# Hybrid Artificial Muscle Robot (HAMR): Exosuit Building Block

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**Introduction**

About 8.4 million people in the United States had mobility disorder in 2016( Okoro, Hollis, Cyrus, & Griffin-Blake, 2018). In the United States, the increase in the aging population may expand the population of people with mobility disorders for the next decades (Bach, Ziegler, Deuschi, Dodel, & Doblhammer-Reiter, 2011).

Recent research research has shown that depression features were apparent in the individuals with varying mobility disabilities (Miller et al., 2007). Rheumatoid Arthritis, For rheumatoid arthritis, one of many mobility disorders, individuals with more social support presented higher life satisfaction (Treharne, Kitas, Lyons, & Booth, 2005). The social support related to movement may be more favorable than emotional integration in the long-term diagnosis of RA (Treharne et al., 2005).

Exoskeletons have been researched to provide functional support for the movement disorder individuals (Esquenazi, Talaty, Packel, & Saulino, 2012). However, exoskeletons, desgined to support partial body movements, may provide improved functional movement, but may not allow for a full range of abilities and independence due to the exoskeleton supplements such as crutches (Esquenazi et al., 2012). Like ReWalk exoskeletons, many of these exoskeletons have restricted motions(Esquenazi et al., 2012).

Providing the human-like movement by developing soft actuators, which have flexible movement compared to traditional mechanical actuators, has been attested(Kellaris, Venkata, Smith, Mitchell, & Keplinger, 2018). Electro Hydraulic transducers (EHT), actuators that use electrostatics to contract and expand by coupling electrostatic forces through fluid, have been shown to have fast actuation times, however, energy requirements from 6KV to 10 KV may limit human use (Kellaris et al., 2018). MXene artificial muscles, where thin spring-shaped structure contract and expand at low energy consumption with fast-actuation speeds, may suggest great application for biomedical devices (Umrao, 2019). But these actuators may not allow for self-sustaining and full biological behaviors for individuals with mobility disorders (Umrao, 2019). Full high-level biological behaviors are achieved through combination of movement by low-level components (Li et al., 2019). These artificial muscles does not provide self-sustaining for the individuals to assemble components creating bridge from low level component to the high-level biological movements(Li et al., 2019).

Hybrid Artificial Muscle Robot (HAMR) is a building block of exosuit, exoskeletons that have been made thinner to fit like sportswear (Lee, 2018), that may be assembled to perform high level biological behaviors, may provide the individuals to self sustain with the full biological movements.

**Design & Function**

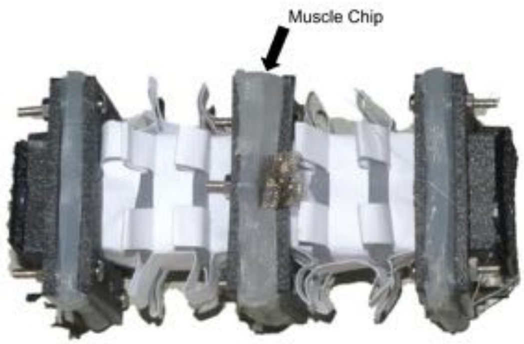


**Figure 1. A HAMR muscle cell unit**

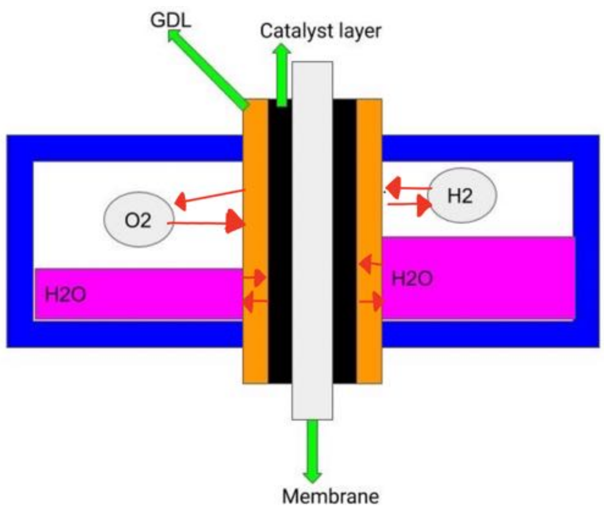


**Figure 2. A HAMR muscle cell**

Each HAMR will be supplied with electricity. The H+ ions from water travels through membrane to the other side, forming hydrogen gas and forming oxygen in the initial chamber. When electricity is turned off, pressure created by the silicones make hydrogen gas go through the separation and hydrogen ion pass through the membrane again to form water by combining with oxygen and electron available at the gas diffusion layer.

**Material/Method**

Fabrication: HAMR body was made from eco flex silicone. Gaskets or cover is carbon fiber/PLA created by 3d printer. Nation membranes, gas diffusion layer, gaskets are used. Current collector is platinized titanium screen. Paper cover was cut and folded(origami) to mimic the fishing net. Data collection: Data was collected using video cameras and electricity meter.

**Results**

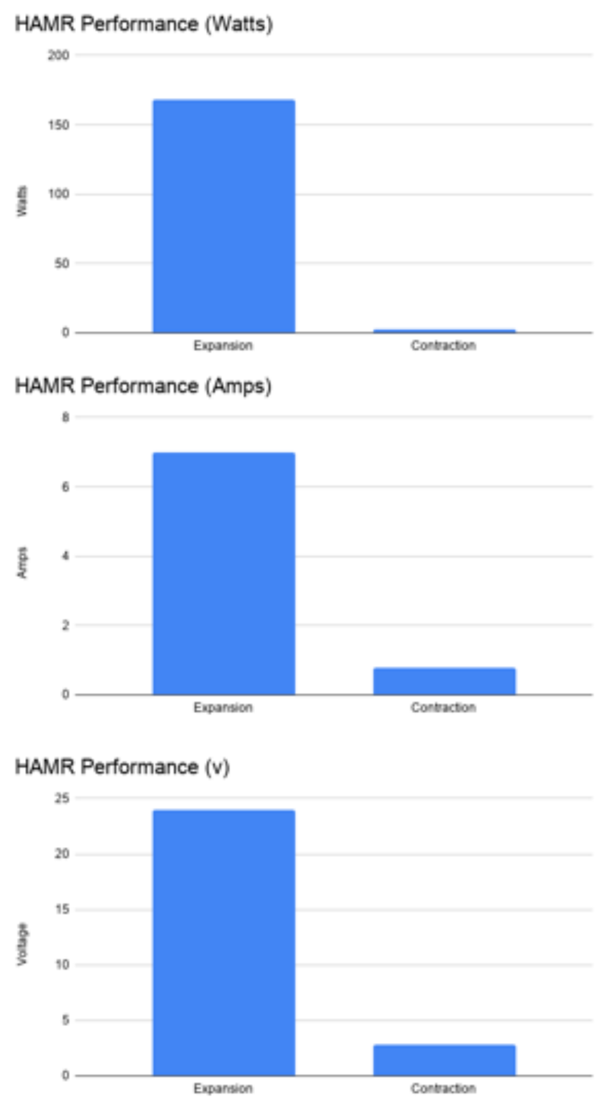

**Figure 3. Energy Graph(voltage, amps, watts are collected through 10 prototypes for 10 trials each)**

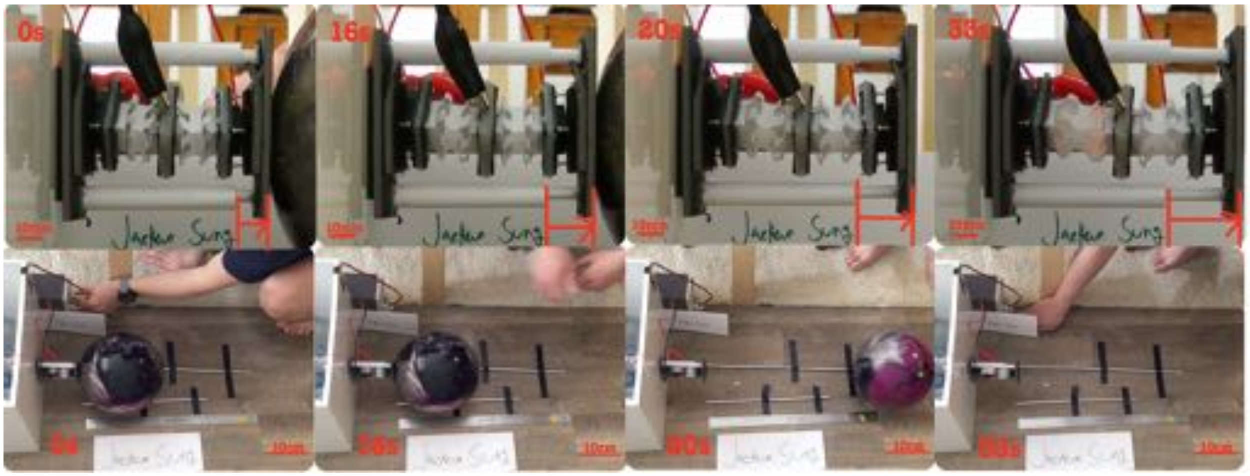

**Figure 4. Vertical Expansion**

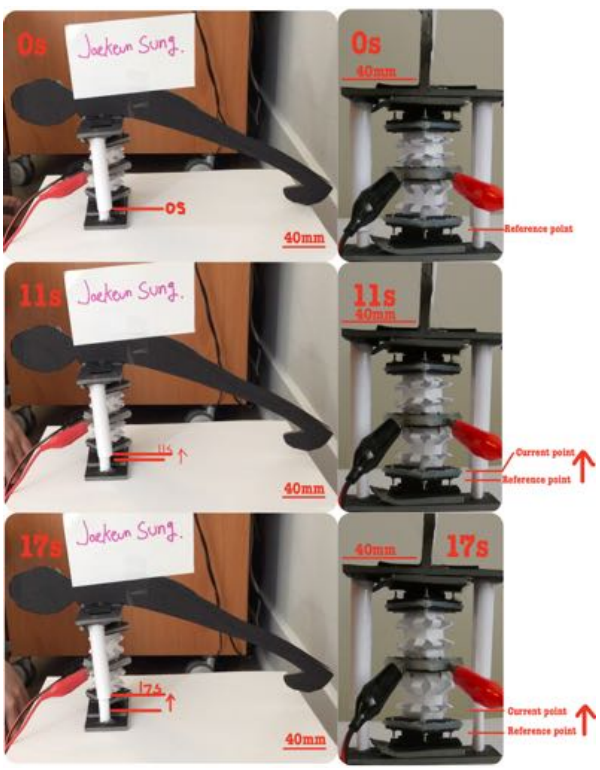


**Figure 5. Horizontal Expansion**

HAMR reaction time was under 3 seconds. At expansion state, energy inputs were 24v, 7 amps, 168 watts overall used. However, energy gain at the contraction state was 2.8v, 0.79 amps, 2.212 watts. Overall, only 1% of its original energy input was produced by HAMR(fig 3).

HAMR expansion length was 2 cm at horizontal position and 3 cm at vertical position (fig 5).

### DIscussion

HAMR only gained 1% of its original energy input. This suggest more improvement is needed to create self-sustainable device. Reaction time was 3 seconds. Device must be improve to make reaction time less than 0.01s, similar to human neurons.

### Conclusion

HAMR may suggest future potential in self sustaining and easy accessible exosuits. In the future, units can be combined in any way the individual wants. At the same time, it will provide robust biological movement through HAMR.

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