Renewable, Biodegradable MEMS Devices Made From Cellulose

Auburn is seeking a licensee or development partner for cellulose-based microelectromechanical systems (MEMS).

Overview: MEMS devices have seen broad adoption in the transportation, communication, medical, and consumer product industries. However, the vast majority of MEMS are based on silicon and fabricated using expensive, energy intensive processing with harsh chemicals. Cellulose-based MEMS devices offer an alternative that is not only greener, but also anticipated to be less expensive and to enable new applications. This technology has potential applications in the following economic sectors:

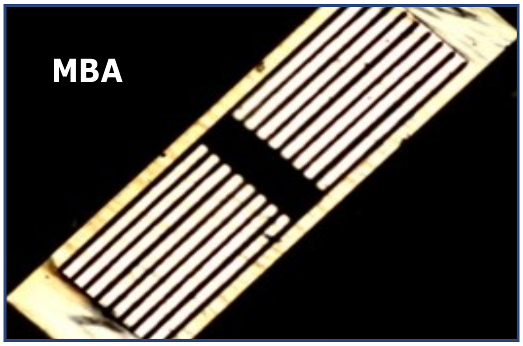
- Bio-MEMS: Point-of-care diagnostics, lab-on-a-chip, high throughput screening
- Sensors: Air pollution detection, water contamination detection
- Consumer electronics: computing, cell phones, optical switches
- Defense & Communications: Resonance systems, signal conditioning

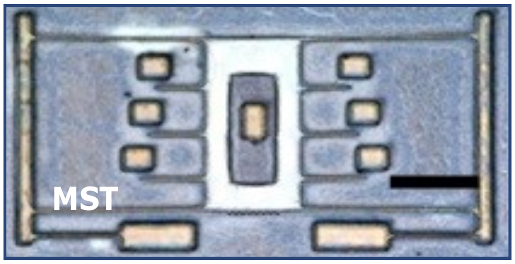
Advantages:

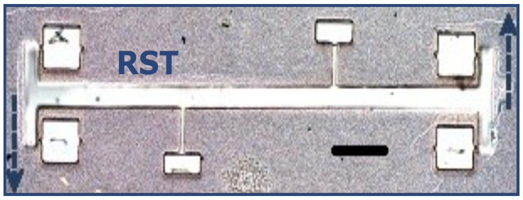
- **COST-EFFECTIVE —** Uses lower temperatures and milder, cheaper chemicals vs. silicon
- **SCALABLE —** Anticipated to be scalable using established methodologies
- **DISPOSABLE —** Cellulose is biodegradable, ideal for disposable point-of-care applications
- **ORGANIC** — Organic chemistry of cellulose enables biological functionalization with significant potential for unique medical and life science applications
- **ANISOTROPIC** — Directionally-dependent properties enable applications in resonance systems, mechanical filters and optical switches

Status:

- Subject of US Patents 9,353,313 and 9,890,259
- Numerous functional MEMS devices have been created and demonstrated, including microcantilever beam arrays (MBA), mechanical strength testers (MST), residual stress testers (RST), doubly clamped beam arrays (DCB), and circular diaphragm resonators
- This technology is available for exclusive or non-exclusive licensing







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Reference:

Saha, et al, ACS Appl. Mater. Interfaces, 2018, 10 (28), pp 24116–24123 (link)

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Renewable, Biodegradable MEMS Devices Made From Cellulose *(Cont'd)*

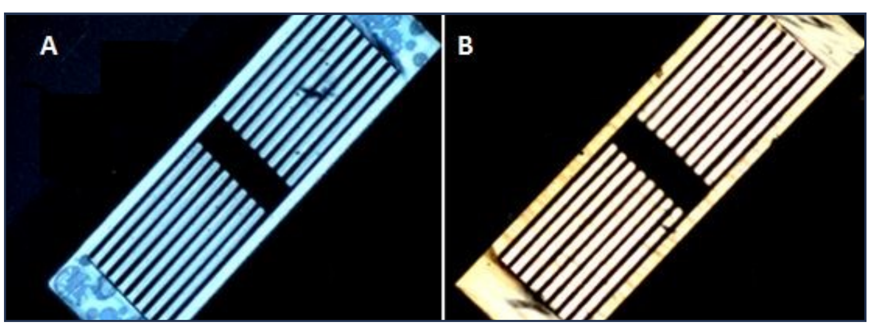
Description: MEMS are complex devices used in sensing and actuation on a micrometer scale. They are a key, but often hidden part of numerous products in the transportation, electronic, medical, and consumer products industries. Micromachining technology for MEMS was derived from integrated circuit fabrication. Thus, silicon has been the material of choice, with the market expected to grow to $20 billion by 2020. However, silicon MEMS have significant disadvantages. Silicon fabrication is energy intensive, requiring processing temperatures on the order of 1000ºC, while etching uses hazardous solvents.

Further, silicon is limited in terms of the range of microstructural and chemical functionalities that can be achieved. For these reasons, polymer MEMS are emerging as an alternative for some applications. Polymer MEMS have some advantages of lower cost, easier fabrication, biocompatibility, and greater ductility. However, they are typically limited in terms of mechanical properties and thermal stability.

Cellulose is a naturally abundant, renewable, and biodegradable material. Cellulose nanocrystal (CNC) film-based MEMS devices can be made using simple fabrication techniques. Process temperatures range from 25-80ºC, and solvents such as isopropanol are used instead of more hazardous hydrofluoric acid or phosphine. CNC MEMS combine the advantages of silicon and polymer MEMS while providing new potential functionalities.

CNC MEMS are lower cost and greener than silicon, have more desirable physical properties (e.g., intrinsic elastic modulus and thermal stability) than polymer materials, can be processed using conventional lithography and wet etching techniques (unlike polymers) and have unique characteristics that enable new functionalities. Such characteristics include:
1.) anisotropy: the ability to achieve different mechanical and optical properties in different directions, enabling new applications in resonance systems, mechanical filters and optical switches, and 2.) organic surface chemistry: opening the door to unique functionalization possibilities in biomedical applications, including lab-on-a-chip, point-of-care diagnostics and other BioMEMS — a rapidly growing subset of the MEMS market.

Actuatable micromechanical devices made from CNC films (see other side) were freestanding and possessed tunable mechanical and optical properties as a function of device thickness and direction of applied shear of the films. Such readily tailorable anisotropic mechanical properties cannot be achieved in traditional silicon MEMS fabrication. For example, microcantilever beam arrays of differing thicknesses produced different birefringence induced interference colors (A: 2µm; B: 4µm). Such optical properties may create new opportunities for optical MEMS.



Early Stage | Prototype | Pilot | Market Ready