

Electroadhesion for Industrial, Biomedical, Military, and Consumer Applications

The Need for Reversible Adhesion

The ability to attach to surfaces with a minimum expenditure of energy, and detach as desired, can be very useful in a variety of real-life situations and market applications. Chemical solutions, such as weak glues, address only a small portion of the market and limit the range of applications that would benefit from a reversible adhesion solution that can be applied repeatedly.

Military and commercial businesses producing industrial, medical, and consumer products can benefit from a technology that provides electrically controlled reversible adhesion. This, in turn, provides a competitive advantage to product offerings and allows for new safety and quality standards beyond what competitors can offer.



General-purpose highly compliant electroadhesive pad

SRI's Electroadhesion Technology

Our breakthrough electroadhesion technology allows electrically controlled reversible adhesion to most surfaces.

Electroadhesion uses electrostatic forces between the substrate material (e.g. wall surface) and the electroadhesive surface. Electroadhesive pads are comprised of conductive electrodes that are deposited on the surface of a polymer.

When alternate positive and negative charges are induced on adjacent electrodes, the electric field sets up opposite charges on the substrate and thus causes electrostatic adhesion between the electrodes and the induced charges on the substrate.



Double-sided application of electroadhesion on a porous wall

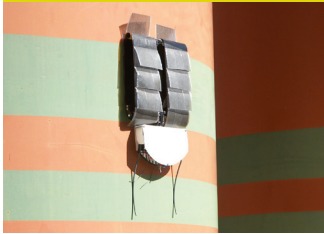


SRI's technology addresses the need for reversible adhesion and creates exciting new product opportunities in a wide range of markets.

The principle of operation is similar to electrostatic chucks used to hold silicon wafers or other specialized grippers for robotic handling of materials. The high compliance of the clamp is key to being able to adhere to a wide range of substrates.



Electroadhesive pads on a wood surface supporting 75 lbs of weight



Electroadhesion-enabled wall-climbing inspection robot on industrial exhaust pipes

Advantages of SRI's Electroadhesion

The technology provides reversible adhesion to a number of surfaces with extremely low steady-state power consumption. The table on the right shows representative values for a number of characteristic properties of the technology. Furthermore, the table below shows the advantages of the technology compared with several other competing solutions.

Electroadhesion adheres to most surfaces such as wood, drywall, paper, glass, concrete, and metals.

Property	Value
Supported Payload	0.8 lbs
Clamping Speed	< 10 ms
Steady-State Power	70 μ W

Assumes 1 inch² pad on wood

Representative values for several characteristic properties of electroadhesion

Technology	Forces	Repeated use on dusty surfaces?	Works on both rough and smooth substrates?	Energy requirements (attachment)	Energy requirements (detachment)	Works on wide range of materials?	Quiet / Non-damaging / no residue?	Low cost
Electroadhesion	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Chemical adhesion	Excellent	Poor	Excellent	Poor	Excellent	Excellent	Poor	Excellent
Suction / vacuum	Excellent	Poor	Poor	Poor	Poor	Excellent	Moderate	Poor
Dry adhesives / Synthetic Gecko feet	Moderate	Poor	Moderate	Excellent	Excellent	Moderate	Excellent	Poor
Aerodynamic Suction (eg. air hogs toys)	Moderate	Moderate	Moderate	Moderate	Poor	Poor	Poor	Poor
Magnetic / electromagnetic	Excellent	Excellent	Excellent	Poor	Moderate	Poor	Excellent	Moderate
Mechanical fastening (screws, claws, spines)	Excellent	Excellent	Poor	Moderate	Excellent	Excellent	Poor	Excellent

Excellent Performance

Moderate / Good Performance

Poor Performance

Comparison of several reversible adhesion technologies against electroadhesion

Application of electroadhesion to gripping complex-shaped objects



Wide-Ranging Market Applications

Electroadhesion can address a wide range of industrial, biomedical, military, and consumer needs. For example, first responders could be provided with wall-climbing robots that allow real-time and longer-term reconnaissance of buildings. In addition, wall-climbing robots can be used for military and commercial inspection of bridges, containers, pipes, storage tanks, buildings, structural walls, ducts,

aircraft and ship hulls, and transmission towers.

Other applications of electroadhesion include robotic grippers, factory and laboratory automation, medical and surgical devices and supplies, and a variety of consumer products, from toys to temporary signage.

The chart below maps a few of the many applications of this patented technology in four primary markets.



Traction enhancement application of electroadhesion to ladder safety

Industries				
Electroadhesion Product Categories	Industrial	Biomedical	Military	Consumer
Wall-Climbing Robots	Inspection robots		Surveillance robots	Toys
Sticky Pads	Automation	Bandages for sensitive skin, human tissue holders for surgeries, bleeding prevention bags	Temporary holding structures, surveillance patches	Hanging devices, temporary signage and banners, skin-mounted consumer devices
Grippers	Robotic grippers, Automation	Lab automation		Consumer devices
Traction Enhancement Devices	Automation	Lab automation	Pads for wall-climbing soldiers, human restraint systems	Traction control for tires and shoes, safety devices
Other	Fittings and couplings, high-precision drives		Smart vehicle door seals, temporary truss structures	



How to Work with SRI

SRI offers flexible working arrangements to address client needs. We conduct contract research to create custom solutions, collaborate to pursue research projects, and license SRI technology to qualified organizations.

SRI's core expertise is solving complex problems for commercial and government clients. SRI routinely leads multi-million dollar government projects and has the requisite infrastructure for cost accounting, legal compliance, and project management. SRI also operates and manages large-scale facilities for the U.S. Government.

SRI has brought several key products to market by a combination of licensing and new company creation. Notable and diverse examples include membrane technology for fuel cells, natural speech recognition, robotic surgery, and materials for the solar industry.

SRI's primary research facilities in Menlo Park, CA, include more than 1.3 million ft² of office and laboratory space, as well as high-bay facilities for pilot-scale testing.

Contact Us

Philip von Guggenberg
Director
Business Development
pvong@sri.com
650.859.5865

About SRI International

Silicon Valley-based SRI International is one of the world's leading independent research and technology development organizations. SRI, which was founded by Stanford University as Stanford Research Institute in 1946 and became independent in 1970, has been meeting the strategic needs of clients and partners for more than 60 years. The nonprofit institute performs sponsored research and development for government agencies, businesses, and foundations. SRI also licenses its technologies, forms strategic alliances, and creates spin-off companies. In 2009, SRI's consolidated revenues, including its wholly owned for-profit subsidiary, Sarnoff Corporation, were approximately \$470 million.

Headquarters

SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025-3493
650.859.2000

Washington, D.C.

SRI International
1100 Wilson Blvd., Suite 2800
Arlington, VA 22209-3915
703.524.2053

Additional U.S. and international locations

www.sri.com

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