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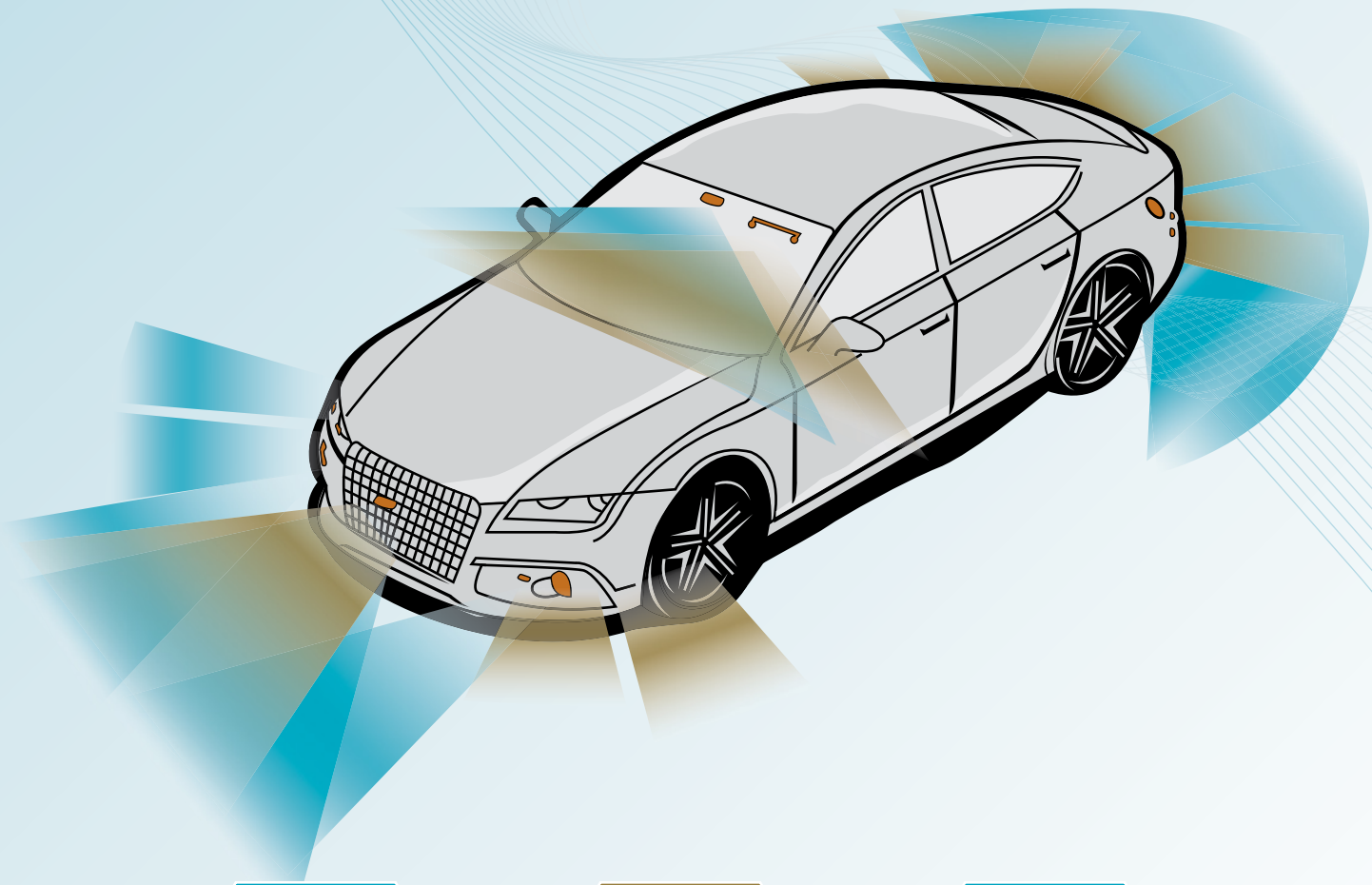
LSR Technology Accelerating Advanced Driver Assistance Systems



Introduction

Seal, damp and protect are key to the performance and reliability of composite electrical and mechanical components in Advanced Driver Assistance Systems (ADAS). Engineering these emerging products requires production processes from component development to design for manufacturing. A technology that lends itself to ADAS products is Liquid Silicone Rubber (LSR) injection molding. This paper compares the main materials for sealing, damping and protection purposes and then focuses on the LSR benefits and processes.

Paradigm Shift in Technology

According to a BCG survey, innovative ADAS features range all the way from active safety and assisted driving to vehicle styling.

Active, as well as passive safety and assisted driving features, are the keys to a paradigm shift in automotive technology toward the fully autonomous car. Advanced Driver Assistance Systems (ADAS) require the integration of electronics, mechatronics, optics, and information connectivity.

The impetus for developing active safety is related to the fact that human error is the primary cause of 93% of accidents. In the U.S. alone, this means 3.9 million people injured, over 33,000 fatalities and a 910 billion USD cost to society every year. (Boston Consuting Group: A Roadmap to Safer Driving Through Advanced Driver Assistance Systems)

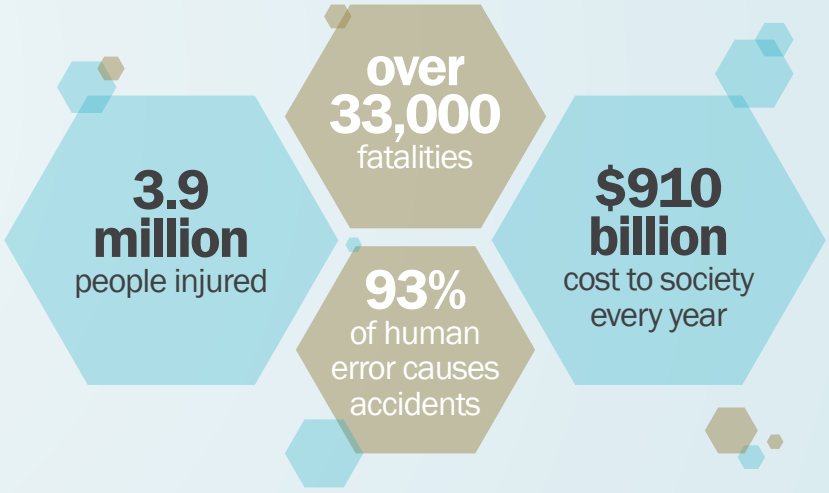
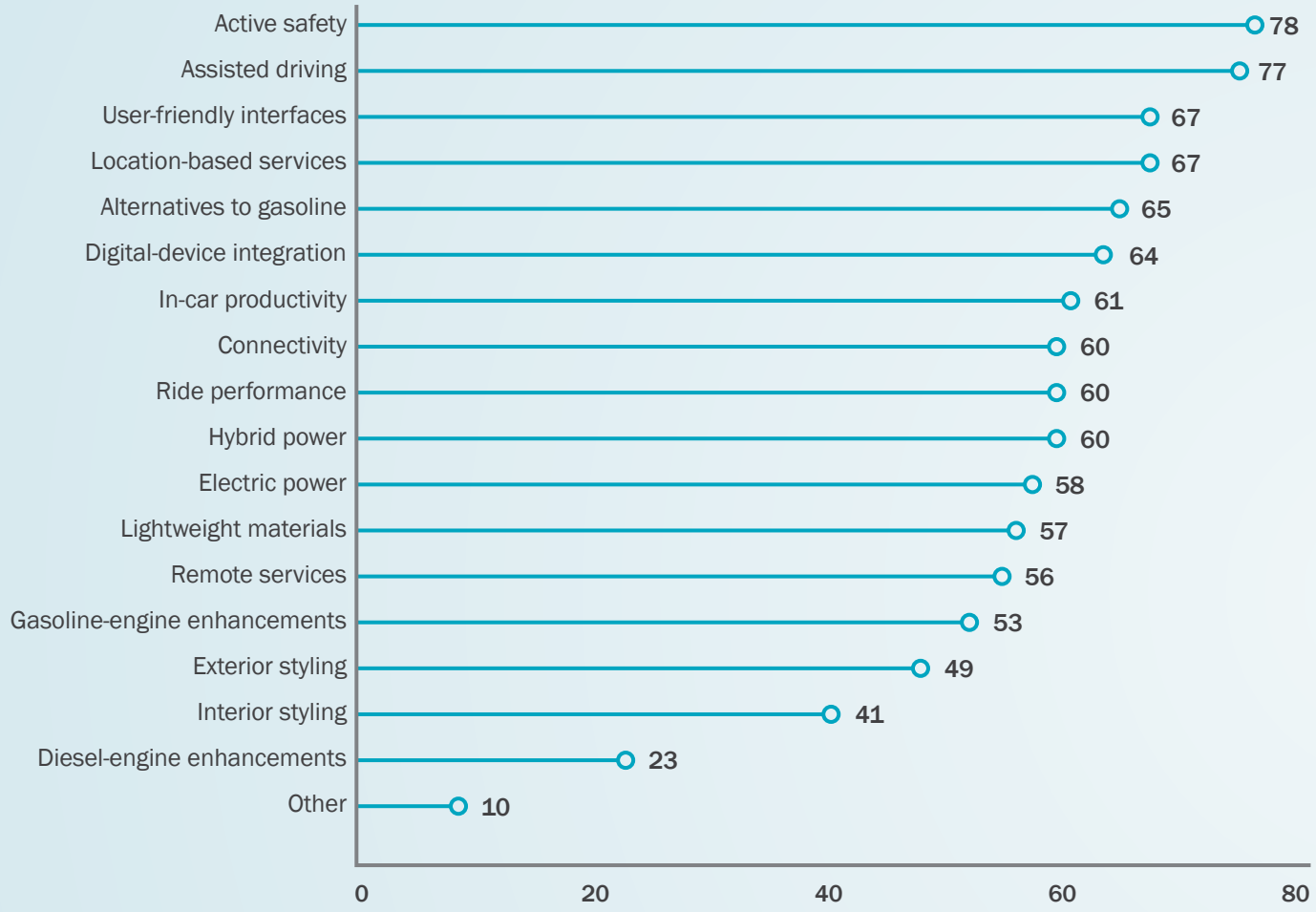


Figure 1: Active Safety and Assisted Driving Top the List of Innovative Features

Auto features that are considered “extremely innovative” or “somewhat innovative”



Source: BCG Consumer Survey, October 2013.

Percentage of respondents

ADAS components include sensors, switches and other controls with electronic, mechatronic and components based on the principals of LIDAR (Light Detection And Ranging), radar and sonar technology.

The Development of ADAS Components

The development of ADAS components hinges on the availability of some specific technologies and materials, as well as processes for seamless integration of these new technologies. Mastery of complex sensor technologies, systems, and processes will shift from individual car manufacturers and tier suppliers to expert suppliers. Expert companies like Bosch, ZF, and TRW already provide customized and integrated electronic, mechatronic, and mechanic modules to the Original Equipment Manufacturers (OEMs).

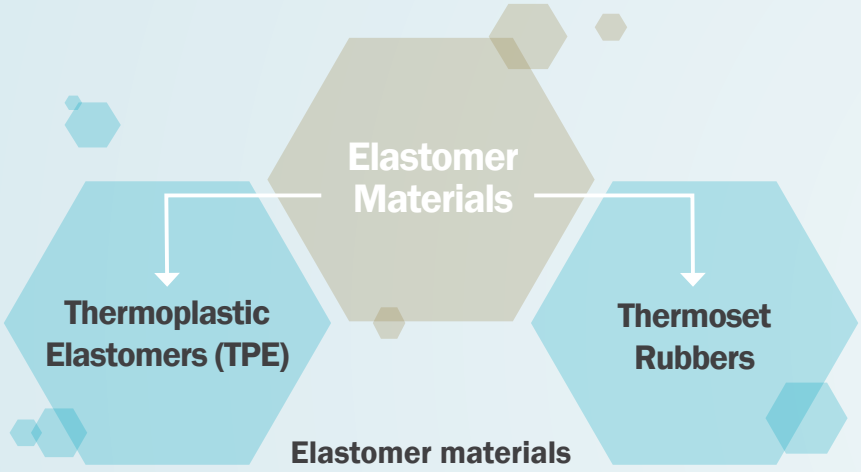
As the development of a specific technology becomes increasingly expensive, it will be available from a few market-leading tier-one suppliers who in turn rely on the expertise of tier-two suppliers for specific processes and capabilities for product design and mass production. These features are not stand-alone product options that can simply be added to an ADAS component as an add-on feature. Instead, they must be designed into a new product early in the product's design and prototyping phases. (Boston Consuting Group: A Roadmap to Safer Driving Through Advanced Driver Assistance Systems)

The development of sophisticated ADAS components requires a seamless interface between OEMs, tier-one and lower tier suppliers, as well as shoulder-to-shoulder engineering between involved parties. For inherent features like sealing, damping and protecting, the integration of an experienced manufacturer in design and prototype phases ensures seamless integration of those features in the final ADAS product.

The conventional product-focused approach of many suppliers does not adequately address the required integration of sealing, damping, and protecting in the product design. Simply including a finished product as if it were just an additional item can increase total system costs and delay market introduction, with the possible risk of rework or, in the worst-case, even recalls.

Material Options

The construction of advanced ADAS components is dependent on suitable materials for functions such as sealing, damping, and protecting. Traditionally, elastomers have been used for these purposes. These can be differentiated into two basic categories, as illustrated below, each with distinct advantages and disadvantages.



Elastomer materials

Thermoplastic elastomers

+ Recyclable and environmentally friendly
+ Excellent mechanical impact resistance
+ Scrap and waste can be reused
+ Fast processing via injection molding
+ Lend themselves to the production of small detailed and intricate parts
+ Favorable haptic and ‘soft touch’ properties
+ Low overall costs
- Limited high temperature capability
- Limited chemical resistance at elevated temperatures
- Inferior compression set properties at elevated temperatures

Thermoset rubbers

+ Excellent low and high temperature resistance
+ High level of dimensional stability
+ Excellent broad ranged chemical resistance
+ Offers great design latitude
+ Processing with a variety of methods
- Not recyclable
- Cannot be remolded or reshaped
- Scrap and waste cannot be reused
- Generally more difficult and time consuming to surface finish

Pros and cons of thermoplastic elastomers and thermoset rubber

Silicones combine the best properties of these two principal categories. In particular, Liquid Silicone Rubber (LSR) is one of the most versatile materials in terms of its properties and its processing capabilities, especially in terms of production of extremely complex and delicate designs in high volumes. a characteristic particularly valuable for ADAS components.

The Most Advanced Choice

Besides silicone's excellent chemical resistance in automotive electronic environments, there are several outstanding qualifications for the material to guarantee the functionality of highly sensitive electronic control and safety systems.

Besides these physical material properties, LSR technology offers a number of processing advantages that perfectly match the designer's quest for smart integrated systems solutions that are reliable, durable and cost-effective.

These include:

- Excellent high and low temperature resistance from -40 °C to +200 °C / -40 °F to +392 °F
- Excellent damping properties
- Weather and UV resistant
- Outstanding electrical properties

Excellent high and low temperature resistance from **-40° C to +200° C / -40° F to +392° F**

- Good adhesion to a multitude of materials and substrates, especially engineered plastics in a highly efficient simultaneous 2-component injection molding process or in overmolding
- Extreme low viscosity to facilitate manufacture of complex shapes with the highest precision
- Production of part geometries and technical solutions not possible otherwise
- Flash-less production minimizing post-molding finishing steps, thereby guaranteeing the highest precision and consistency of quality over millions of parts
- Short cure times to facilitate economical high volume production
- Minimal waste of material through specialized high precision LSR toolmaking
- Lowest total cost of quality

Advanced 2-Component LSR Processes

Commonly also referred to as 2-component, 2C, 2K-technology or 2 shot-technology, this injection method has been around for some time for plastic components. In it, two, three, or more dissimilar types of plastics are co-injected in a single shot or in multiple steps. Not so commonly available and therefore limited to a few specialist manufacturers, is the capability to co-inject an engineered plastic with LSR, and thereby create high precision, high performance, hard-soft combinations for safety-critical applications such as ADAS.

This provides numerous significant advantages, such as:

- Offers designers much more latitude in design solutions by integrating multiple components into one fully-bonded high precision solution
- Enables lighter weight components by replacing metals with an engineered plastic
- Risks and costs associated with secondary assemblies can be avoided
- Much higher precision and performance alternative to FIPFG (Formed-in-Place Foam Gaskets)
- Lowers overall cost by reducing the number of components in the customer's supply chain
- Eradicates potential leak paths
- Only robust and cost-effective way of combining a technical plastic and a silicone component. Alternatives are gluing or assembly of loose parts. Both would introduce additional process steps that can lead to variability in process and quality, as well as extra direct, indirect and possibly hidden costs.

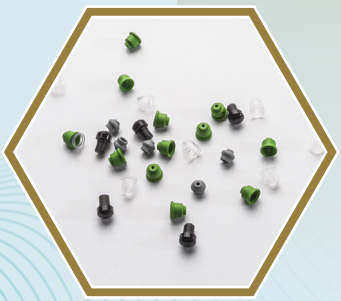
Application Examples

LSR components have already been used for pressure and ultrasonic sensors as part of ADAS systems, as well as switches and transmitters for interior control features.

Seal or gasket for housings of electrical control units or sensors

The design of LSR seals and gaskets can be perfectly matched to mating components within the tightest of dimensional tolerance constraints with a high precision, flash-less seal. Combined in a 2C process with an engineered plastic, and possibly further integrated elements or materials, it makes for a cost-effective and technically robust solution that protects the electronics and guarantees perfect functionality over the intended life of the ECU or sensor

Customized micro-components

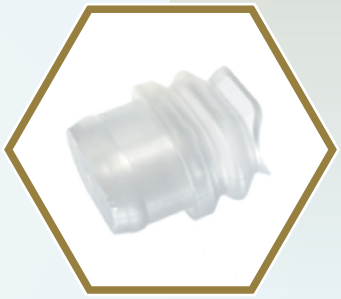


LSR is suitable for micro-sized and nano-sized silicone injection weights for the tiniest of components (< 10mg) in flash-less quality to protect critical electrical and electronic features.

High performance membranes for repeated operation over a complete service life

Specialized LSR liquid injection molding creates the thinnest of flash-less membranes (0.1mm) with absolute dimensional consistency over millions of parts. The durability of LSR guarantees repeated operation of interior control panels for the service life of an automobile.

Complex features such as undercuts or blind sections



LSR supports production of any desired geometry in flash-less quality and without waste. Application-specific tools enable small as well as large scale production, regardless of part complexity.

Integrated design solutions, combining two or more components and materials

LSR has outstanding bonding capability with a multitude of other substrates, such as metal or engineered plastic, into a single fully bonded part, for producing the most demanding and complex sealing, damping, and protecting features.

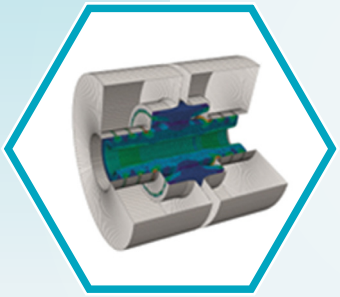
A Partnership Approach

While LSR technology has affinities with both rubber and plastic injection molding, the requirements LSR poses on a processor are challenging in terms of tool making, processing, and process automation.

When selecting an expert supply partner, the key criteria are, firstly, a one-stop-shop with integrated capabilities from concept to large-scale serial production, and secondly, a shoulder-to-shoulder engineering approach between supplier and customer. Sealing, damping and protecting in an ADAS component cannot be achieved by an off-the-shelf product but should be the result of an integrated process between the ADAS component manufacturer and the LSR supplier.

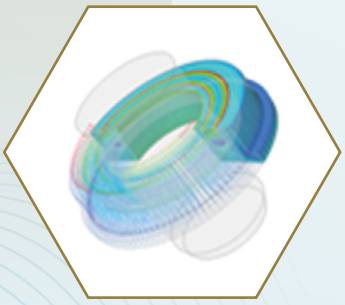
Concept Stage

At the concept stage of new products, critical sealing, damping, or protecting features have to be incorporated in the design of the product. Early analysis of these requirements optimizes product performance, service life, and total system cost. In this stage, 3D models are valuable to visualize and optimize both complex products and production processes. The supplier's application, design, and material engineers have to support the customer's technical team to help develop the concept with their expert input.



Design Stage

The decision to involve the supplier for a black box solution or to work with him on the basis of value-engineering an existing concept, or thirdly, to use an existing product that is possibly adapted, is made in the design stage. Non-Linear Finite Element Analysis (NLFEA) is a critical and valuable tool for soft components such as those produced from LSR and should be used to model the behavior of components under assembly and application conditions. This improves the design under functional criteria to prepare for the next stage of producing prototypes. The supplier's tool and process engineers are key to this stage and to optimizing the design in terms of functionality and manufacturing feasibility.



Prototype Stage

Depending on application and customer preference, the production of first prototypes or models, with the help of additive manufacturing techniques in similar or close-to-identical materials, might be an important step in the development process. Following that, the feasibility to produce parts in a real material and real process should be assessed via production samples from a prototype tool.

In this phase, modeling the flow of the LSR material into the tool via an advanced flow simulation tool becomes valuable. Computer modeling confirms details such as the ideal location and form of injecting the material into the mold as well as the optimized processing specifications to guarantee the expected outcome. Alterations to the tool construction can be made quickly before the actual tool is machined. Selecting the right tool construction and processes accelerates the time for first samples, whether it be off an initial test mold as or a multi-cavity serial mold.

Serial Production

Initial small-scale and later large-scale serial production depends on the optimum design and setup of tools and processes, including automation. The integrated knowledge accumulated by the experts of the supplier and the customer during all earlier stages should be fully incorporated in the production process. Working shoulder-to-shoulder with the same supply partner through all stages ensures seamless integration and the best outcome in the shortest possible time, from first concept to mass production.

Summary of LSR Benefits

In comparison with conventional materials, LSR offers an ideal combination of physical properties and processing characteristics for sealing, damping and protecting elements in Advanced Driver Assistance Systems. In combination with advanced processing, the most demanding designs can be realized with LSR in both low and high production volumes. The benefits are maximized by cooperation with a supplier with in-depth expertise during the design and prototype phases. This holistic approach ensures the incorporation of LSR benefits in inherent product design.

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Trelleborg is a world leader in engineered polymer solutions that seal, damp and protect critical applications in demanding environments. Its innovative solutions accelerate performance for customers in a sustainable way. The Trelleborg Group has local presence in over 40 countries around the world.

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