White Paper: Switchable Human Skin Adhesive Materials

Bility – Background

Bility is a Research & Development company, committed to revolutionize artificial limbs, utilizing our futuristic conceptual model, synergistic R&D framework and newly developed technologies.

Explain collaborative R&D & funded research

Bility's internal Core R&D mission is to develop nonspecific software, data, functional materials and prototypes that will break conceptual and physical barriers in the development of artificial limbs. To expand our R&D width and fields of expertise that are required to achieve superior products, we have established a multidisciplinary R&D collaboration framework, that will allow to jointly work with added value expert partners in different fields, to achieve groundbreaking technology advances in a predefined list of challenges. One of these challenges is a **Robotic Body Interface.**

Bility Conceptional Artificial Limb Model

We had designed a proprietary conceptual model (Figure 1) of next-generation artificial limbs to inspire and set a path of challenges to be overcome by our core team and collaborators. Our conceptual model addresses a set of problems that we had identified to be a major obstacles and disadvantages in current limb prosthetics, and define the engineering, technological & conceptual properties required to create next generation artificial limb.

Figure 1 – Artificial limb conceptional model.

a. Top level view of Bility's conceptual artificial limb.
b. The active, robotic body interface module

The Robotic Body Interface module

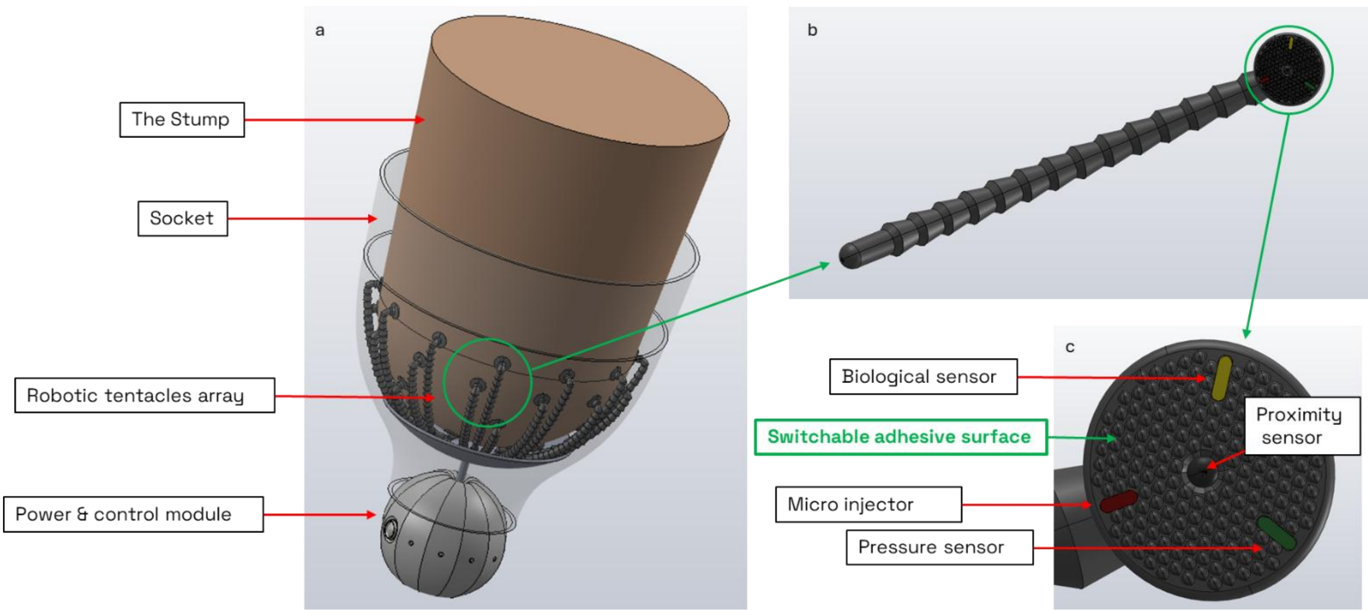
Current limitations and disadvantages of prosthetics body interface

Current body interface is mainly based on non-breathable, silicon sock that is worn tightly around the stump, they are difficult to wear or remove, without the ability to adjust to the stump morphology, while the stump, being a biological organ is subject to many morphological and physiological changes. As a result of the dynamic nature of the stump trapped inside a rigid structure of the body interface, palette of physical and medical problems occurs, including pressure wounds, extensive sweating, skin irritation and blood supply interference.

Conceptual Robotic Body Interface

Therefore, Bility is looking to develop a dynamic, robotic, tentacle-based body interface (Figure 2) which will autonomously connect to the stump, dynamically adjust to the stump morphology, and use our proprietary tentacle tip to sense stump proximity, sense the pressure implied by the robotic tentacle onto the stump tissue, capture physiological and biological information of the stump, and deliver the captured data downstream into the artificial limb platform.

Figure 2 – Robotic body interface model, robotic tentacles and tentacles tip.



a. Components illustration of the robotic body interface model.
b. Conceptional model of a single robotic tentacle.
c. Conceptional model and components of the **tentacle tip**.

What are we looking for and why

We are looking for a collaborator that have the scientific foundation to develop human skin **switchable adhesive material** to be used as the tip surface area material that is in contact with the limb skin and provide effective switchable adhesion properties that are elaborated in the table below.

The development of an effective human skin switchable adhesive material, that allows for reversible adhesion in response to external stimuli, such as electricity, pressure, electromagnetic fields, or light. can revolutionize the way amputees engage with their artificial limbs. These materials offer the potential to significantly enhance the interface between the artificial limb and the human body, addressing major challenges such as pressure wounds, skin irritation, ventilation and the need for frequent fitting.

Materials designed for human skin switchable adhesion should be safe, bio-compatible, elastic, and responsive to external stimuli, while maintaining stable adhesion, effective switching response time and lasting durability in changing environmental conditions.

Important Attributes:

Mechanism of action	Nonchemical, preferably electric or optic
Response time	Seconds
Weight	Minimal
Power consumption	Minimal
Rheology	Soft (elasticity under 10kPa)
Bio compatible	Hypoallergic
Environment	Durable, effective in wet conditions

<u>Our focus of interest in the wide research scope</u>

Adhesives have long and illustrious examples throughout human history. Science has come a long way since humans have used water and clay to connect stones and wood for tools as far back as 5000 years ago. The development of synthetic polymers has highly improved adhesions in terms of their strength and environmental tolerance. As soft robotics, flexible electronics, and intelligent gadgets become more prevalent, adhesives with changeable adhesion capabilities will become more necessary[1]. Recently, switchable actuators and adhesives became a reconfigurable matter. Scientists focused on material and device structure designs to shorten the response time, enhance the reversibility, Mult stimuli responsiveness, and smart adhesion for efficient shape transformation and functional actuations[2].

We are excited for the opportunity to harness current, and in-development scientific knowledge, accumulated over many years of research, for the benefit of developing next generation artificial limbs, and more importantly for the benefit of their future users.

[1] **Switchable Adhesion: On-Demand Bonding and Debonding;** Ziyang Liu and Feng Yan; *Adv. Sci.* **2022**, 9, 2200264.
[2] **Smart Actuators and Adhesives for Reconfigurable Matter;** H. Ko, A. Javey, *Acc. Chem. Res.* **2017**, *50*, 691.

To continue a discussion please contact liath@bility.center