(SD2015-105) 3D Fabrication of Piezoelectric Polymer Composite Materials

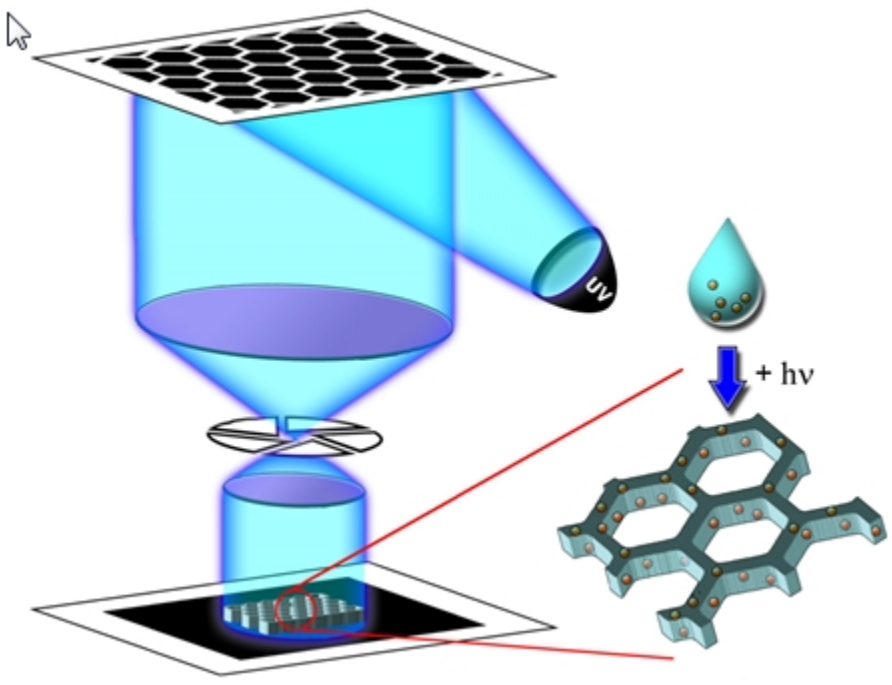
Tech ID: 24418 / UC Case 2014-159-0

BACKGROUND

Piezoelectric materials are key components in a range of devices including acoustic imaging, energy harvesting, and actuators and typically rely on brittle ceramic monoliths to perform their functions. To control the size and or shape of the piezoelectrics, it is common to use mechanical dicing or saws. However, this limits not only the size of the piezoelectric element but also the dimensionality. It is nearly impossible with current cutting techniques to shape brittle ceramics into higher order 3D structures, which could have a huge impact on compact sensor designs, tunable acoustic arrays, efficient energy scavengers, and diagnostic devices. There is an unmet need for simple approaches to fabricating 3D structures in piezoelectric polymers or multilayered architectures which would open up infinite possibilities in the design of more complicated device geometries.

TECHNOLOGY DESCRIPTION

Nanoengineers from UC San Diego have patented piezoelectric nanoparticle–polymer composite materials that can be optically printed into three-dimensional (3D) microstructures using digital projection printing. Piezoelectric polymers were fabricated by incorporating barium titanate ($BaTiO_3$, BTO) nanoparticles into photoliable polymer solutions such as polyethylene glycol diacrylate and exposing to digital optical masks that could be dynamically altered to generate user-defined 3D microstructures. This technology lays the groundwork for creating highly efficient piezoelectric polymer materials via nanointerfacial tuning. Details of this invention are published (Kim *et al.* 2014).



APPLICATIONS

Applications range from loud speakers and acoustic imaging to energy harvesting and electrical actuators. The potential to print virtually any

3D piezoelectric shape, while maintaining a strong piezoelectric coefficient and biocompatible properties, this technology will find application in:

• biomimic materials (*e.g.*, artificial skin, tympanic membrane)

• integrated micro/nanoelectromechanical systems (*e.g.* mechanical actuators), sensors (*e.g.* acoustic detection)

CONTACT
Skip Cynar
scynar@ucsd.edu
tel: 858-822-2672.

OTHER INFORMATION

KEYWORDS
piezoelectric; 3D printing; nanoparticle; PEG; polymer; photopolymerization

CATEGORIZED AS
- Energy
  - Other
- Materials & Chemicals
  - Composites

RELATED CASES
2014-159-0

• bio-imaging (high resolution, compact ultrasonic imaging instruments)

• *in vitro* energy scavenging

RELATED MATERIALS

▶ Kim K, W Zhu, X Qu, C Aaronson, S Chen, and DJ Sirbuly. 3D Optical Printing of Piezoelectric Nanoparticle-Polymer Composite Materials. ACS Nano, DOI: 10.1021/nn503268f Pub Date: July 21, 2014. - 07/21/2014

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Published Application	0161534 A1	05/21/2020	2014-159

OTHER INFORMATION

UC San Diego is actively seeking companies interested in commercializing technology protected by two US patents:

Piezoelectric nanoparticle-polymer composite structure

Application US14/974,582

US 10,199,560 (26 claims)

https://patents.google.com/patent/US10199560B2/

(12) **United States Patent**
Sirbuly et al.

(10) **Patent No.: US 10,199,560 B2**
(45) **Date of Patent: Feb. 5, 2019**

(54) **PIEZOELECTRIC NANOPARTICLE-POLYMER COMPOSITE STRUCTURE**

(71) Applicant: **The Regents of the University of California**, Oakland, CA (US)

(72) Inventors: **Donald J. Sirbuly**, Carlsbad, CA (US); **William R. McCall**, Woodside, CA (US); **Kanguk Kim**, La Jolla, CA (US)

(73) Assignee: **The Regents of the University of California**, Oakland, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 233 days.

(21) Appl. No.: **14/974,582**

(22) Filed: **Dec. 18, 2015**

(65) **Prior Publication Data**

US 2016/0181506 A1 Jun. 23, 2016

B29K 2105/002 (2013.01); *B29K 2105/167* (2013.01); *B29K 2995/0003* (2013.01)

(58) **Field of Classification Search**
CPC H01L 41/183; H01L 41/37; B29C 67/202; B29K 2075/00; B29K 2105/0002; B29K 2105/167; B29K 2083/00; B29K 2995/0603
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,310,134 B2 * 11/2012 Ajayan H01L 41/113 310/357
2011/0281150 A1 * 11/2011 Yong C08J 5/18 429/144
2014/0260653 A1 * 9/2014 Merrell G01L 1/16 73/774

(Continued)

OTHER PUBLICATIONS

McCall et al, "piezoelectric Nanoparticle-Polymer Composite Foams",

Piezoelectric nanoparticle-polymer composite structure

Application US16/228,608

US 11,171,281 (20 claims)

https://patents.google.com/patent/US11171281B2/en?oq=US11171281B2

(12) **United States Patent**
Sirbuly et al.

(10) **Patent No.: US 11,171,281 B2**
(45) **Date of Patent: Nov. 9, 2021**

(54) **PIEZOELECTRIC NANOPARTICLE-POLYMER COMPOSITE STRUCTURE**

(71) Applicant: **The Regents of the University of California**, Oakland, CA (US)

(72) Inventors: **Donald J. Sirbuly**, Carlsbad, CA (US); **William R. McCall**, Woodside, CA (US); **Kanguk Kim**, La Jolla, CA (US)

(73) Assignee: **THE REGENTS OF THE UNIVERSITY OF CALIFORNIA**, Oakland, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 126 days.

(21) Appl. No.: **16/228,608**

(22) Filed: **Dec. 20, 2018**

(65) **Prior Publication Data**

US 2019/0252599 A1 Aug. 15, 2019

Related U.S. Application Data

(63) Continuation of application No. 14/974,582, filed on

(52) **U.S. Cl.**
CPC ***H01L 41/183*** (2013.01); ***B29C 67/202*** (2013.01); ***H01L 41/37*** (2013.01); *B29K 2075/00* (2013.01); *B29K 2083/00* (2013.01); *B29K 2105/002* (2013.01); *B29K 2105/167* (2013.01); *B29K 2995/0003* (2013.01)

(58) **Field of Classification Search**
CPC H01L 41/183; H01L 41/37
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,310,134 B2 11/2012 Ajayan et al.
8,803,406 B2 * 8/2014 Lee H01L 41/37 310/339
10,199,560 B2 * 2/2019 Sirbuly H01L 41/37
(Continued)

FOREIGN PATENT DOCUMENTS

CN 103289363 * 9/2013

OTHER PUBLICATIONS

D. Kim et al, "Preparation and chacterization of UV-cured polyuretane acrylate/ZnO nanocomposite films based on surface modified ZnO", Progess in Organic Coating, 74, pp. 435-442, Feb. 4, 2012.*
(Continued)

University of California, San Diego
Office of Innovation and Commercialization
9500 Gilman Drive, MC 0910, ,
La Jolla,CA 92093-0910

Tel: 858.534.5815
innovation@ucsd.edu
https://innovation.ucsd.edu
Fax: 858.534.7345

© 2014 - 2023, The Regents of the University of California
Terms of use
Privacy Notice