Goal
- Enhanced aerosol jet printed sensor design via contact angle goniometry and custom mechanical test fixtures to inform material selection and cyclic test design
- Key metrics – surface wettability and cyclic loading for printed circuit implanted in the arm

Advanced Testing of Printed Flexible Sensors: Contact Angle and Bending Fatigue Analyses

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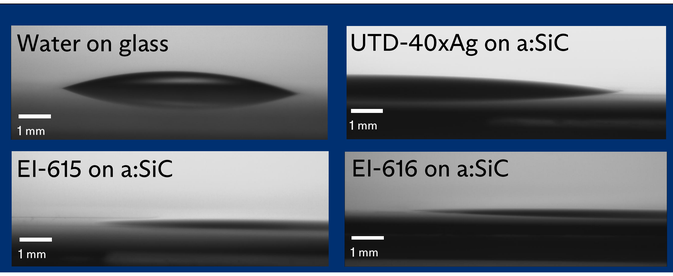
Contact angle goniometry: Assessing ink and substrate interactions

Keys for the experiment…
- Test 3 silver inks on an amorphous silicon carbide (a:SiC) substrate to assess wettability
- Use contact angle goniometer to image and analyze angle between ink and a:SiC surface
- Lower angles should indicate higher wettability and better adhesion, guiding ink selection for optimal sensor performance

Materials and Methods

- Deposited droplets from three different silver inks onto a:SiC surface
- Used contact angle goniometer to capture droplet profiles and measure the angles formed at the ink-substrate interface
- Analyzed and recorded contact angles to evaluate wettability

- Cleaned substrates with isopropyl alcohol
- Performed calibration with water droplet on a glass slide
- Obtained silver nanoparticle (UTD-40xAg) and silver precursor inks (EI-615, EI-616)



Results

Type of Ink	UTD-40xAg	EI-615	EI-616
Contact Angle	7.9°	5.6°	4.3°

- Water on glass = 33.2° compared to 33° ± 2° [1]
- EI-616 ink exhibited highest wettability
- Findings support selection of EI-616 for optimal ink wettability to the a:SiC substrate

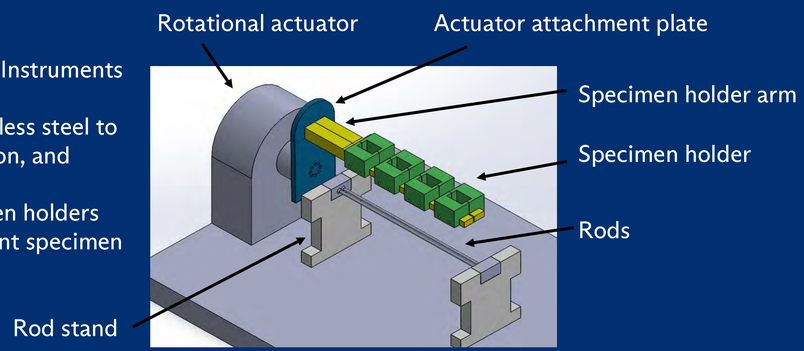
[1] Y Sun, et al., *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, (591) 2020.

Design of bending fatigue testing apparatus and protocol

Keys for the design…
- Replicate worst-case scenario conditions for handling and in-vivo applied strains
- Design custom fixtures for rotational actuator to apply cyclic bending conditions to flexible sensors
- Create a model for use in Ansys finite element analysis (FEA) to evaluate applied stresses on custom fixture and strains on specimens

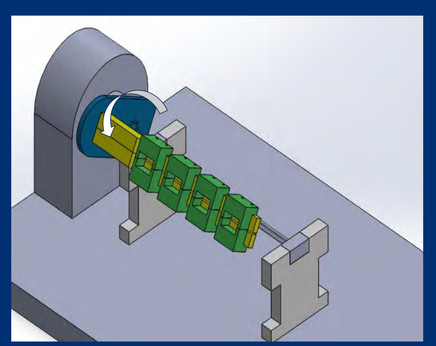
Materials and Methods

- Obtained measurements from TA Instruments ElectroForce actuator
- Selected Delrin and polished stainless steel to ensure light weight, minimal friction, and corrosion resistance
- Rods, rod separation, and specimen holders designed to accommodate different specimen sizes



Proposed Test Protocol

- Apply 5 mm diameter stainless steel rods to stand
- Load specimens into holders and between rods
- Apply cyclic bending motion (0 ± 90°) to mimic worst-case strains at frequency of 1 Hz for 20 cycles to simulate handling during fabrication and surgery
- Repeat with 2 cm diameter rod for 1 million cycles to simulate chronic in vivo movement



Future Work

- Fabricate design elements
- Test protocol with witness specimen

Expectations
- Test results will provide information on mechanical reliability of the sensors
- Validated FEA will estimate applied strains to inform design decisions
- Results cannot simulate exact in vivo conditions, but will be useful for quickly approximating whether a design will meet desired requirements

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