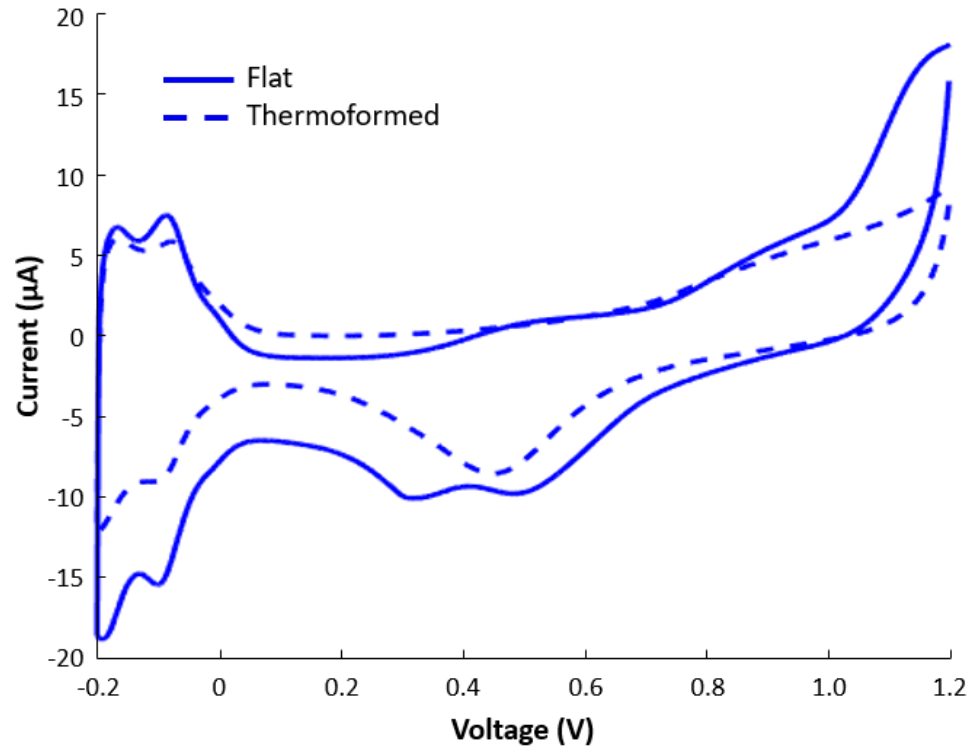


# Electrochemical Testing: CV



## Sulfuric Acid, 250 mV/s



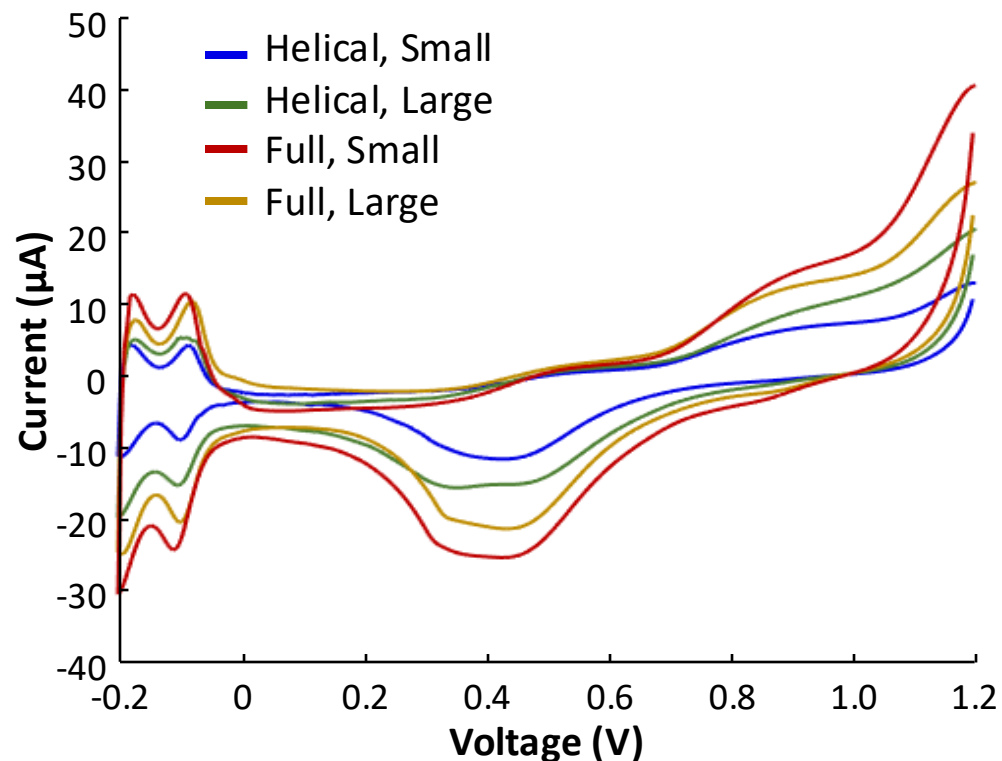
$$\text{Electrochemical Surface Area} = \frac{\text{H}^+ \text{ Desorption Charge}}{\left( \text{Charge Density of H}^+ \right) \left( \text{Atoms Adsorped to Pt} \right)}$$

$$\text{Charge Storage Capacity} = \frac{\text{Cathodic Charge}}{\text{Geometric Surface Area}}$$

# Electrochemical Testing: CV



## Sulfuric Acid, 250 mV/s, Flat

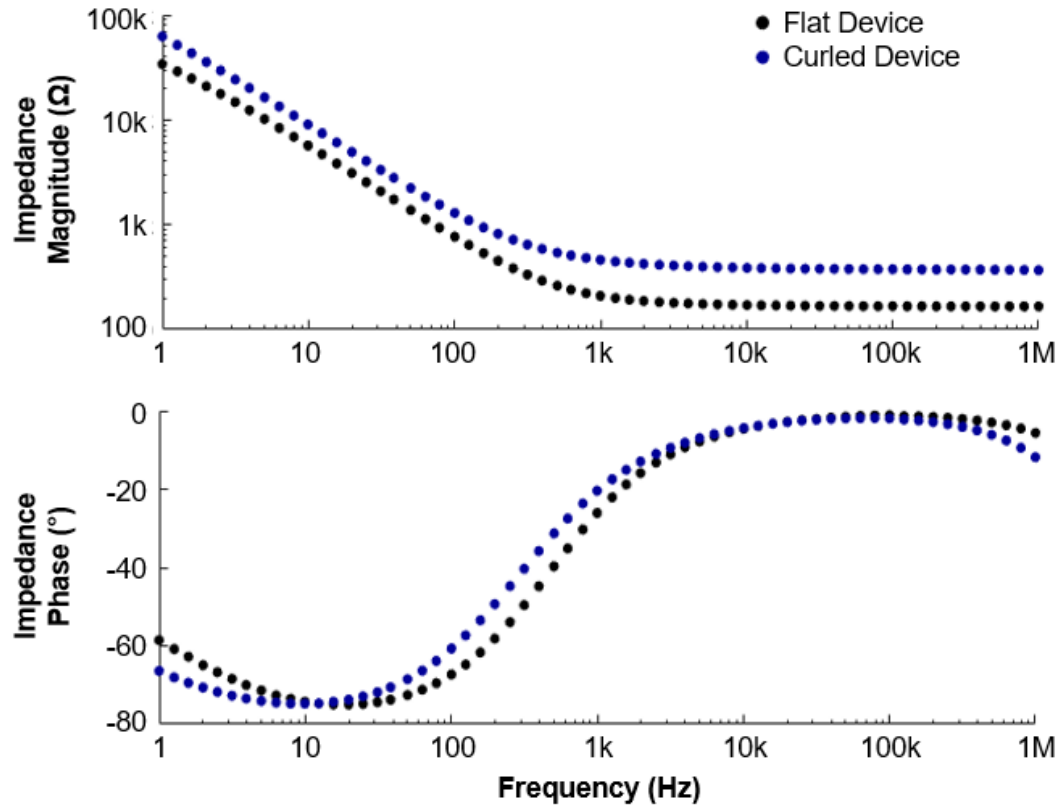


$$\text{Electrochemical Surface Area} = \frac{\text{H}^+ \text{ Desorption Charge}}{\left( \frac{\text{Charge Density of H}^+}{\text{Atoms Adsorbed to Pt}} \right)}$$

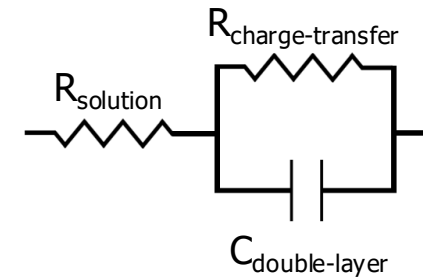
$$\text{Charge Storage Capacity} = \frac{\text{Cathodic Charge}}{\text{Geometric Surface Area}}$$

| Device Configuration |        | GSA (mm <sup>2</sup> ) | ESA (mm <sup>2</sup> ) | CSC (µC/cm <sup>2</sup> ) |
|----------------------|--------|------------------------|------------------------|---------------------------|
| Helical Small        | Flat   | 1.7                    | 1.3 ± 0.3              | 1549 ± 167                |
|                      | Curled | 1.7                    | Insufficient Data      |                           |
| Helical Large        | Flat   | 2.8                    | 2.6 ± 0.9              | 1537 ± 136                |
|                      | Curled | 2.8                    | 1.8 ± 0.6              | 1365 ± 208                |
| Full Small           | Flat   | 4                      | 3.1 ± 1.1              | 1481 ± 209                |
|                      | Curled | 1.7                    | 2.3 ± 0.8              | 3107 ± 831                |
| Full Large           | Flat   | 3.4                    | 3.0 ± 0.7              | 1571 ± 176                |
|                      | Curled | 1.6                    | Insufficient Data      |                           |

# Electrochemical Testing: EIS



Randles Circuit

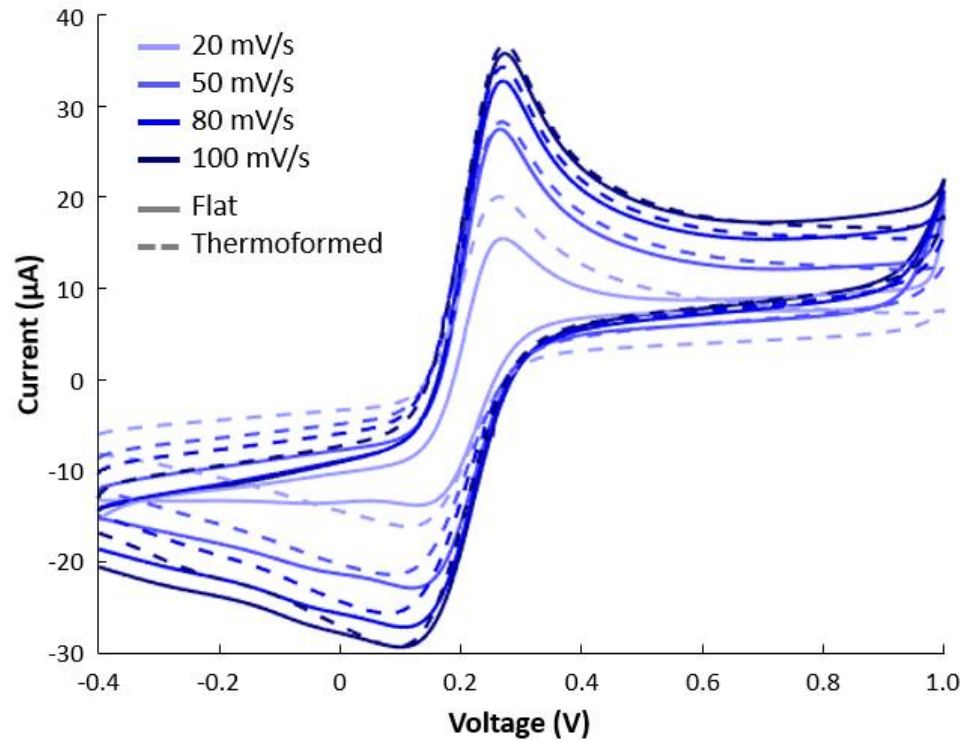


| Device Configuration |        | $ Z $ @ 1 kHz ( $\Omega$ ) |
|----------------------|--------|----------------------------|
| Helical Small        | Flat   | No Data                    |
|                      | Curled | $300 \pm 37$               |
| Helical Large        | Flat   | $218 \pm 15$               |
|                      | Curled | $206 \pm 14$               |
| Full Small           | Flat   | No Data                    |
|                      | Curled | $563 \pm 178$              |
| Full Large           | Flat   | $184 \pm 18$               |
|                      | Curled | No Data                    |

# Electrochemical Testing: CV



## Ferri/Ferro



Electrochemical Surface Area  $\propto \frac{\text{Peak Current}}{\sqrt{\text{Scan Rate}}}$

$$i_p = 0.4463nFC \sqrt{\frac{nFvD}{RT}} \times (ESA)$$

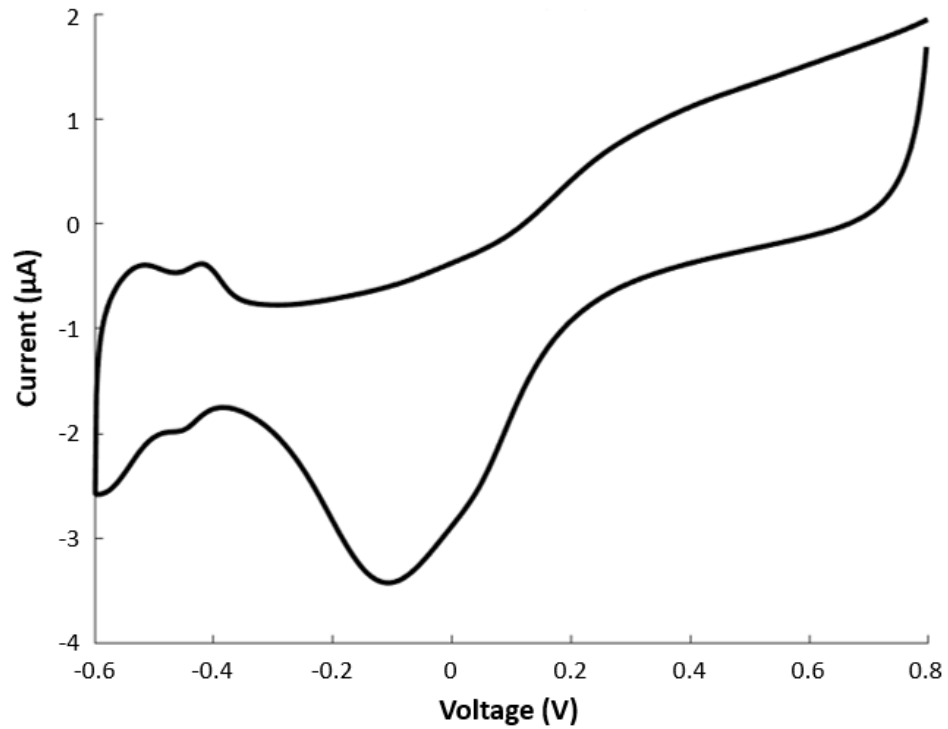
| Device Configuration |      | GSA | ESA <sub>FF</sub>         | ESA <sub>H2SO4</sub>      | ESA <sub>FF</sub> / ESA <sub>H2SO4</sub> |
|----------------------|------|-----|---------------------------|---------------------------|--|
| Helical Small        | Flat | 1.7 | 3.3 ± 0.2 mm <sup>2</sup> | 3.0 ± 0.3 mm <sup>2</sup> | 1.1 ± 0.1                                |
|                      | TF   | 1.7 | 2.8 ± 0.3 mm <sup>2</sup> | 2.1 ± 0.4 mm <sup>2</sup> | 1.4 ± 0.2                                |
| Full Small           | Flat | 4.0 | 7.6 ± 0.3 mm <sup>2</sup> | 6.6 ± 0.5 mm <sup>2</sup> | 1.2 ± 0.1                                |
|                      | TF   | 1.7 | 5.7 ± 0.5 mm <sup>2</sup> | 4.3 ± 0.8 mm <sup>2</sup> | 1.4 ± 0.3                                |
| All Devices          | Flat | --  | --                        | --                        | 1.1 ± 0.1                                |
|                      | TF   | --  | --                        | --                        | 1.5 ± 0.4                                |

*TF = Thermoformed, GSA = Geometric Surface Area, ESA = Electroactive Surface Area, FF = Ferri/Ferrocyanide*

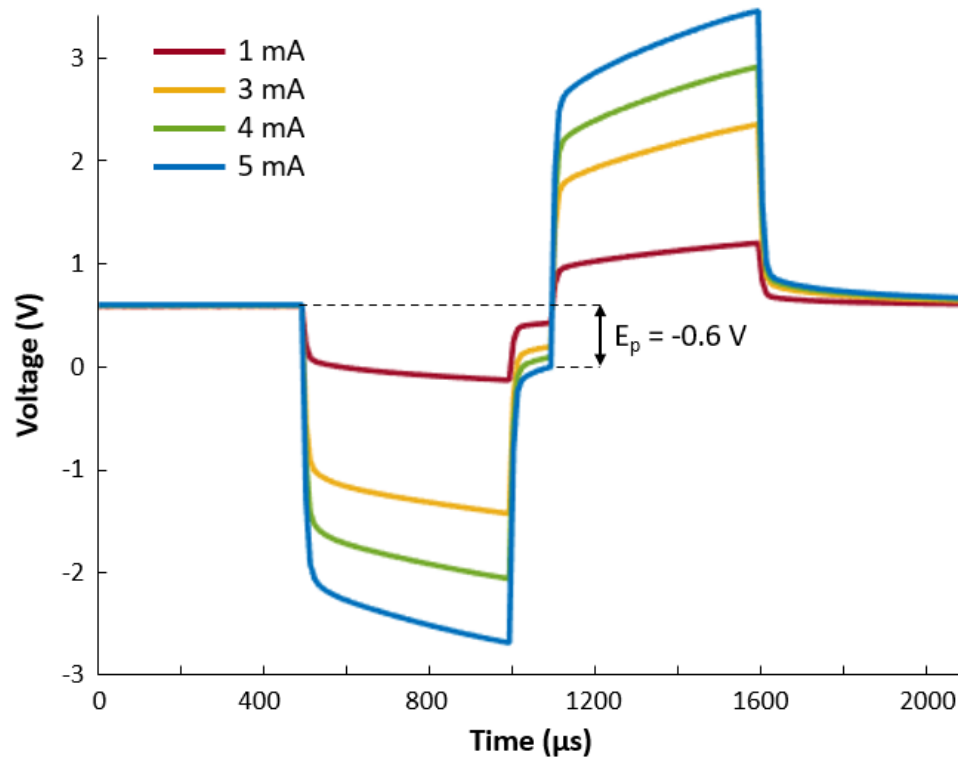
# Electrochemical Testing: CV



**PBS, 50 mV/s, Curled**



## VT, 1x PBS (thermoformed)



$$\text{Charge Injection Capacity} = \frac{\left( \text{Current at } E_p \text{ Limit} \right) \times (\text{Pulse Width})}{\text{Geometric Surface Area}}$$

| Device Configuration |        | CIC<br>( $\mu\text{C}/\text{cm}^2$ )<br>@ 200 $\mu\text{s}$ | $I_{\text{max}}$<br>(mA) | CIC<br>( $\mu\text{C}/\text{cm}^2$ )<br>@ 500 $\mu\text{s}$ | $I_{\text{max}}$<br>(mA) |
|----------------------|--------|---|--------------------------|---|--------------------------|
| Helical Small        | Curled | $78 \pm 11$   | 6.6                      | $131 \pm 43$  | 4.4                      |
| Helical Large        | Curled | $70 \pm 3$  | 9.8                      | $93 \pm 4$  | 5.2                      |
| Full Small           | Curled | $101 \pm 20$  | 8.6                      | $177 \pm 48$  | 6.0                      |
| Full Large           | Curled | Insufficient Data   |                          |   |                          |
| Average              | Curled | $92 \pm 21$   | -                        | $155 \pm 52$  | -                        |

# Electrochemical Testing Summary



| Device Configuration |           | GSA<br>(mm <sup>2</sup> ) | ESA<br>(mm <sup>2</sup> ) | CSC<br>(μC/cm <sup>2</sup> ) | Z <br>@ 1 kHz<br>(Ω) | CIC<br>@ 200 μs<br>(μC/cm <sup>2</sup> ) | CIC<br>@ 500 μs<br>(μC/cm <sup>2</sup> ) |
|----------------------|-----------|---------------------------|---------------------------|------------------------------|----------------------|--|--|
| Helical,<br>Small    | Pre-TF    | 1.7                       | 1.3 ± 0.3                 | 1549 ± 167                   | -                    | -  | -  |
|                      | TF curled | 1.7                       | -                         | -                            | 300 ± 37             | 78 ± 11                                  | 131 ± 43                                 |
| Helical,<br>Large    | Pre-TF    | 2.8                       | 2.6 ± 0.9                 | 1537 ± 136                   | 218 ± 15             | -  | -  |
|                      | TF flat   | 2.8                       | 2.4 ± 0.4                 | 1469 ± 126                   | 234 ± 59             | 66 ± 13                                  | 91 ± 6                                   |
|                      | TF curled | 2.8                       | 1.8 ± 0.6                 | 1365 ± 208                   | 206 ± 14             | 70 ± 3                                   | 93 ± 4                                   |
| Full,<br>Small       | Pre-TF    | 4                         | 3.1 ± 1.1                 | 1481 ± 209                   | -                    | -  | -  |
|                      | TF curled | 1.7                       | 2.3 ± 0.8                 | 3107 ± 831                   | 563 ± 178            | 101 ± 20                                 | 177 ± 48                                 |
| Full,<br>Large       | Pre-TF    | 3.4                       | 3.0 ± 0.7                 | 1571 ± 176                   | 184 ± 18             | -  | -  |
|                      | TF flat   | 3.4                       | -                         | -                            | 208 ± 27             | 130 ± 16                                 | 178 ± 7                                  |
|                      | TF curled | 1.6                       | -                         | -                            | -                    | -  | -  |
| Average              | Pre-TF    | -                         | -                         | 1526 ± 178                   | -                    | -  | -  |
|                      | TF flat   | -                         | -                         | 1469 ± 126                   | -                    | 107 ± 35                                 | 149 ± 43                                 |
|                      | TF curled | -                         | -                         | 2672 ± 1072                  | -                    | 92 ± 21                                  | 155 ± 52                                 |