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	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER 611102

6. AUTHORS	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES University of Texas at Austin 101 East 27th Street Suite 5.300 Austin, TX 78712 -1532	8. PERFORMING ORGANIZATION REPORT NUMBER
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9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS (ES) U.S. Army Research Office P.O. Box 12211 Research Triangle Park, NC 27709-2211	10. SPONSOR/MONITOR'S ACRONYM(S) ARO
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13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.
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14. ABSTRACT
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15. SUBJECT TERMS
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a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU	19b. TELEPHONE NUMBER 512-471-0228

# RPPR Final Report

as of 06-Jan-2020

Agency Code:

Proposal Number: 70784MS

**Agreement Number: W911NF-17-1-0561**

**INVESTIGATOR(S):**

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**Email:** zheng@austin.utexas.edu  
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**Principal:** Y

Organization: **University of Texas at Austin**

Address: 101 East 27th Street, Austin, TX 787121532

Country: USA

DUNS Number: 170230239

EIN: 746000203

**Report Date:** 14-Nov-2019

Date Received: 13-Nov-2019

**Final Report** for Period Beginning 15-Oct-2017 and Ending 14-Aug-2019

**Title:** Optically Assembled Meta-Materials

**Begin Performance Period:** 15-Oct-2017

**End Performance Period:** 14-Aug-2019

**Report Term:** 0-Other

Submitted By: Yuebing Zheng

Email: zheng@austin.utexas.edu

Phone: (512) 471-0228

**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**STEM Degrees:** 2

**STEM Participants:** 2

**Major Goals:** Optical meta-materials (OMMs) enable electromagnetic cloaking and novel sensing for U.S. Army applications. Bottom-up assembly of colloidal particles paves a promising way towards high-quality OMMs. The assembly overcomes limits of top-down lithography that has spatial control limited to scale above tens of nanometers. Chemically synthesized colloidal particles have perfect atomic-scale crystallinity and narrow size distribution. Despite tremendous progress in bottom-up assembly of meta-materials, two problems have prevented the broader implementation of the OMMs. One is that it is challenging to make the OMMs with precisely controlled properties for desired applications. The other is that severe loss in metallic OMMs in the visible and near-infrared parts of electromagnetic spectrum limits their applications. We aim to tackle these problems through innovations in design and optical assembly of OMMs with colloidal particles (CPs) as building blocks, which will lead to OMMs with programmable functions, loss compensation and scalable production. For the initial 18 months of the project, our specific research aims include:

Aim 1: Assembly of 2D meta-molecules. I propose to employ optical tweezers to assemble CPs into metamolecules and to realize in-situ polymerization of the meta-molecules.

Aim 2: Programmable chiral OMMs. I propose to develop optically assembled chiral OMMs with dynamic control of their optical responses.

Aim 3: Loss management in OMMs. I propose to reduce loss in the OMMs by using dielectric CPs or metallic CPs coupled to gain molecules.

**Accomplishments:** 1. We achieved low-power opto-thermophoretic manipulation of colloidal particles in complex hydrogels and further demonstrate the all-optical construction of colloidal superstructures. Specifically, we exploit the micelle-mediated thermoelectric field and depletion attractive force in a light-controlled temperature field for versatile manipulation and assembly of colloidal particles in photocurable hydrogels. Furthermore, through UV-induced photopolymerization of the hydrogels, we successfully immobilize the assembled colloidal superstructures via the polymer joint. With the low operation power, versatile control, and in situ polymerization-based bonding, our opto-thermophoretic manipulation in hydrogels will find applications in colloidal devices and materials science.

2. We demonstrated the all-optical atom-by-atom assembly of chiral metamolecules and in-situ measurement of the optical chirality. Specifically, chiral metamolecules can be disassembled into isolated metaatoms for reorganization into their enantiomers (or diastereomers) for on-demand modulation of the optical chirality. The all-optical and reconfigurable assembly of chiral metamolecules provides a new platform to understand chirality at colloidal scale, which will open a new door for on-demand manufacture of chiral metamaterials for biosensing and active chiral photonic devices.

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3. We demonstrated the use of plasmonic heating to trap vesicles in a temperature gradient, allowing long-range attraction, parallel trapping, and dynamic manipulation. The capabilities and limitations with respect to thermal effects on vesicle structure and optical spectroscopy were studied. This simple approach allows vesicle manipulation using down to 3 orders of magnitude lower optical power and at least an order of magnitude higher trapping stiffness per unit power than traditional optical tweezers while using a simple optical setup. In addition to the benefit provided by the relaxation of these technical constraints, this technique can complement optical tweezers to allow detailed studies on thermophoresis of optically trapped vesicles and effects of locally generated thermal gradients on the physical properties of lipid vesicles.

4. We provided a framework for thermoelectric (TE) field in colloidal suspensions with various ions and surfactants at the single-nanoparticle level. In particular, we revealed the spatial variation of TE field around a dielectric particle under temperature gradient to determine the thermoelectric trapping force on the particle. Our theoretical results on the trapping stiffness predicted from the TE force profile match well with the experimental optothermoelectric trapping stiffness of particles in the solutions where the temperature gradient was well controlled by a laser beam. With insights into the TE field and force in complex systems, our framework and methodology can be extended to engineer the TE field for versatile optothermoelectric manipulations of arbitrarily shaped particles with nonuniform surface morphology and to advance the scientific research in cellular biology.

5. We developed an all-optical technique, termed optothermally-gated photon nudging (OPN), for the versatile manipulation of colloidal particles and nanowires on a solid substrate. By optically heating the particles with a laser beam, the surrounding surfactant undergoes a localized phase transition from a crystalline phase to a “quasi-liquid” structure. This phase transition opens the optothermal gate and enables the movement of particles through optical scattering forces. OPN is capable of on-demand manipulation and patterning of colloidal particles of variable sizes (from sub-50 nm to micrometre scale), shapes (e.g., spheres and wires) and compositions (e.g., gold, silver, silicon, titanium dioxide, and metal-dielectric hybrids) at nanoscale accuracy. Along with in situ optical spectroscopy for characterizations of the colloidal particles, our non-invasive and contactless solid-phase nanomanipulation technique will find various applications in nanofabrication, nanophotonics, nanoelectronics, and colloidal sciences.

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- Training Opportunities:**
1. J. Li, L. Lin, X. Peng and Y. B. Zheng, "Plasmon-enhanced optical scissors for nanopatterning of two-dimensional materials," SPIE Optics + Photonics, San Diego, CA, August 19-23, 2018.
  2. Y. Liu, L. Lin, B. B. Rajeeva, X. Peng and Y. B. Zheng, "Opto-thermophoretic trapping on single plasmonic nanoantenna," SPIE Optics + Photonics, San Diego, CA, August 19-23, 2018.
  3. L. Lin, X. Peng, and Y. B. Zheng, "Opto-thermal tweezers for low-power manipulation and assembly of colloidal nanoparticles," SPIE Optics + Photonics, San Diego, CA, August 19-23, 2018.
  4. X. Peng, L. Lin, J. Li, and Y. B. Zheng, "Trapping and assembly of colloidal particles with opto-thermophoretic tweezers," SPIE Optics + Photonics, San Diego, CA, August 19-23, 2018.
  5. Y. B. Zheng, "Optothermal manipulations of colloidal particles and living cells," SPIE Optics + Photonics, San Diego, CA, August 19-23, 2018.
  7. Y. B. Zheng, "Directed-Assembled Nanomaterials," "Materials Today: The Future of Materials Science in the Next Two Decades" workshop, Rice University, Houston, TX, September 27-28, 2018.
  8. L. Lin, X. Peng, and Y. B. Zheng, "Opto-thermal tweezers for low-power manipulation and assembly of colloidal nanoparticles," the first "Materials Today: The Future of Materials Science in the Next Two Decades" workshop, Rice University, Houston, TX, September 27-28, 2018.
  9. Y. B. Zheng, "Digital Manufacturing of Nanomaterials," NASCENT Seminar, The University of Texas at Austin, Austin, TX, October 5, 2018.
  10. Y. B. Zheng, "Digital Assembly and Applications of Hybrid Nanomaterials with Complex Architectures," MRS Spring Meeting & Exhibit, Phoenix, AZ, April 22-26, 2019.
  11. Y. B. Zheng, "Optothermal Manipulations of Colloidal Particles and Living Cells," Biophotonics Congress: Optics in the Life Sciences, Tucson, AZ, April 14-17, 2019.
  12. L. Lin, X. Peng, and Y. B. Zheng, "Manipulating Fano Coupling in the Opto-thermoelectric Trap," Conference on Lasers and Electro-Optics, San Jose, CA, May 5-10, 2019.
  13. J. Li, Y. Liu, and Y. B. Zheng, "Light-Directed Nanomanipulation of Colloidal Particles in Ambient Environments," Conference on Lasers and Electro-Optics, San Jose, CA, May 5-10, 2019.
  14. K. Yao and Y. B. Zheng, "Near-Ultraviolet Dielectric Metasurfaces for Surface-Enhanced Circular Dichroism Spectroscopy and Handedness-Preserved Reflection," Conference on Lasers and Electro-Optics, San Jose, CA, May 5-10, 2019.
  15. Y. Liu, L. Lin, B. B. Rajeeva, and Y. B. Zheng, "Nanoradiator-Mediated Deterministic Opto-thermoelectric Manipulation," Conference on Lasers and Electro-Optics, San Jose, CA, May 5-10, 2019.
  16. Y. B. Zheng, "Opto-Thermo-Fluidics," Harrington Symposium – Physics of Microfluidics, Austin, TX, June 9-11, 2019.
  17. M. L. De Marco, T. Jiang, J. Fang, B. Miller, B. Korgel, Y. B. Zheng, P. Barois, G. L. Drisko and C. Aymonier, "Silicon Particles with Optical Magnetic and Electric Mie Scattering: from the Synthesis to the Assembly of a Metamaterial," Meta 2019, Lisbon, Portugal, July 23 - 26, 2019.
  18. L. Lin, X. Peng, and Y. B. Zheng, "Opto-thermofluidic nanotweezers in reconfigurable assembly of functional colloidal matter," ASME-AJKFLUIDS2019, San Francisco, CA, July 28-August 1, 2019.
  19. H. Ding, L. Lin, and Y. B. Zheng, "Factors affecting trapping ability of opto-thermoelectric nanotweezer: experimental and theoretical studies," ASME-AJKFLUIDS2019, San Francisco, CA, July 28-August 1, 2019.
  20. X. Peng, L. Lin, Z. Chen, J. Fang, H. Ding and Y. B. Zheng, "Opto-thermofluidic feedback control of micro-swimmers," ASME-AJKFLUIDS2019, San Francisco, CA, July 28-August 1, 2019.

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21. L. Lin, X. Peng, and Y. B. Zheng, "Manipulating Fano coupling in all-dielectric meta-molecules", OSA Advanced Photonics Congress 2019, Burlingame, CA, Jul 29 - Aug 1, 2019.
22. J. Li, Y. Liu, and Y. B. Zheng, "Nanomanipulation of Colloidal Particles via Optothermally-gated Photon Nudging," OSA Advanced Photonics Congress, Burlingame, CA, July 29-Aug 1, 2019.
23. L. Lin, X. Peng, and Y. B. Zheng, "Thermoelectricity-driven nanotweezers for reconfigurable assembly of chiral meta-molecules," SPIE Optics + Photonics, San Diego, CA, August 11-15, 2019.
24. X. Peng, L. Lin, Z. Chen, J. Fang, and Y. B. Zheng, "Active optical control of thermophoretic microswimmers", SPIE Optics + Photonics, San Diego, CA, August 11-15, 2019.
25. J. Li, Y. Liu, and Y. B. Zheng, "Nanomanipulation of colloidal particles and nanowires with optothermally gated photon nudging," SPIE Optics + Photonics, San Diego, CA, August 11-15, 2019.
26. H. Ding, L. Lin, and Y. B. Zheng, "How to design a forceful opto-thermoelectric nanotweezer?", SPIE Optics + Photonics, San Diego, CA, August 11-15, 2019.
27. P. S. Kollipara, L. Lin, and Y. B. Zheng, "Opto-thermoelectric nanotweezers: Quantitative estimation of trap stiffness", SPIE Optics + Photonics, San Diego, CA, August 11-15, 2019.
28. A. Kotnala and Y. B. Zheng, "Opto-thermophoretic fiber tweezers: Design and Applications", SPIE Optics + Photonics, San Diego, CA, August 11-15, 2019.
29. X. Peng, Z. Chen, and Y. B. Zheng, "Active Optical Control of Thermophoretic Microswimmers," Texas Advanced Computing Center Symposium, Austin, TX, September 26-27, 2019.
30. H. Ding, L. Lin, P. Kollipara, and Y. B. Zheng, "Factors Affecting Trapping Ability of Opto-Thermal Nanotweezers: Experimental and Theoretical Studies," Texas Advanced Computing Center Symposium, Austin, TX, September 26-27, 2019.

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**Results Dissemination:** We have been selected to receive the 2019 University Co-op Research Excellence Award for Best Paper (August 2019).

Our optothermal tweezers were featured by Medical Device Developments as "Little wonders" (April 2019).

Our work All-Optical Reconfigurable Chiral Metamolecules has been featured by Nanowerk as "Bottom-up assembled chiral meta-molecules" (March 2019).

Our work on Manipulating Nanoparticles in an Opto-Thermoelectric Field has been elected as OPN's Year in Optics and featured as Front Cover Article (November 2018).

The Engineering Translator- Episode 4 - A Game of Light with Yuebing Zheng (October 2018).

Our work on Opto-Thermophoretic Manipulation and Construction of Colloidal Superstructures in Photocurable Hydrogels will be featured as Front Cover Article of ACS Applied Nano Materials (August 2018).

Our work on Opto-Thermoelectric Nanotweezers has been featured by Austin National Public Radio - KUT Public Media. (March 2018)

Our work on Opto-Thermophoretic Manipulation of Colloidal Particles in Non-Ionic Liquids was selected as cover article by Journal of Physical Chemistry C (June 2018).

Our work on Opto-Thermoelectric Nanotweezers has been featured by Focus Laser World as "Opto-thermoelectric nanotweezers improve particle-trapping efficiency."; also featured on the magazine cover (May 2018).

Our work on "Reconfigurable Opto-Thermoelectric Printing of Colloidal Particles" has been featured by Atlas of Science as "Erasable opto-thermoelectric printing." (April 2018).

Intel's HPC editorial program features some of our research in "Nanoparticle Research Provides New Applications for Industry and Everyday Life." (April 2018).

Our work on Opto-Thermoelectric Nanotweezers has been featured by Photonics.com as "Optically Heated Nanotweezers Manipulate Materials at Nanoscale." (April 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by NextBIGfuture as "Opto-thermoelectric Nanotweezers on path to commercialized nano-particle manipulators integrated to smartphones." (April 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Austin National Public Radio - KUT Public Media. (March 2018)

Our work on Opto-Thermoelectric Nanotweezers, which is published in Nature Photonics 12 (2018) 195-201, is among Nature Collection of Nobel Prize in Physics 2018.

Our work on Nanoradiator-Mediated Deterministic Opto-Thermoelectric Manipulation, which is published in ACS Nano, has been featured by Nanowerk as "Nanoradiators allow precise optical manipulation of nanoparticles" (October 2018)

Our work on "opto-thermoelectric tweezers and assembly" has been chosen as 2018 OPN's Year in Optics and featured as Manipulating Nanoparticles in an Opto-Thermoelectric Field in the December issue of Optics & Photonics News. Each year, the December issue of Optics & Photonics News—the monthly magazine of The Optical Society—highlights the most exciting optics research to emerge in the preceding 12 months (October 2018).

Our work on Opto-Thermoelectric Nanotweezers has been featured by Austin National Public Radio - KUT Public Media. (March 2018)

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2018).

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Our work on Opto-Thermoelectric Nanotweezers has been featured by NextBIGfuture as "Opto-thermoelectric Nanotweezers on path to commercialized nano-particle manipulators integrated to smartphones." (April 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured as "'Nanotweezers' trap cells and nanoparticles with a laser beam" in "Five important biomedical technology breakthroughs" by Kurzweil Accelerating Intelligence. (March 2018)

Our work on Moiré Chiral Metamaterials is selected to be included in the virtual Best of Advanced Optical Materials 2017 issue. (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured in Nature Photonics "News & Views" as "Thermoelectric fields hold nanoparticles." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by OSA-OPN as "Putting Metallic Nanoparticles in Their Place." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Nanotechweb as "Optical traps feel the heat." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Azo Nano as "Opto-Thermoelectric Nanotweezers Could Revolutionize the Field of Medicine." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by The Daily Texan as "Newly invented nanotweezers can manipulate matter on tiny scales." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by VERDICT Medical Devices as "Nanotweezers could manipulate cells." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Product Design and Development as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Science Daily as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Controlled Environments as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by NovusLight as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by MDTmag as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Scienmag as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Nanowerk as "New nanotweezers open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by News-Medical as "New 'nanotweezers' could pave way for innovations in health monitoring and mobile technology." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Science Newline as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

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Our work on Opto-Thermoelectric Nanotweezers has been featured by IEEE Electronics360 as "Nanotweezers Developed Could be Huge for Medical Technology." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Phys.org as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by SciTechDaily as "Nanotweezers open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by Eurekalert! as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

Our work on Opto-Thermoelectric Nanotweezers has been featured by UT News as "New 'nanotweezers' open door to innovations in medicine, mobile tech." (March 2018)

### **Honors and Awards:** Yuebing Zheng:

2019 University Co-op Research Excellence Award for Best Paper

2019 Texas Health Catalyst Consulting Award

2019 Department of Defense DURIP Award

2019 Top 5% of Highly Cited Authors in Analytical Portfolio of Royal Society of Chemistry

2019 Senior Member of the Optical Society of America

2019 J. Mike Walker Faculty Scholarship, UT Austin

2019 Fellow of the Institute of Physics

2019 Franklin Award for Outstanding Teaching, Research and Service, UT Austin

2018 Fellow of the Royal Society of Chemistry

2018 Materials Today Rising Star Award, Elsevier Ltd

2017 National Institute of Health (NIH) Director's New Innovator Award

2017 Early Career Faculty Award, National Aeronautics and Space Administration (NASA)

2017 Young Investigator Award, Office of Naval Research (ONR)

2017 Chemical Communications Emerging Investigator, Royal Society of Chemistry

### Jimi Wang:

2019 Professional Development Award, Office of Graduate Studies, UT Austin

### Hongru Ding:

2019 Professional Development Award, Office of Graduate Studies, UT Austin

### Eric Hill:

2018 Leadership of an Independent Junior Research Group, Germany

### Rohit Unni:

2018 Cockrell School of Engineering Fellowship, UT Austin

### Xiaolei Peng:

2018 University Graduate Continuing Fellowship, Office of Graduate Studies, UT Austin

### Pavana Kollipara:

2017 Provost's International Graduate Excellence Fellowship, UT Austin

### **Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

### **PARTICIPANTS:**

**Participant Type:** Postdoctoral (scholar, fellow or other postdoctoral position)

**Participant:** Abhay Kotnala

**RPPR Final Report**  
as of 06-Jan-2020

**Person Months Worked:** 3.00

**Funding Support:**

Project Contribution:  
International Collaboration:  
International Travel:  
National Academy Member: N  
Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Hongru Ding

**Person Months Worked:** 3.00

**Funding Support:**

Project Contribution:  
International Collaboration:  
International Travel:  
National Academy Member: N  
Other Collaborators:

**Participant Type:** Graduate Student (research assistant)

**Participant:** Jingang Li

**Person Months Worked:** 3.00

**Funding Support:**

Project Contribution:  
International Collaboration:  
International Travel:  
National Academy Member: N  
Other Collaborators:

**CONFERENCE PAPERS:**

**Publication Type:** Conference Paper or Presentation

**Publication Status:** 1-Published

**Conference Name:** CLEO: Applications and Technology

Date Received: 13-Nov-2019      Conference Date: 13-May-2018      Date Published:

Conference Location: San Jose, California

**Paper Title:** Optothermal Nanolithography for Versatile Low-Power Patterning of Atomic-Thin Two-Dimensional Materials

**Authors:** Jingang Li, Linhan Lin, Xiaolei Peng, Yuebing Zheng

Acknowledged Federal Support: **Y**

**Publication Type:** Conference Paper or Presentation

**Publication Status:** 1-Published

**Conference Name:** CLEO: QELS\_Fundamental Science

Date Received: 13-Nov-2019      Conference Date: 13-May-2018      Date Published:

Conference Location: San Jose, California

**Paper Title:** Opto-Thermophoretic Trapping in Simple Polar Liquids

**Authors:** Xiaolei Peng, Linhan Lin, Yuebing Zheng

Acknowledged Federal Support: **Y**

**RPPR Final Report**  
as of 06-Jan-2020

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** CLEO: Science and Innovations  
Date Received: 13-Nov-2019 Conference Date: 13-May-2019 Date Published:  
Conference Location: San Jose, California  
**Paper Title:** All-optically reconfigurable chiral metamolecules  
**Authors:** Linhan Lin, Xiaolei Peng, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** CLEO: Science and Innovations  
Date Received: 13-Nov-2019 Conference Date: 05-May-2019 Date Published:  
Conference Location: San Jose, California  
**Paper Title:** Manipulating Fano coupling in the opto-thermoelectric trap  
**Authors:** Linhan Lin, Xiaolei Peng, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** CLEO: Science and Innovations  
Date Received: 13-Nov-2019 Conference Date: 05-May-2019 Date Published:  
Conference Location: San Jose, California  
**Paper Title:** Light-Directed Nanomanipulation of Colloidal Particles in Ambient Environments  
**Authors:** Jingang Li, Yaoran Liu, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** CLEO: Applications and Technology  
Date Received: 13-Nov-2019 Conference Date: 05-May-2019 Date Published:  
Conference Location: San Jose, California  
**Paper Title:** Near-Ultraviolet Dielectric Metasurfaces for Surface-Enhanced Circular Dichroism Spectroscopy and Handedness-Preserved Reflection  
**Authors:** Kan Yao, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** CLEO: QELS\_Fundamental Science  
Date Received: 13-Nov-2019 Conference Date: 05-May-2019 Date Published:  
Conference Location: San Jose, California  
**Paper Title:** Nanoradiator-Mediated Deterministic Opto-Thermoelectric Manipulation  
**Authors:** Yaoran Liu, Linhan Lin, Bharath Bangalore Rajeeva, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** Novel Optical Materials and Applications  
Date Received: 13-Nov-2019 Conference Date: 29-Jul-2019 Date Published:  
Conference Location: Burlingame, California  
**Paper Title:** Manipulating Fano coupling in all-dielectric meta-molecules  
**Authors:** Linhan Lin, Xiaolei Peng, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**RPPR Final Report**  
as of 06-Jan-2020

**Publication Type:** Conference Paper or Presentation **Publication Status:** 1-Published  
**Conference Name:** Novel Optical Materials and Applications  
Date Received: 13-Nov-2019 Conference Date: 29-Jul-2019 Date Published:  
Conference Location: Burlingame, California  
**Paper Title:** Nanomanipulation of Colloidal Particles via Optothermally-gated Photon Nudging  
**Authors:** Jingang Li, Yaoran Liu, Yuebing Zheng  
Acknowledged Federal Support: **Y**

**DISSERTATIONS:**

**Publication Type:** Thesis or Dissertation  
**Institution:** The University of Texas at Austin  
Date Received: 13-Nov-2019 Completion Date: 8/1/19 2:21PM  
**Title:** Optothermal Manipulation of Colloidal Particles and Biological Objects  
**Authors:** Xiaolei Peng  
Acknowledged Federal Support: **Y**

**PATENTS:**

**Intellectual Property Type:** Patent Date Received: **13-Nov-2019**  
**Patent Title:** Optical Printing Systems and Methods  
**Patent Abstract:** We invented systems and methods for optical printing  
**Patent Number:** 16/227,292  
Patent Country: USA  
Application Date: 20-Dec-2018 Application Status: 1  
Date Issued:

**Intellectual Property Type:** Patent Date Received: **13-Nov-2019**  
**Patent Title:** Optical Patterning Systems and Methods  
**Patent Abstract:** We invented optical patterning systems and methods  
**Patent Number:** 2019/042756  
Patent Country: USA  
Application Date: 23-Jul-2018 Application Status: 1  
Date Issued:



# Optically Assembled Meta-Materials

Yuebing Zheng/ University of Texas at Austin



Journal covers:

