(SD2015-105) Piezoelectric Nanoparticle-Polymer Composite Foams

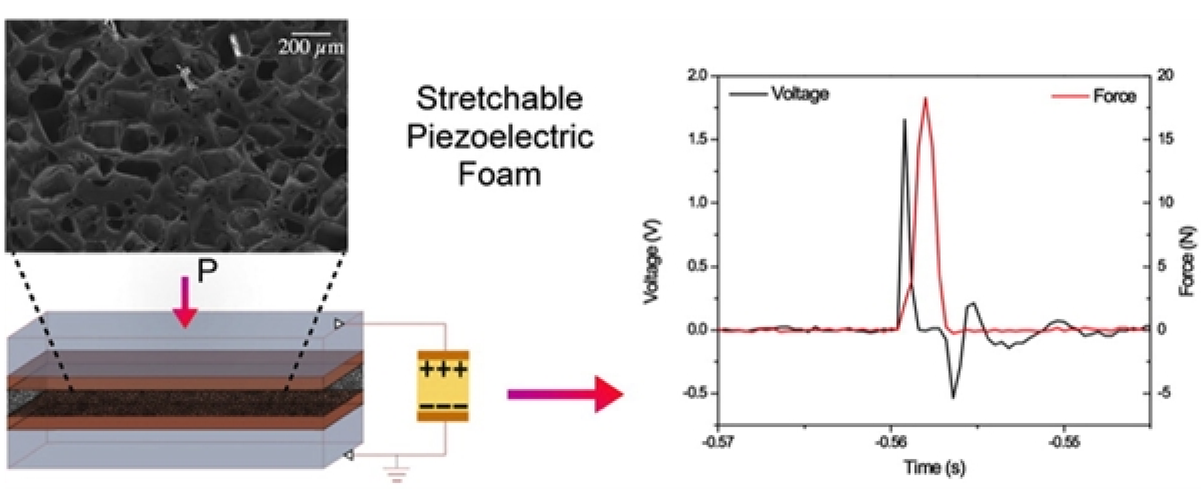
Tech ID: 25043 / UC Case 2015-105-0

BACKGROUND

Mechanically flexible piezoelectric materials are highly sought after when building advanced sensors, actuators, and energy scavenger devices. The most common piezoelectric materials used in applications are focused on electroceramic thin films made from lead zirconate titanate or barium titanate. Although these materials can have large piezoelectric moduli, as thin films they are extremely brittle and difficult to shape into highly mechanically compliant structures. Improving mechanical flexibility of piezoelectrics, and creating higher order structures, is critical for driving new applications such as biological energy harvesting, compact acoustic transducers, and in vivo biodiagnostics. There is a need to develop alternative materials that offer high piezoelectric coefficients while maintaining elasticity and isotropic mechanical integrity—that are also cheap to produce.

TECHNOLOGY DESCRIPTION

Researchers from UC San Diego have invented and patented a process to create highly elastic piezoelectric polymers that maintain 3D structural isotropy (properties of a material are the same in all directions) and strong piezoelectric behavior. This technology leverages a piezoelectric nanoparticle-polymer composite blend that can be cheaply and easily processed into a variety of shapes. The final material is extremely light and stretchable while retaining excellent piezoelectric properties.



STATE OF DEVELOPMENT

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OTHER INFORMATION

CATEGORIZED AS

- **Energy**
  - Other
- **Materials & Chemicals**
  - Nanomaterials
- **Nanotechnology**
  - Materials

RELATED CASES

2015-105-0

Power studies indicated that these materials can operate under mechanical loads and have enough power to drive low power devices. Given the tunable porosity, mechanical flexibility of the foams, high surface area, high piezoelectric sensitivity, isotropic microstructure, and more biocompatible chemical makeup compared to bulk electroceramics, these foams should find immediate applications in energy scavenging platforms, biosensors, and acoustic transducers. Patent rights are available for licensing in the USA.

Techniques, systems , and devices are disclosed for implementing fabrication of stretchable nanoparticle-polymer composite structures, such as foams that exhibit piezoelectric properties. The mechanical and electrical properties of the material can be tuned based on the level of porosity introduced as well as compositional variations such as loading fractions of nanoparticles. The disclosed stretchable nanoparticle-polymer composite structures that exhibit piezoelectric properties can have various applicationsincluding high resolution, compact ultrasonic imaging instruments; acoustic sensors; chemical sensors; mechanical actuators; biodiagnostic materials (e.g ., microfluidics , small molecule force sensing); remote interfacing (e.g., acoustic detection) with portable electronics ; and energy scavenging.

RELATED MATERIALS

- McCall WR, K Kim, C Heath, G La Pierre, and DJ Sirbuly. Piezoelectric Nanoparticle–Polymer Composite Foams. ACS Appl. Mater. Interfaces, 2014, 6 (22), pp 19504–19509 (29-Oct-2014). - 10/29/2014

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,199,560	02/05/2019	2015-105

Additional Patents Pending

OTHER INFORMATION

Two US Patents are available for commercial development:

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)

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(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**

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Related U.S. Application Data

(60) Provisional application No. 62/093,927, filed on Dec. 18, 2014.

(51) **Int. Cl.**

B29C 67/20	(2006.01)
B29K 75/00	(2006.01)
B29K 83/00	(2006.01)
H01L 41/37	(2013.01)
B29K 105/00	(2006.01)
B29K 105/16	(2006.01)
H01L 41/18	(2006.01)

(52) **U.S. Cl.**

CPC ***H01L 41/183*** (2013.01); ***B29C 67/202*** *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.

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(57) **ABSTRACT**

Methods, systems, and devices are disclosed for implementing a stretchable nanoparticle-polymer composite foams that exhibit piezoelectric properties. In one aspect, a nanoparticle-polymer composite structure includes a curable liquid polymer; piezoelectric nanoparticles; and graphitic carbons.

Patent No. 11,171,281

(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)

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(*) 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**

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Related U.S. Application Data

(63) Continuation of application No. 14/974,582, filed on Dec. 18, 2015, now Pat. No. 10,199,560.

(60) Provisional application No. 62/093,927, filed on Dec. 18, 2014.

(51) **Int. Cl.**

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B29K 105/00	(2006.01)
B29K 75/00	(2006.01)
B29K 105/16	(2006.01)

(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.

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Primary Examiner — C Melissa Koslow
(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(57) **ABSTRACT**

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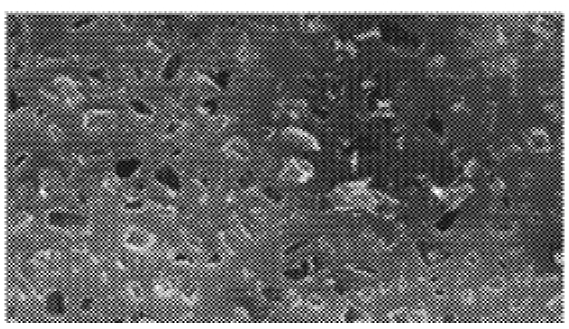
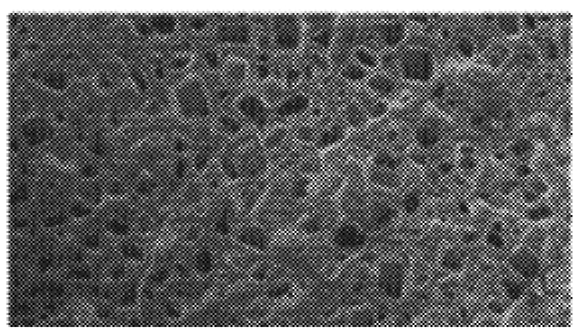
20 Claims, 17 Drawing Sheets





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