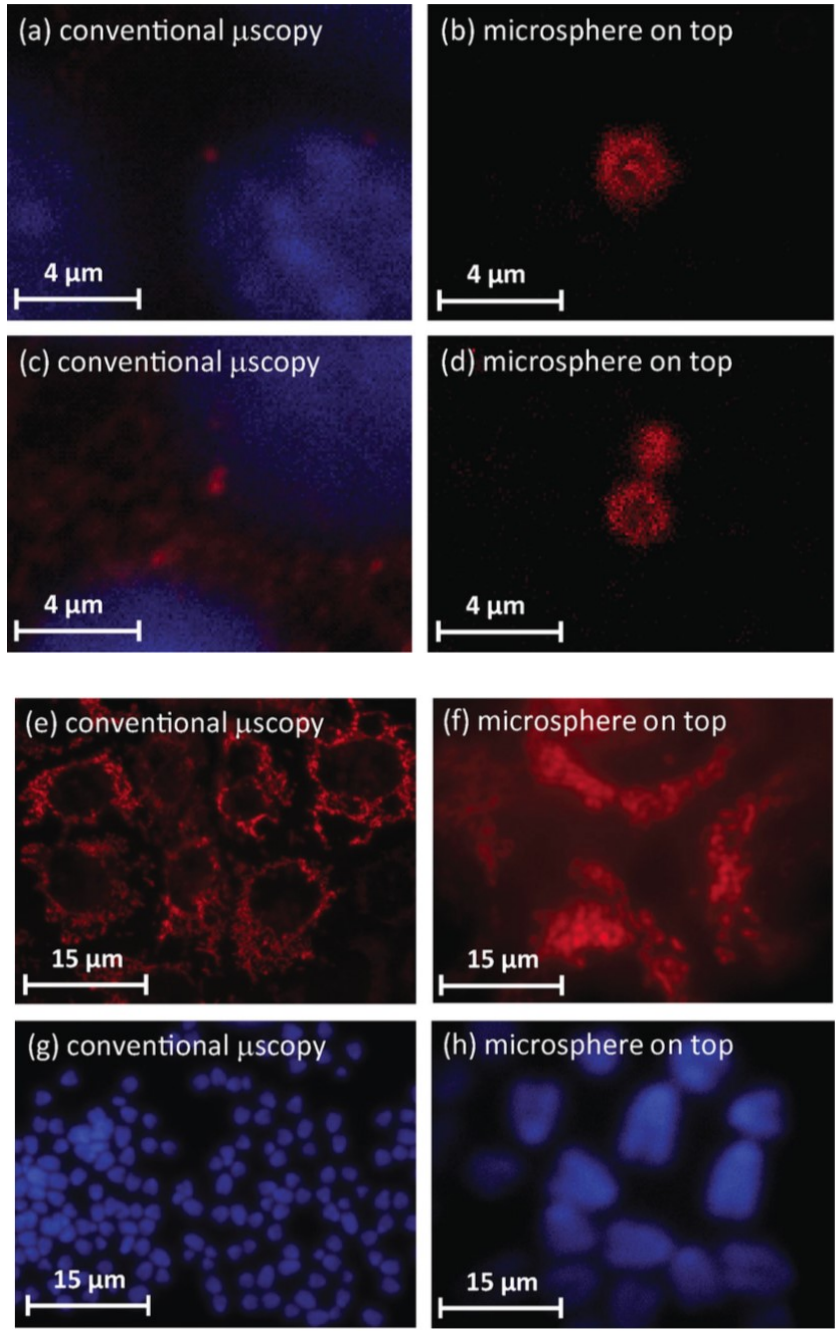
small 2014, *10,* No. 9, 1712–1718

Fluorescence Imaging

Super-Resolution Biological Microscopy Using Virtual Imaging by a Microsphere Nanoscope

*Hui Yang, Norman Moullan, Johan Auwerx, and Martin A. M. Gijs**





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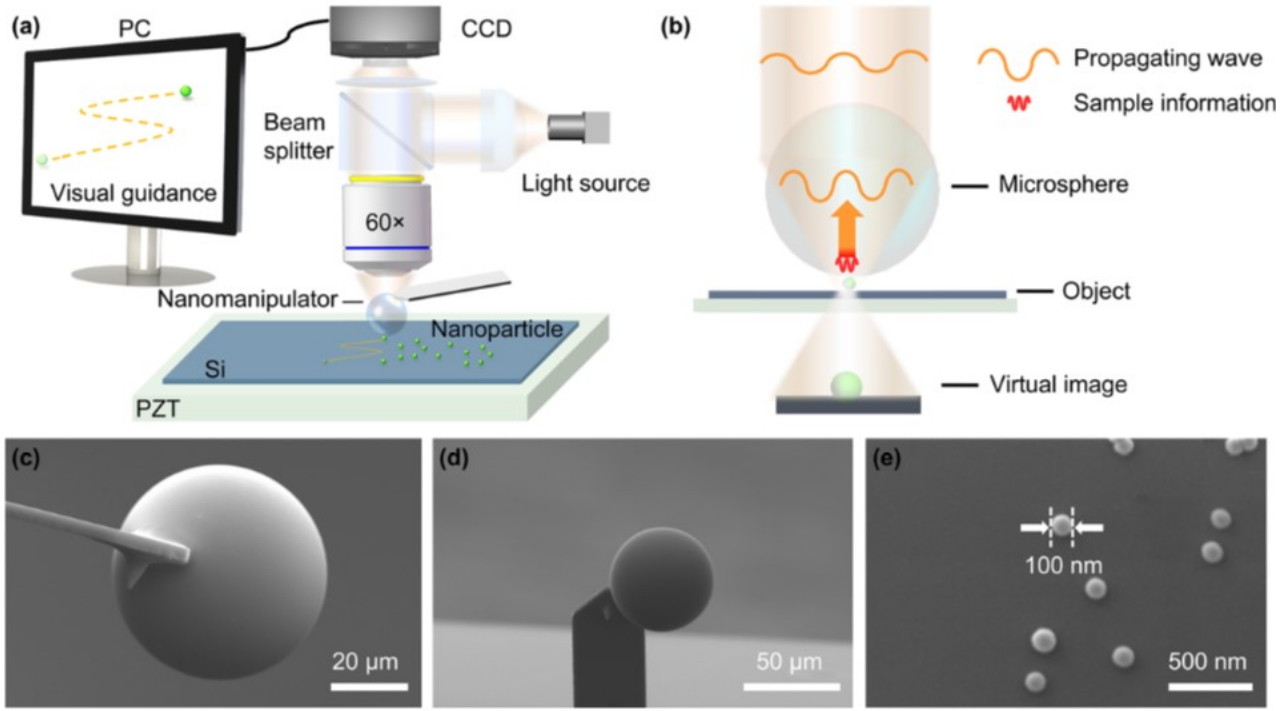
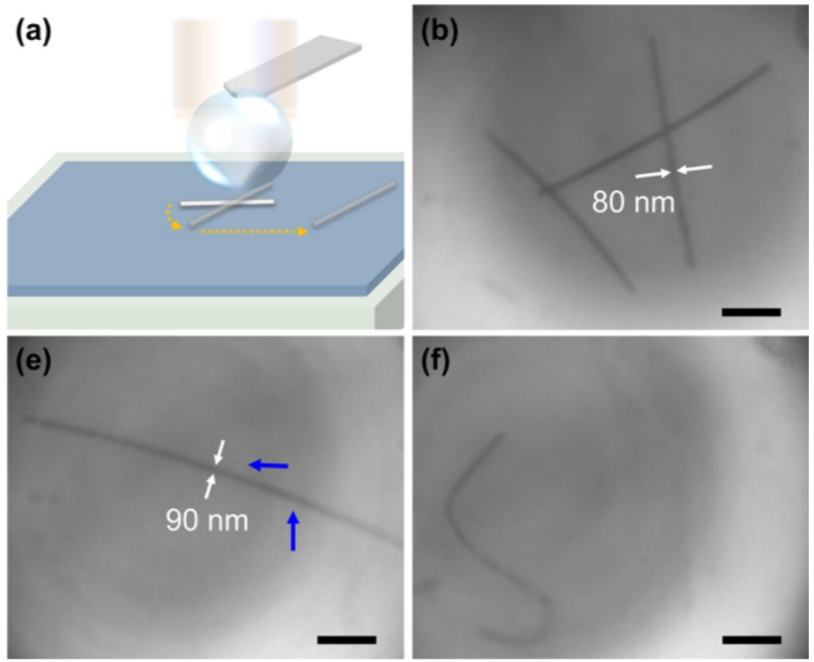
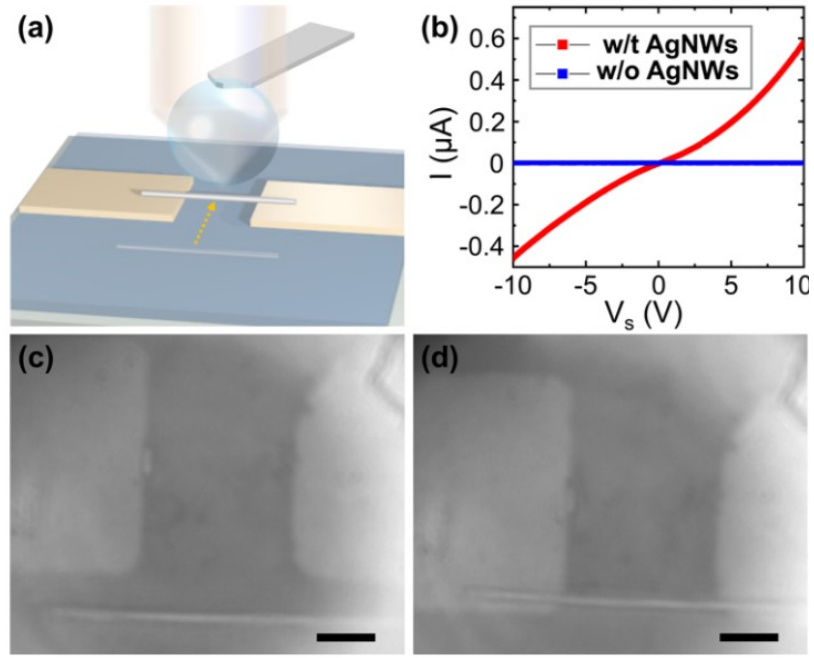
Microsphere-Based Super-Resolution Imaging for Visualized Nanomanipulation

Tianyao Zhang, Haibo Yu,* Pan Li, Xiaoduo Wang, Feifei Wang, Jialin Shi, Zhu Liu, Peng Yu, Wenguang Yang, Yuechao Wang, and Lianqing Liu*

Cite This: *ACS Appl. Mater. Interfaces* 2020, 12, 48093–48100 Read Online







Research Article | Vol. 25, No. 22 | 30 Oct 2017 | OPTICS EXPRESS 27551

Optics EXPRESS

Influence of the photonic nanojet of microspheres on microsphere imaging

SONGLIN YANG, FENGGE WANG, YONG-HONG YE,* YANG XIA, YUN DENG, JIANGUO WANG, AND YURONG CAO

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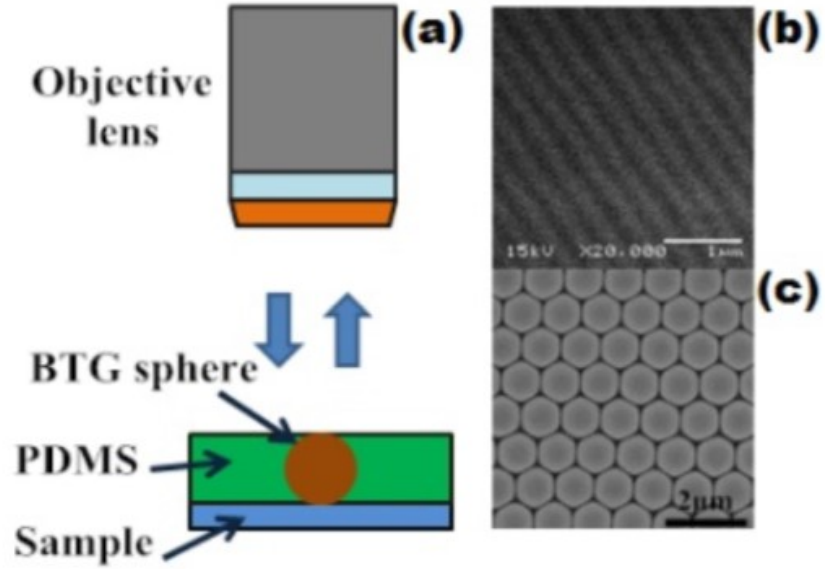

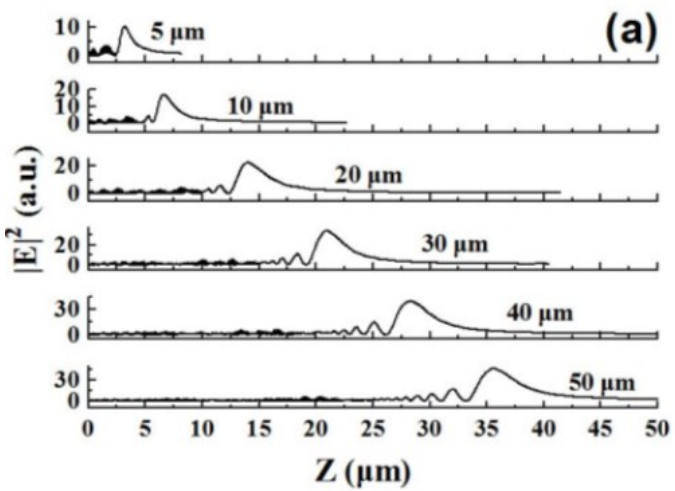

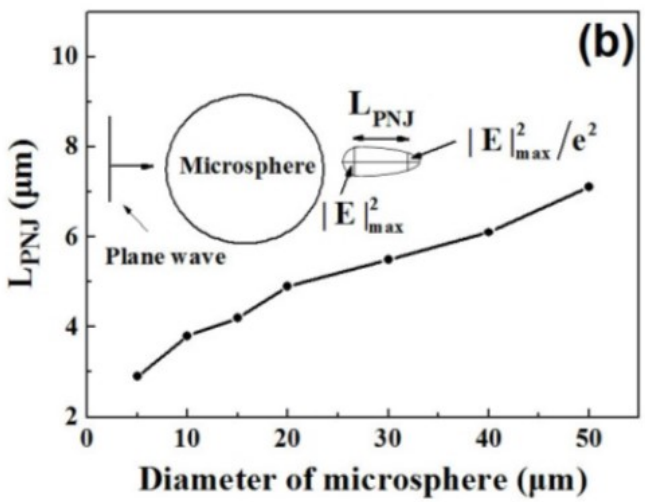

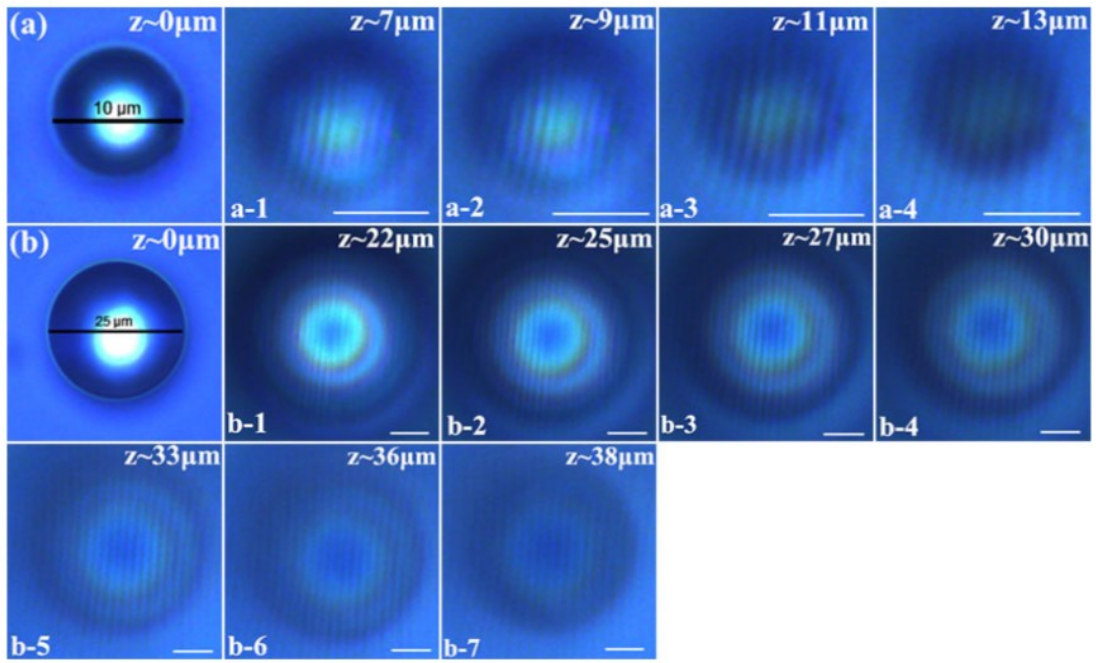

NANO LETTERS

Letter

DOI: 10.1021/acs.nanolett.6b01255
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Nano Lett. 2016, 16, 4862−4870

Super-Resolution Imaging of a Dielectric Microsphere Is Governed by the Waist of Its Photonic Nanojet

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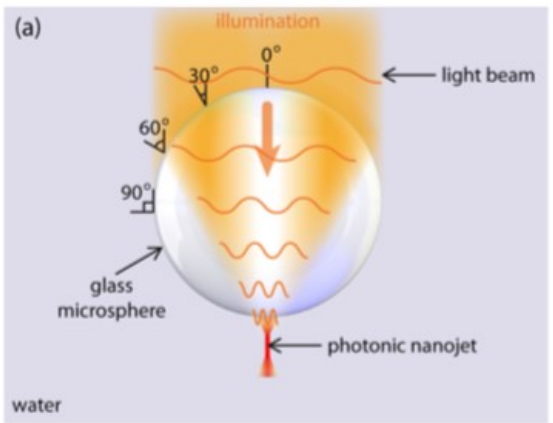
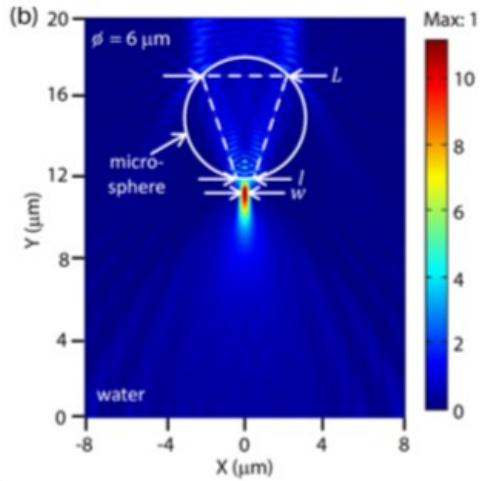
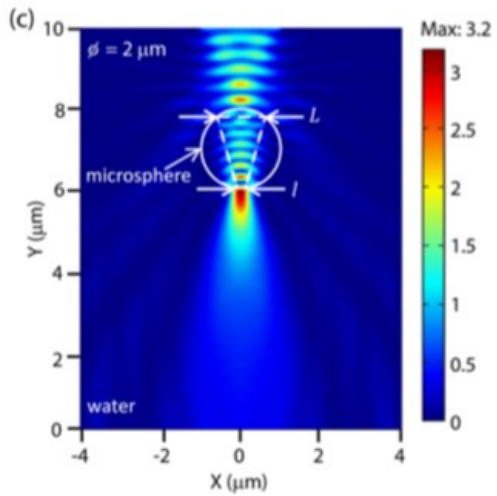
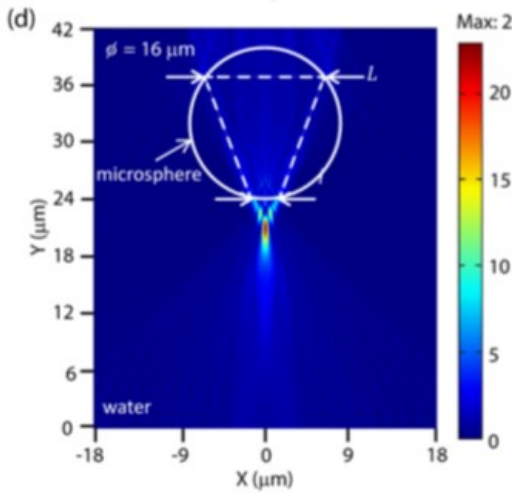
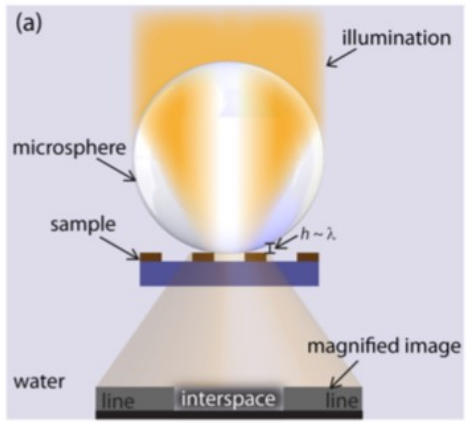
Laboratory of Microsystems, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

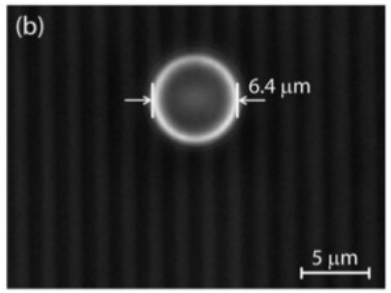


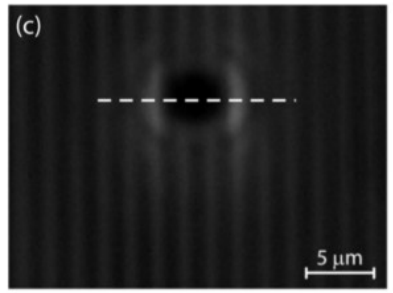


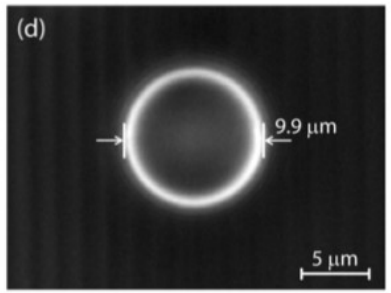


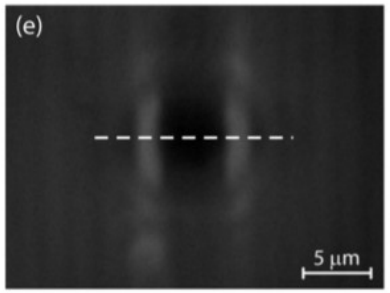


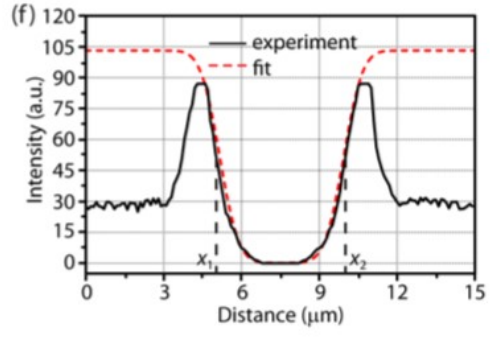


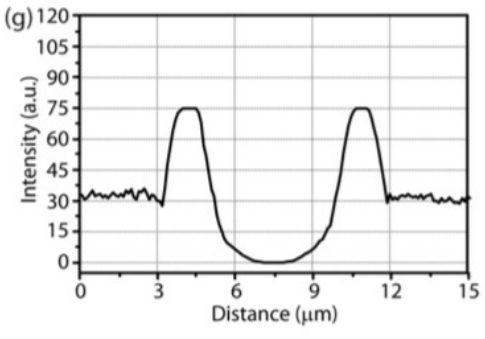












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Microsphere enhanced optical imaging and patterning: From physics to applications

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All-dielectric concentration of electromagnetic fields at the nanoscale: the role of photonic nanojets

Jinlong Zhu * and Lynford L. Goddard