Mapping the Path to a Successful Device Design

How Using Thin, Piezoresistive Tactile Sensing Technologies in R&D Can Lay the Framework for an Embedded Feature in Your Final Design

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Table of Contents

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Break Down the 'Silo Mentality' in Technology Evaluation

Whether or not its a conscious choice, we often group design engineering technologies into one of two categories: those looking for an R&D/instrumentation tool, and those that are seeking embedded components to make up the bill of materials (BOM). As a result, we may fall victim to a silo mentality when it comes to evaluating certain technologies, and miss out on the exciting possibilities they offer.

It takes engineering ingenuity to break down those silos, and realize that in some cases, a single technology can function interchangeably – and may even lay the framework for the next breakthrough design.

With each new innovation, the job of a design engineer only gets more difficult. They face the never-ending struggle to cram more smarts into an ever-shrinking space. From consumer devices, to the design of a complex network of automated systems or machines, the same technology used to validate a design could very well become an embedded feature to streamline certain processes, or create a more user-friendly experience.

Thin, resistive, force- and pressure-sensing technologies are a clear example of this.

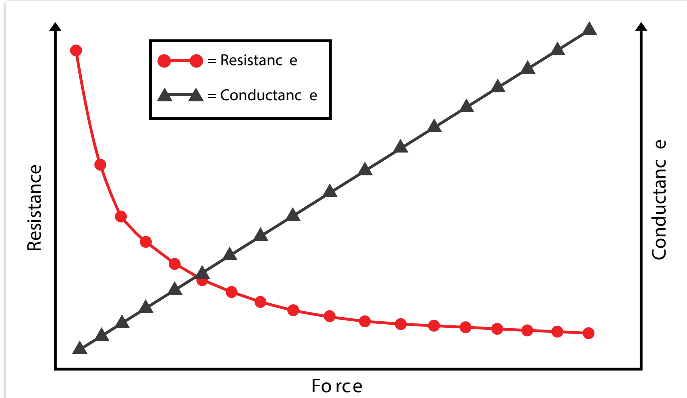
Thin, printed sensor technologies have become an emerging category to help design engineers in their R&D efforts. In the case of thin force- and pressure-sensing technologies, however, these technologies are not new at all. For decades, design engineers have used piezoresistive tactile sensing technologies as a test & measurement/instrumentation tool, or as an embedded feature within a device design.

However, some design engineers have come to realize how tactile sensing technologies used in R&D can map the path to create new applications that edge out the competition.

This eBook will explain the basics behind resistive force- and pressure-sensor technology, and the diverse opportunities they offer design engineers both in R&D instrumentation, and as an embedded application. It will then share real-world devices and applications where force- and pressure-testing validation efforts during product development efforts led design engineers on a new path to develop a first-of-its-kind device.

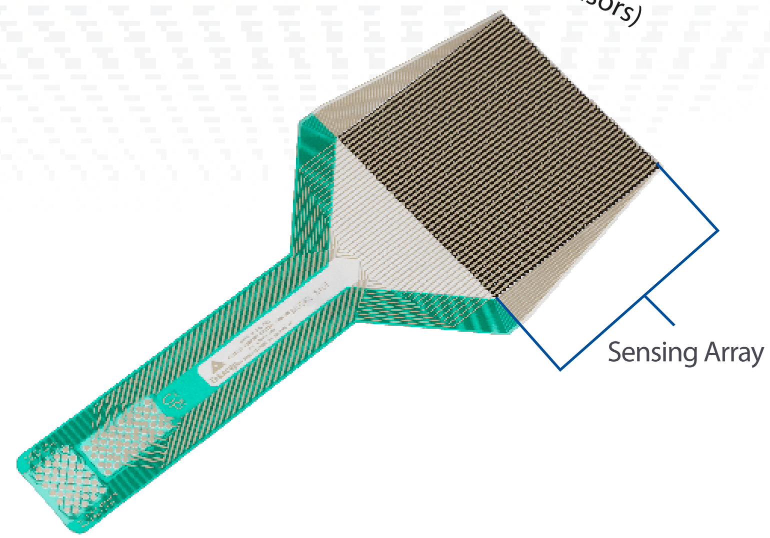
Technical Principles of Thin, Resistive, Force- and Pressure-Sensors

Single-Point Sensors
(FlexiForce™ Sensors)



FOR BOTH SINGLE-POINT AND MATRIX:
When a load is applied to the sensing area, the sensor's resistance decreases. This presents a linear relationship between applied force and conductance of the sensor.

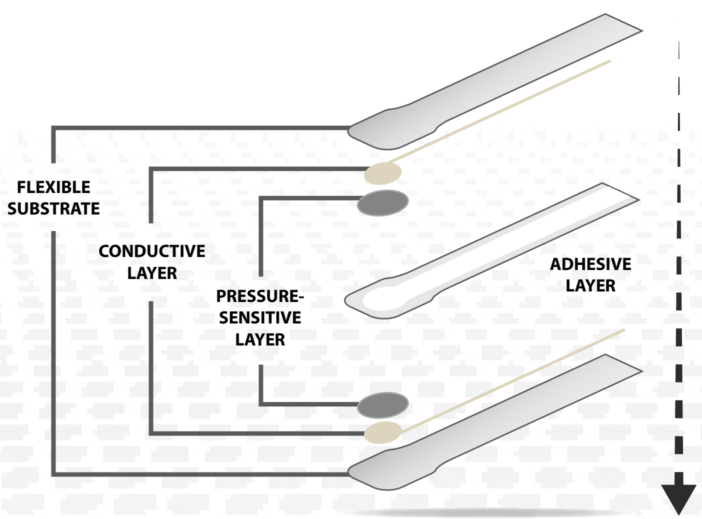
Matrix Sensors
(Pressure Mapping Sensors)



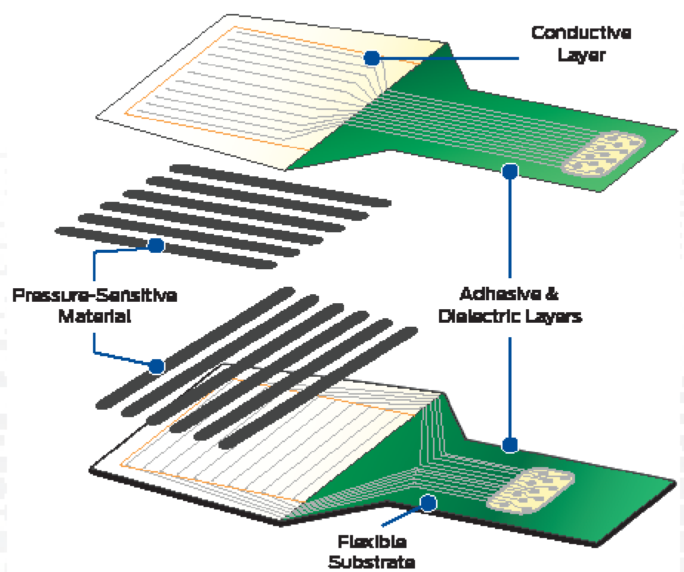
Tekscan's single-point sensors are called FlexiForce sensors. They are ultra-thin and flexible printed circuits, which can be easily integrated into force measurement applications. FlexiForce sensors are ideal for OEM products, thanks to Tekscan's ability to customize for an application's specific needs.

Manufacturing Capabilities:

- Force Range: Up to 31,138 N (3,175 kg)
- Size: Active area diameters as small as 1.86mm, and as large as 402.6mm
- Operating Environment: Standard= -40°C to 60°C High Temperature= -40°C to 204°C
- Customizable for Different Connection Methods



Matrix sensors, otherwise known as pressure mapping sensors, capture several points of pressure across the sensing array. These sensors can be designed into different shapes and sizes to accommodate most surfaces. While most commonly used in R&D design, matrix sensors can be integrated into a design.

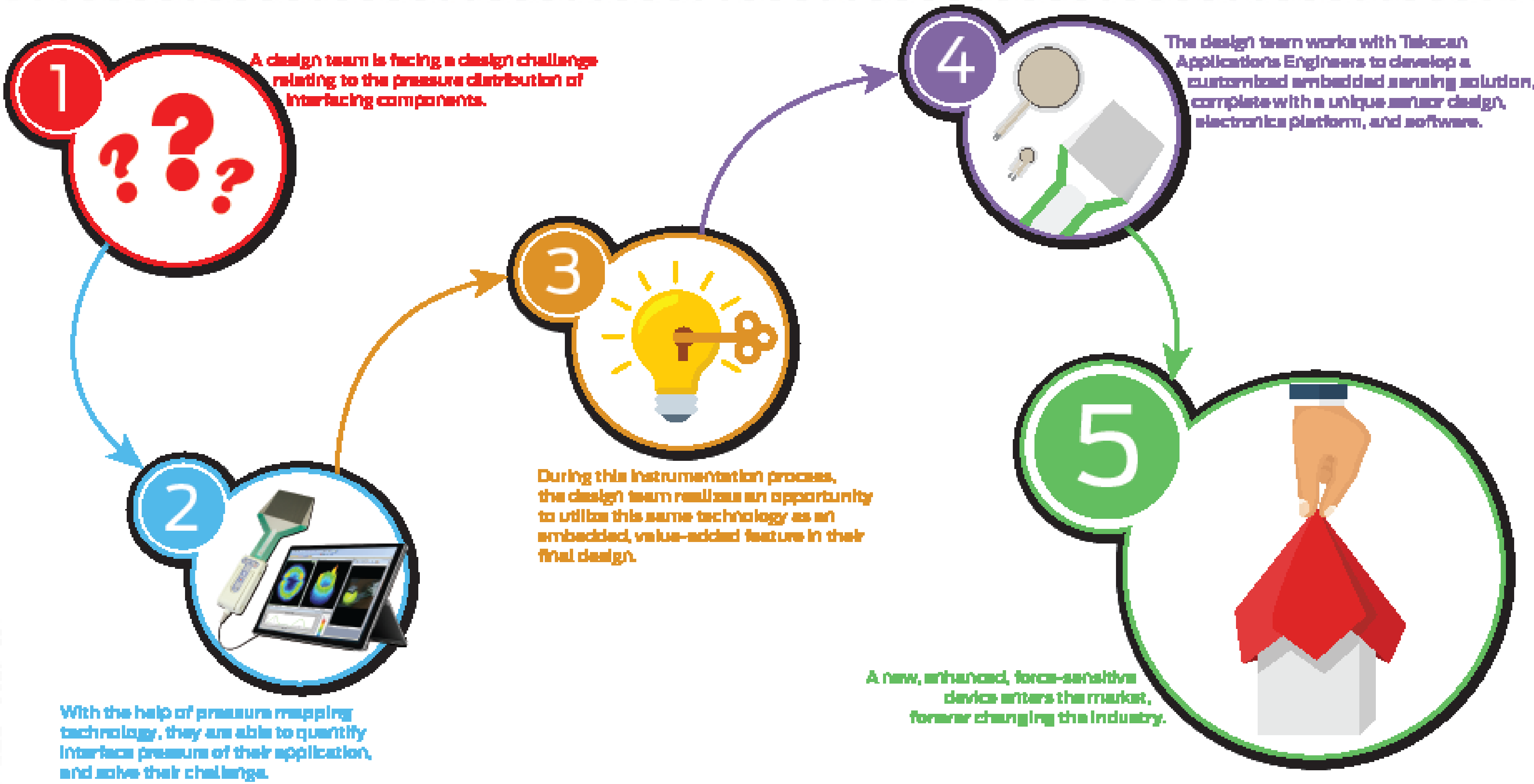


Manufacturing Capabilities:

- Sensing Points: 250,000 sensing points possible
- Pressure Range: Up to 25,000 PSI (1,700 BAR)
- Sensing Point Density: 1,600 sensing elements/in^2
- Operating Environment: Standard= -40°C to 60°C High Temperature= -40°C to 204°C (-40°F to 400°F)

Laying the Framework for Innovation

While every design story follows its own unique path, this provides a broad framework of how some design engineers achieve the full potential for tactile sensing technology.



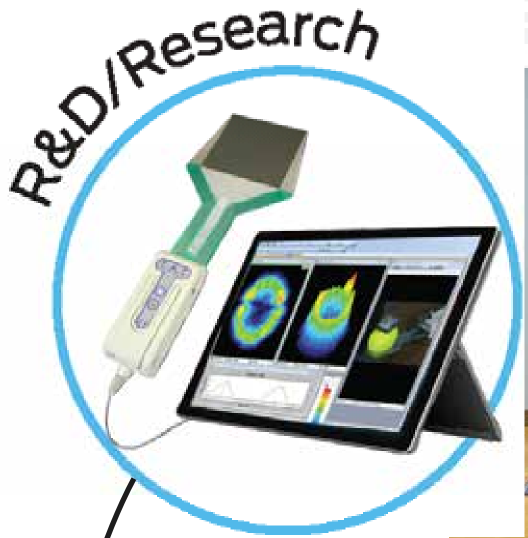
R&D-to-Integration Application Examples

The Dr. Scholl's Custom Fit Orthotics Kiosk

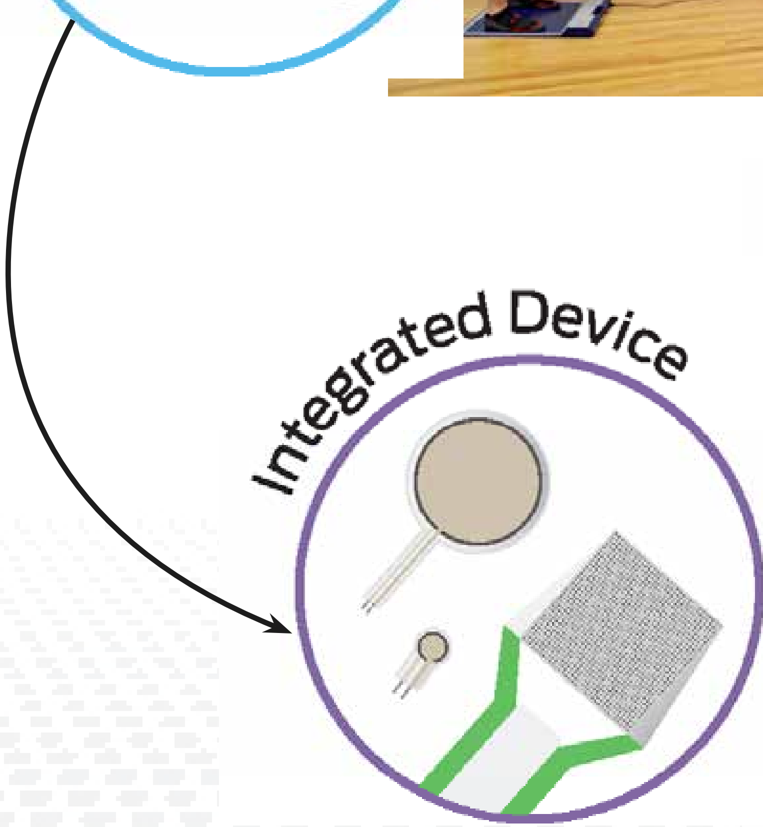
Pressure-sensitive platforms employing a matrix sensor have long been used by podiatrists and clinical researchers. These platforms, which are typically connected to real-time analysis software, identify asymmetries between a patient's left and right foot, and monitor effectiveness of a treatment program, among several other uses. Moreover, these platform systems are useful tools to educate patients about pathologies through a clear visual representation of biofeedback.

Given the success of this pressure-sensitive technology in a clinical setting, combined with a very competitive orthotics market, Schering-Plough (now under the Bayer brand) realized an opportunity to integrate a platform system into a unique sales tool. The end result – the Dr. Scholl's Custom Fit Orthotics Kiosk – turned a successful clinical technology into an educational experience that connects a customer with an orthotic that addresses the needs of their exact footprint.

In essence, the Dr. Scholl's kiosk simulates the experience of being evaluated by a podiatrist, which helps cultivate the customer's trust in the Dr. Scholl's brand.



Tekscan's MobileMat™ system features a low-profile pressure-sensitive matrix and software program used by clinicians and researchers to evaluate static and dynamic foot function. This helps in the diagnosis and treatment of postural instability, balance, sway, and sports injury recovery.



The Dr. Scholl's Custom Fit Orthotic Kiosk employs a pressure-sensitive matrix as a method to connect a customer with an orthotic specific to their unique needs. This design combines a successful clinical research method into an engaging retail experience for customers.

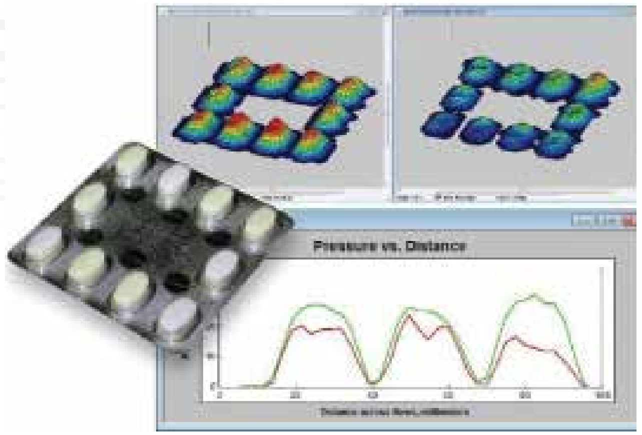
Advanced Blister Pill Pack Machine

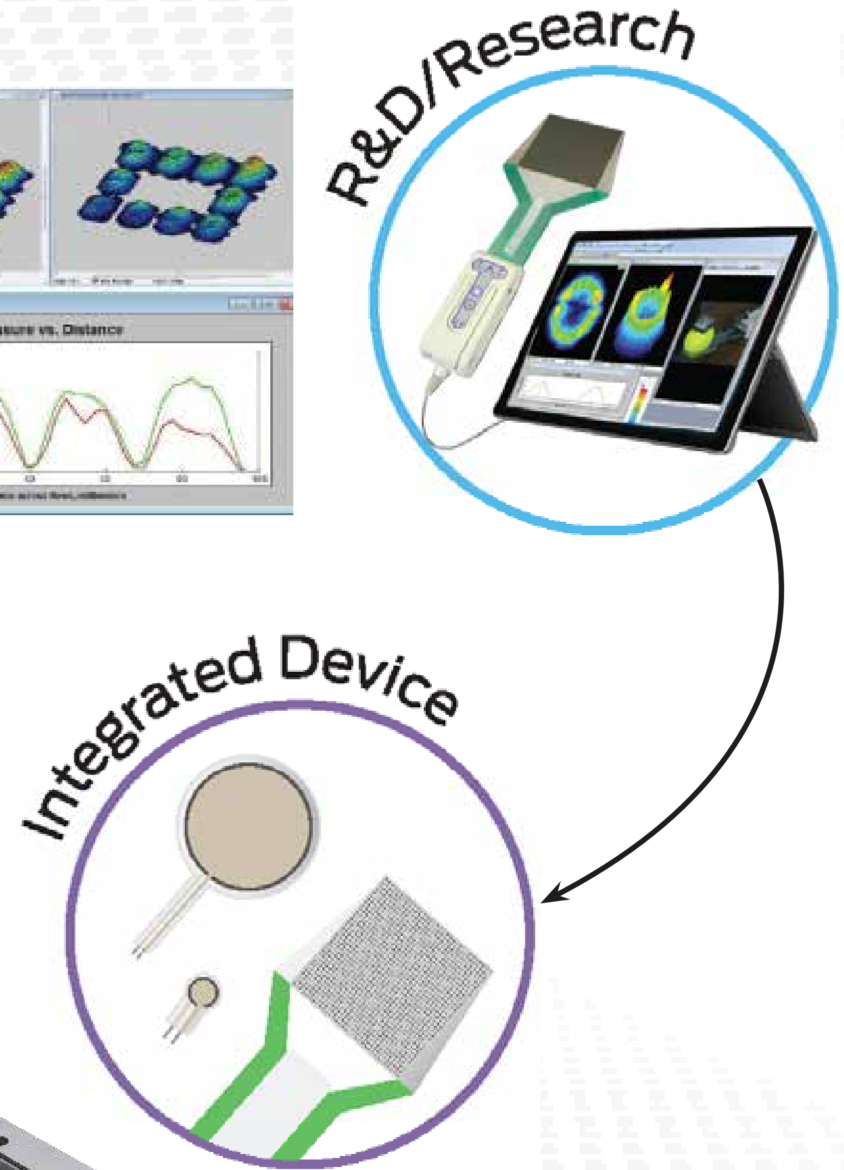
Packaging for medications or medical supplies must follow strict quality control standards. In the past, pill blister packs were evaluated for seal leaks through an outdated and time-consuming ink test. In this process, testing ink is applied to the outside of the blister packs after a production run, which would then seep into any crevices in the blister cavity to identify faulty product.

In an effort to reduce the risk of an uneven seal, one pill pack machine designer used an I-Scan™ pressure mapping system to evaluate the alignment of a new machine design. During this process, the R&D team had a breakthrough – they realized this same technology could be a useful application within the machine's interface, to help operators streamline their machine alignment process.

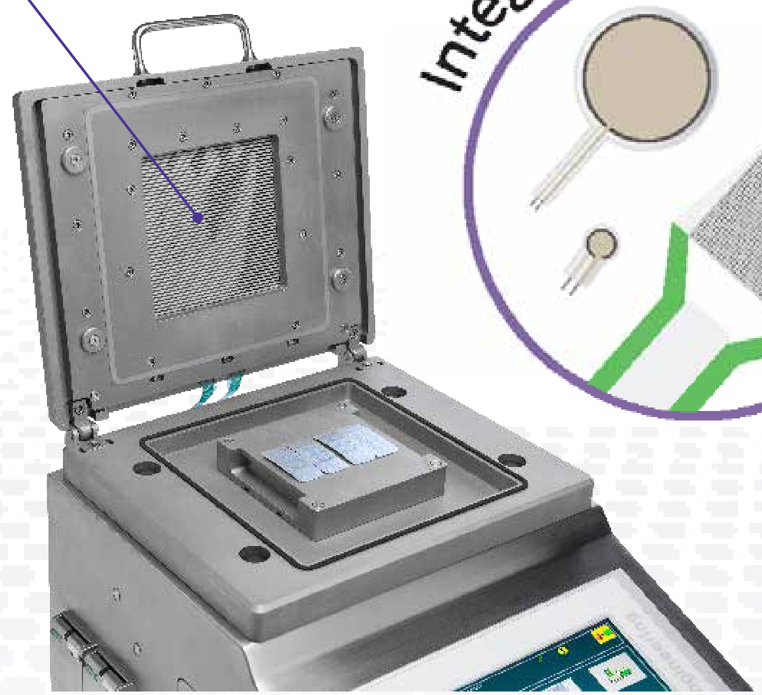
As a result, a custom matrix sensor was designed and embedded into the lid of the machine, to capture pressure distribution while the machine creates a vacuum and depressurizes the chamber. As the blister cavities within the packaging swell, the sensor measures the pressure distribution of each cavity. Cavities with a low pressure were clearly shown on the machine's display, indicating a leak in the blister. This unique application would become a key competitive advantage for this new machine design, saving their users time, money, and medication loss.

The I-Scan system proved to be an effective way to measure pressure distribution across a blister pack machine. The pressure data identified weak spots in the sealing process, helping the design engineers address misalignments, and develop a robust, repeatable machine.





Inspired by the I-Scan insights, the design team identified an opportunity to embed a pressure matrix sensing array into the machine's lid as a method to streamline machine setup, and improve quality control. With this feature, the operator could instantly determine whether the blister pack machine needed adjusting.

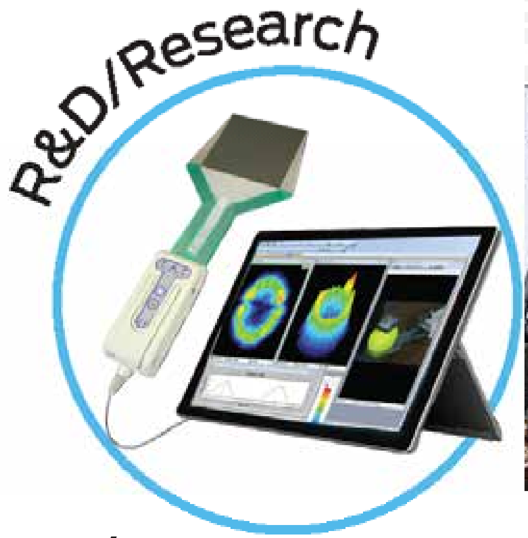


Bottling Quality Control

There are several twists and turns that a product encounters on its way through an automated manufacturing process. Visual inspection of bottles and containers for scuffs or damages only serves to identify that a problem has occurred somewhere in the process, but it may be physically impossible to determine where in the process these impacts happened.

A fill-line machine design team used an I-Scan system to better assess impacts and glances from bottles advancing through their process. Sensors positioned along different areas of the rail line captured relative impact pressure from product units, which helped the design team develop a more repeatable machine.

Taking this concept one step further, one of our clients had an idea to embed a force-sensing matrix on a product unit as an on-site quality control measure. This product captures forces applied to bottles and cans by rail lines, robotic grippers, and adjacent product units during production, and transmits this data wirelessly to the operator. This devices helps manufacturers significantly minimize losses due to damaged goods, and improve the efficiency of their operation.



I-Scan sensors were positioned along the rail lines of an automated bottling machine to determine areas where excessive impacts could occur in the process.

The FlexiForce sensors are wrapped around a model bottle or can. The sensor captures impacts on the bottle or can throughout the entire fill-line process, and transmits the data wirelessly to the operator. This helps fill line operators minimize loss, and improve their efficiency.

Quantifying Robotic Grip

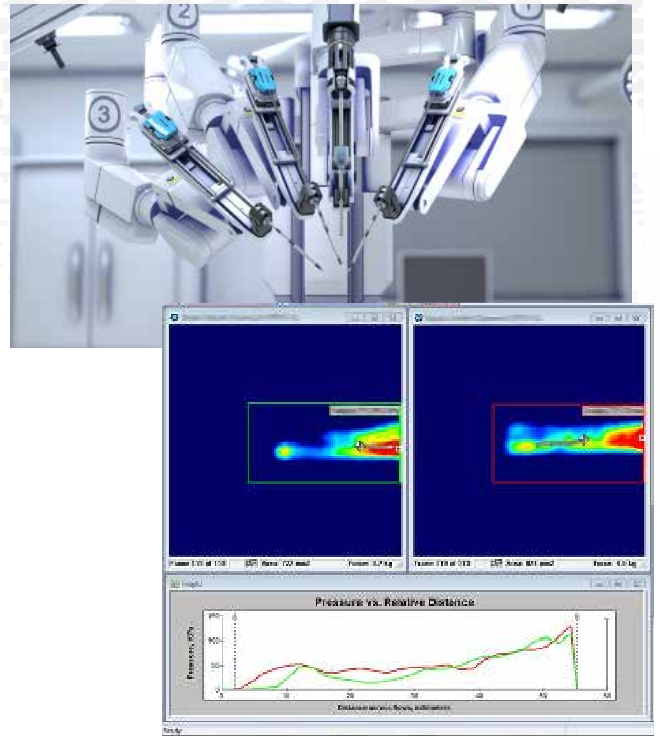
As technology advances, more and more minimally-invasive surgical procedures are being performed by complex robotic systems. These systems are designed to make specific actions with a high level of consistency. While these systems go a long way in streamlining routine procedures, mechanical error can be just as detrimental.

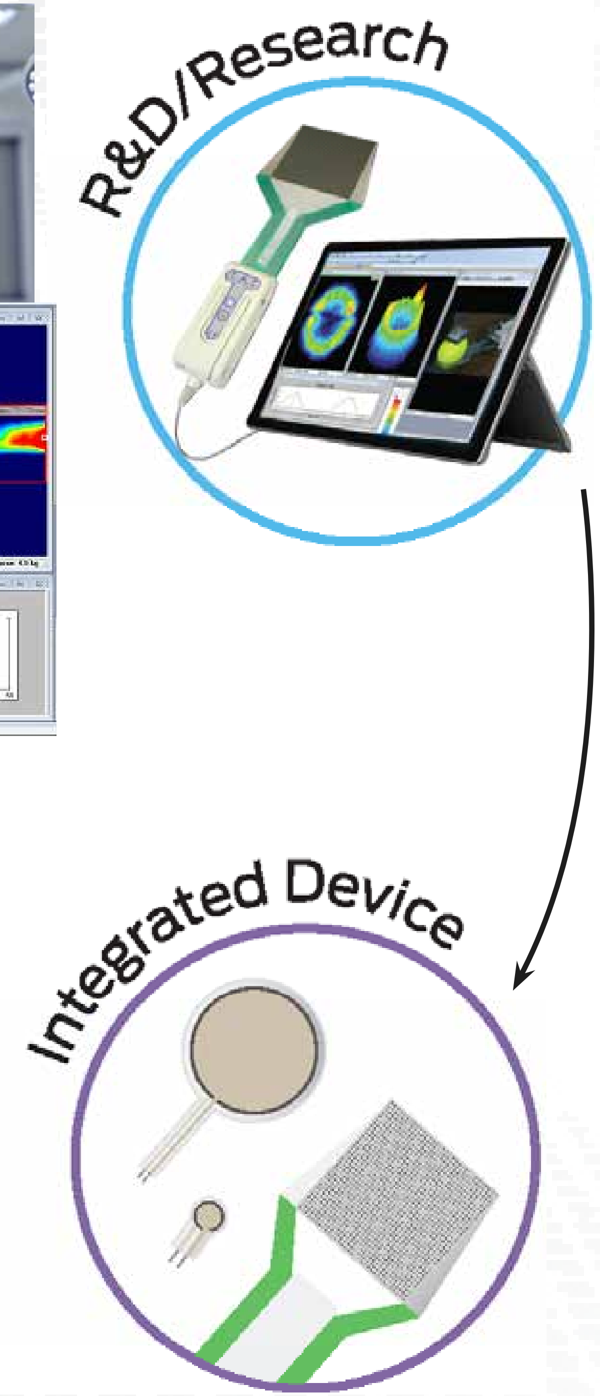
Recently, a robotic surgical system manufacturer wanted to understand a robot's surgical grip force, and evaluate its hinge design. A high-resolution pressure mapping sensor was placed between different gripper prototypes, to read the pressure distribution and grip force administered by the robot in real time.

In a separate but similar concept, researchers from the University of Los Angeles California School of Medicine developed a surgical gripper training device utilizing a FlexiForce sensor. The sensor was encased within a thin plastic cover on either sides of the gripper ends, which was used to measure the force exerted by the surgeon. The haptic feedback would be transmitted to the surgeon via a headband apparatus, which would prompt a tapping sensation on the surgeon's forehead. If too much force was being applied, the apparatus would tap faster, instructing the surgeon to loosen their grip.

This same concept has also been applied for training surgeons on the use of robotic surgical systems.

A high-resolution I-Scan system was used in the development of a robotic surgical system used for laparoscopic procedures. The system measured grip force of different gripper prototypes to determine whether the robot was exhibiting an excessive amount of force for the programmed procedure.





In this medical training application, a team of medical researchers embedded a FlexiForce sensor within either side of a surgical gripper, to help instruct students on proper technique.

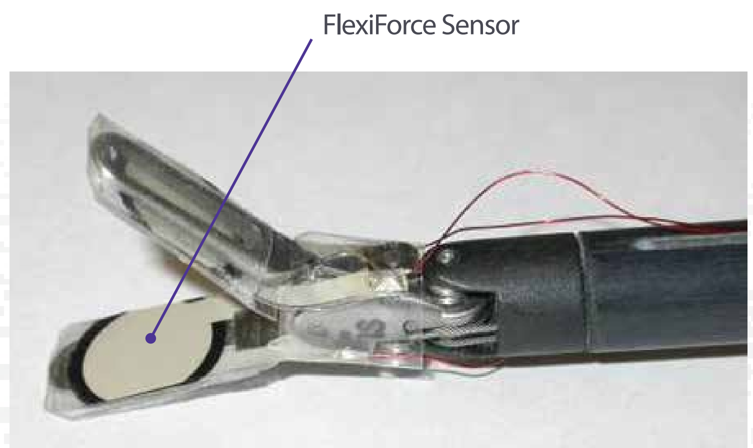


Image courtesy of the UCLA School of Medicine.

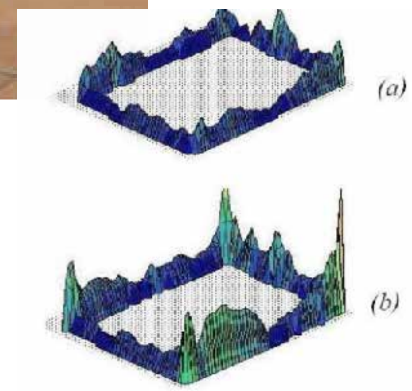
Smart, Safe Inventory Management

Misalignment of corrugated boxes stacked on top of each other, such as when stacked on a pallet, considerably reduces the strength of the boxes. Most inventory managers can only assume that the stacked packages are safe and secure, but data analysis may say otherwise.

A group of researchers[1] used pressure mapping technology to evaluate what happens when boxes unevenly stacked would distribute pressure after compression was applied. As the data on the right shows, there was a significant discrepancy of pressure distribution between boxes stacked uniformly versus non-uniformly. This data helped identify ways to improve the box design, and also develop some best practices for warehouses to employ when stacking packages.

Not only can tactile sensing technology help enhance warehouse safety, it can also curb against theft when embedded into an inventory management system.

In this application, a medical storage manufacturer used FlexiForce sensors to develop a real-time wireless inventory reporting system. Custom sensors positioned below vial holding cells were used to capture real-time force readings. These force readings were matched with the pharmacy's inventory management system to determine whether medication had been removed without proper authorization, or against protocol. This system helps reduce the need for frequent manual inventory checks, and also streamlines order scheduling processes.



In a recent study, an I-Scan system was used by researchers to assess compression from different box prototypes. Subfigure (a) represents a uniform load distribution before buckling the sidewalls. Subfigure (b) shows non-uniform distribution.

(1) Source: Meng, Guanqun, et. al. "Stacking Misalignment of Corrugated Boxes - a Preliminary Study" (2007) Presentation at the IAPRI Symposium on Packaging.

As a method to curb theft, a medication drawer design team used small, minimally-invasive FlexiForce sensors to read the resting force of vials stored within the unit. Any change in force - without being recorded in the inventory system - could signal foul play.

CONCLUSION

LET’S BEGIN ON YOUR PATH TOGETHER

As this eBook has shared, the endless capabilities for thin tactile sensing technologies open a world of opportunity, no matter what your end destination may be. Whether it’s a R&D challenge, or an embedded sensing application, Tekscan has a proven track record for helping design engineers achieve high-value products with force sensing technology. Your return on investment comes in the form of confidence in your product design, a shortened development process time, and an improved end user experience.

Interested in Tekscan Technology for your Application? Let’s start a conversation.

R&D Instrumentation:
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