Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Recent progress in the development of dielectric elastomer materials and their multilayer actuators

Cite this as: Shengchao JIANG, Junbo PENG, Lvting WANG, Hanzhi MA, Ye SHI, 2024. Recent progress in the development of dielectric elastomer materials and their multilayer actuators. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 25(3):183-205.
https://doi.org/10.1631/jzus.A2300457

Two Research Trends

Dielectric Elastomer

Material Innovation

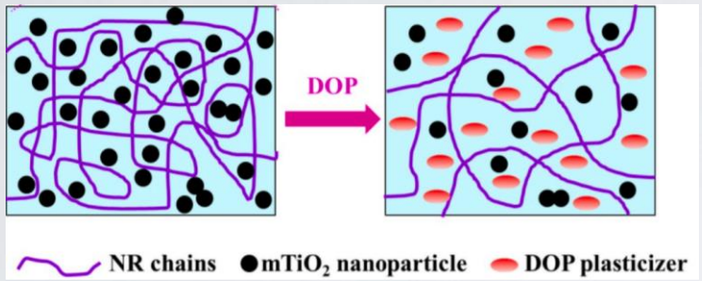
- Reducing stiffness
- Increasing dielectric permittivity
- Suppressing viscoelasticity loss
- Suppressing electromechanical instability

Multilayer Stacking Method Innovation

- Conventional Dry Stacking
- Wet Stacking
- Novel Dry Stacking
- Stacking with micro-fabrications

Trend 1 – Material Innovation

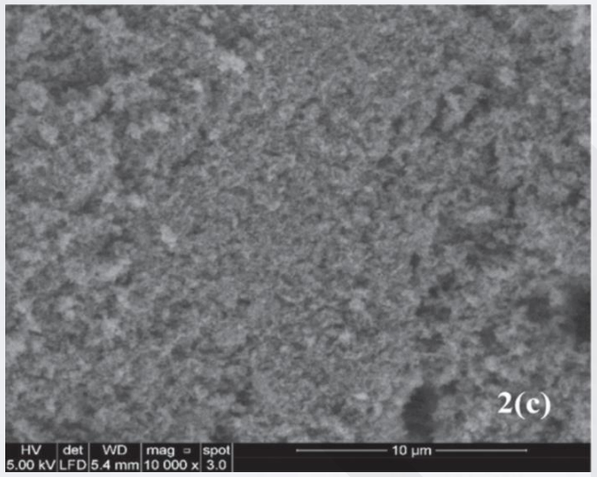
- Reducing stiffness



DOP Plasticizer

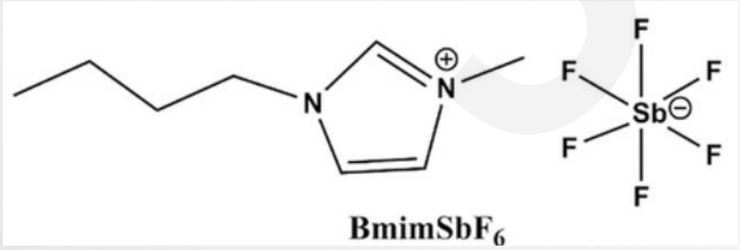
Composites Science and Technology 195 (2020)

- Increasing dielectric permittivity



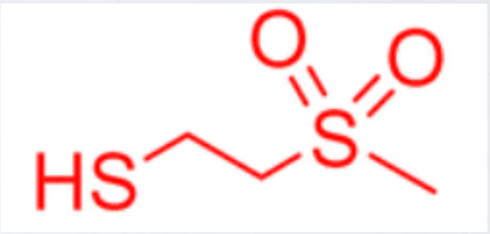
Conductive Fillers - TiO_2

Smart Mater. Struct. 23, 10 (2014)



Ionic Liquids

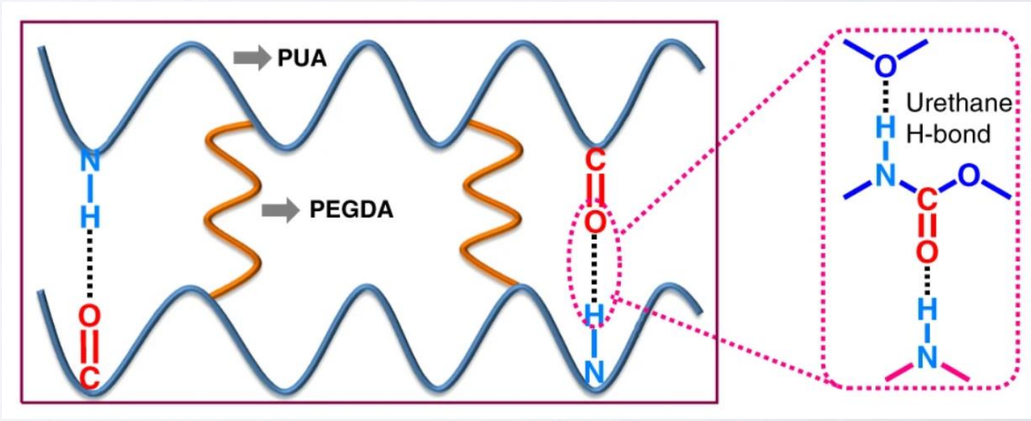
Adv. Eng. Mater. 21, 10 (2019)



Polar Groups

J. Mater. Chem. C, 11, 7367 (2023)

- Suppressing viscoelasticity loss

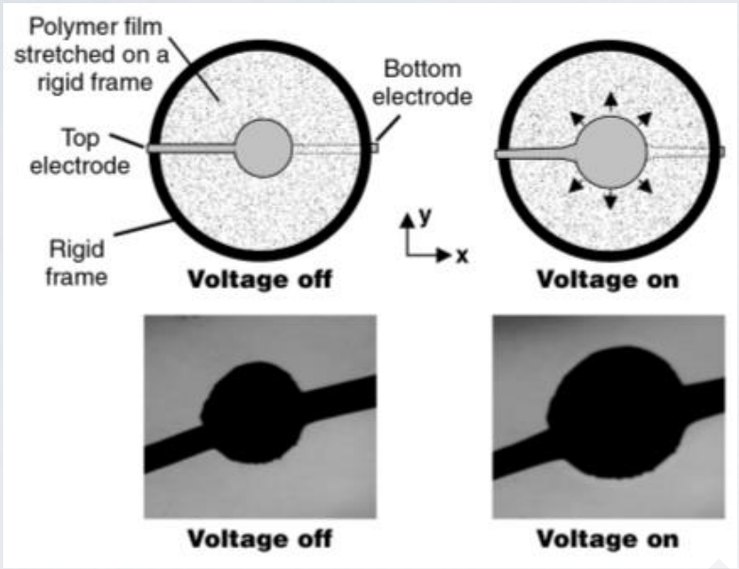


Copolymerization with polar crosslinker

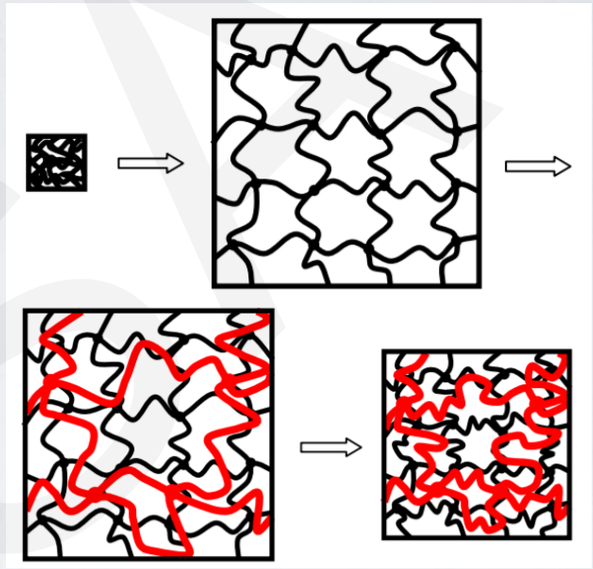
NPG Asia Materials 11, 62 (2019)

Trend 1 – Material Innovation

- Suppressing electromechanical instability with pre-strain

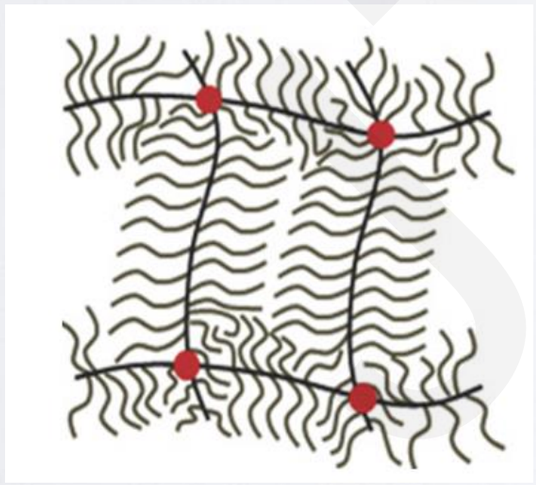


Pre-stretching with rigid frame
Science 287, 5454(2000)

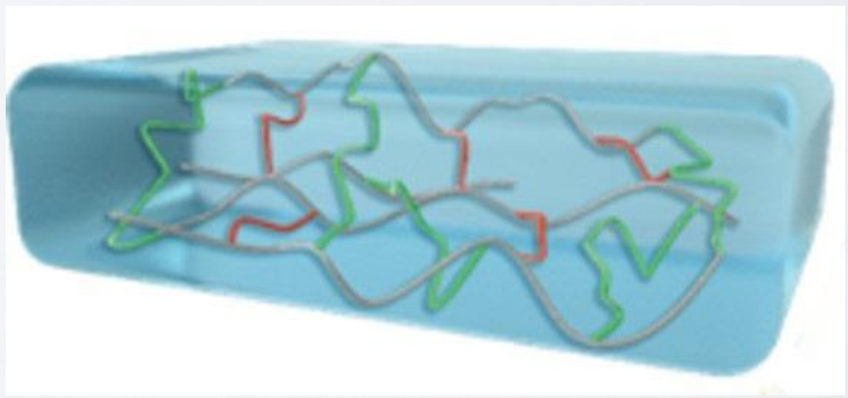


Interpenetrating Polymer Network
Smart Mater. Struct. 16, 2 (2007)

- Suppressing electromechanical instability without pre-strain



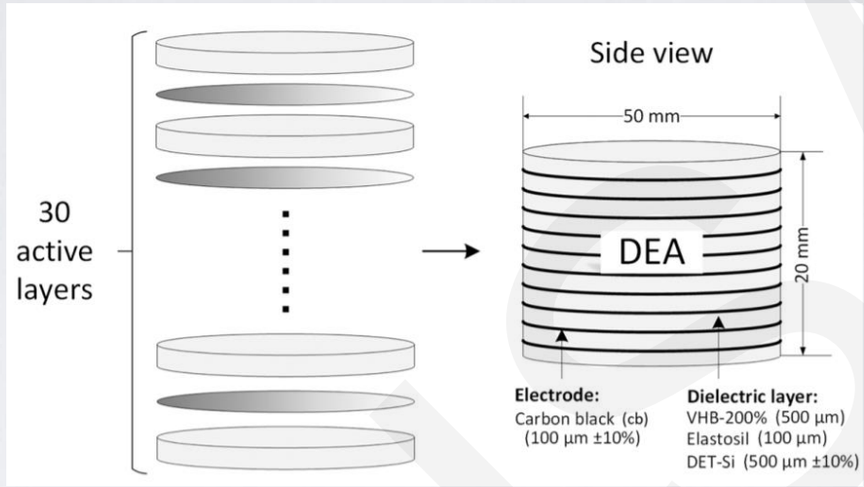
Bottlebrush Polymer
Advanced Materials 29, 2 (2017)



Bimodal Network Polymer
Science 377, 6602 (2022)

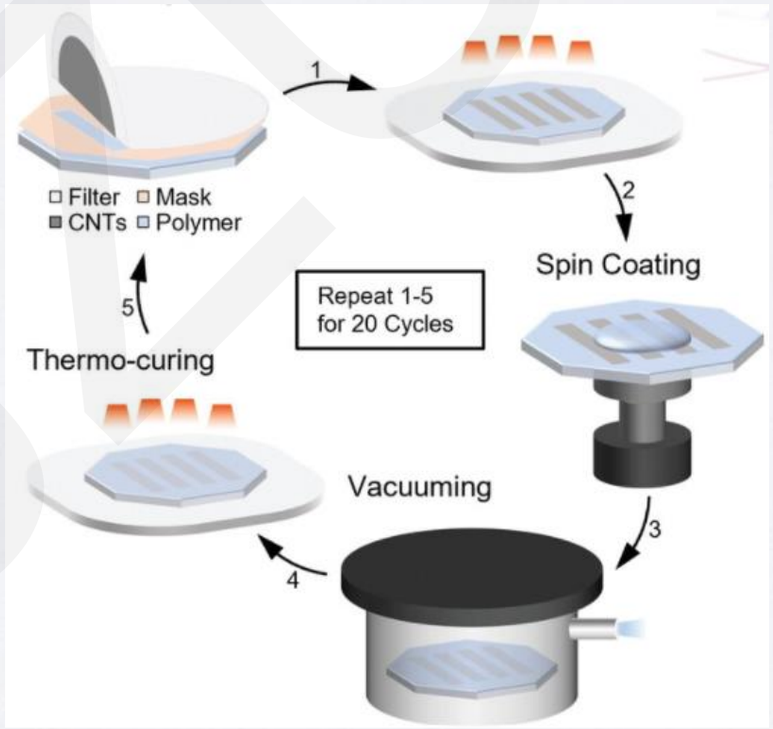
Trend 2 – Multilayer Stacking

- Conventional Dry Stacking



Chemical Engineering Journal 364 (2019)

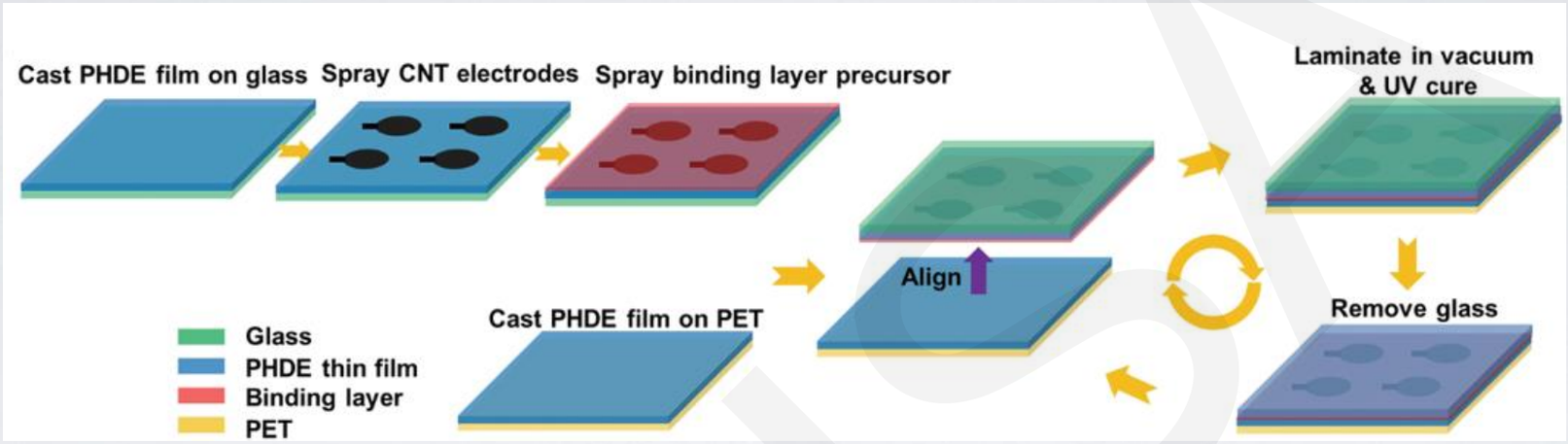
- Wet Stacking



Adv. Mater. 34, 7 (2022)

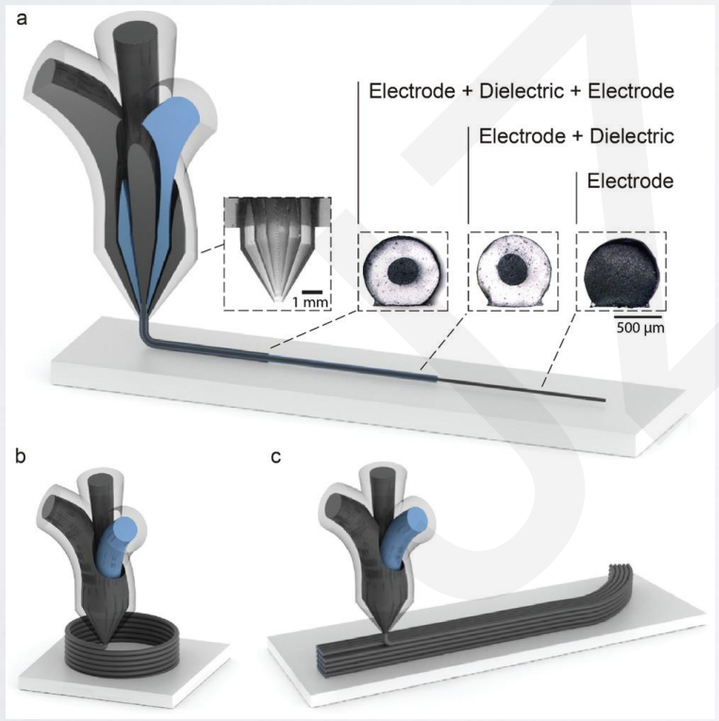
Trend 2 – Multilayer Stacking

- Novel dry stacking



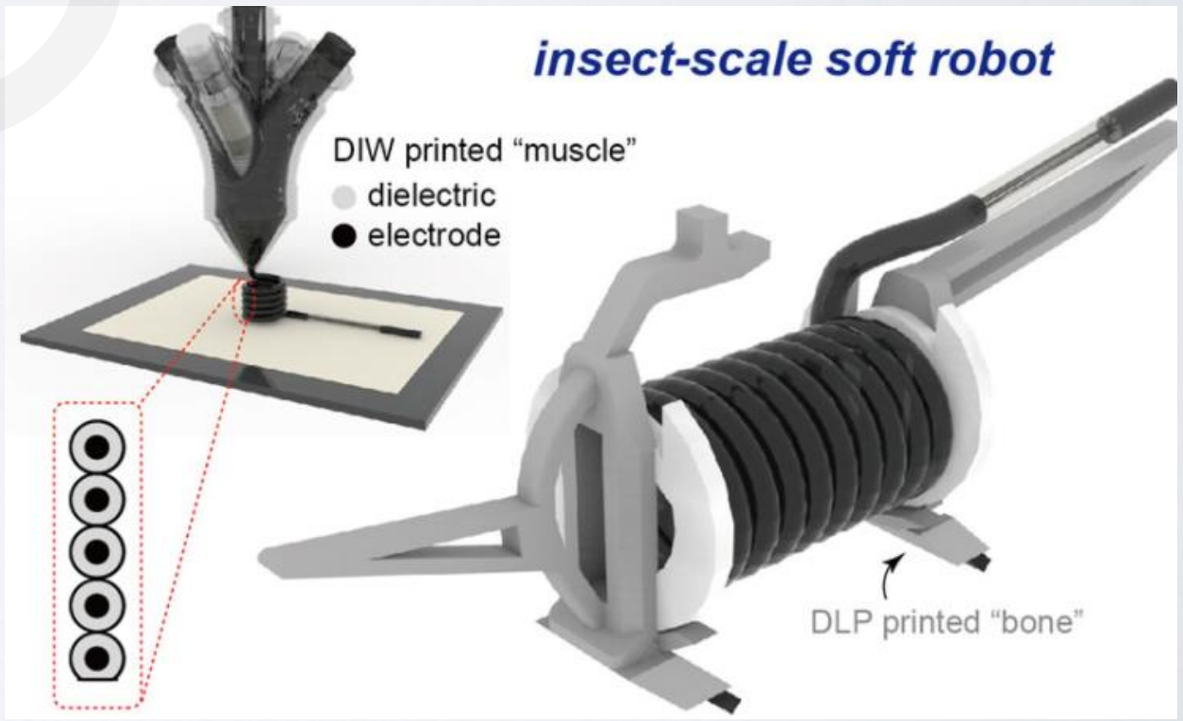
Science 377, 6602 (2022)

- Micro-fabrication



3D Printing

Adv. Funct. Mater. 31, 22 (2021)



3D Printing

ACS Materials Lett. 5, 3 (2023)

Research Priorities

Material Innovation

- large and stable actuation under high frequencies
- long-term stability
- high environment tolerance
- work safety under high-voltage input

Multilayer Stacking Methods

- ultrathin films
- manufacturing scalability