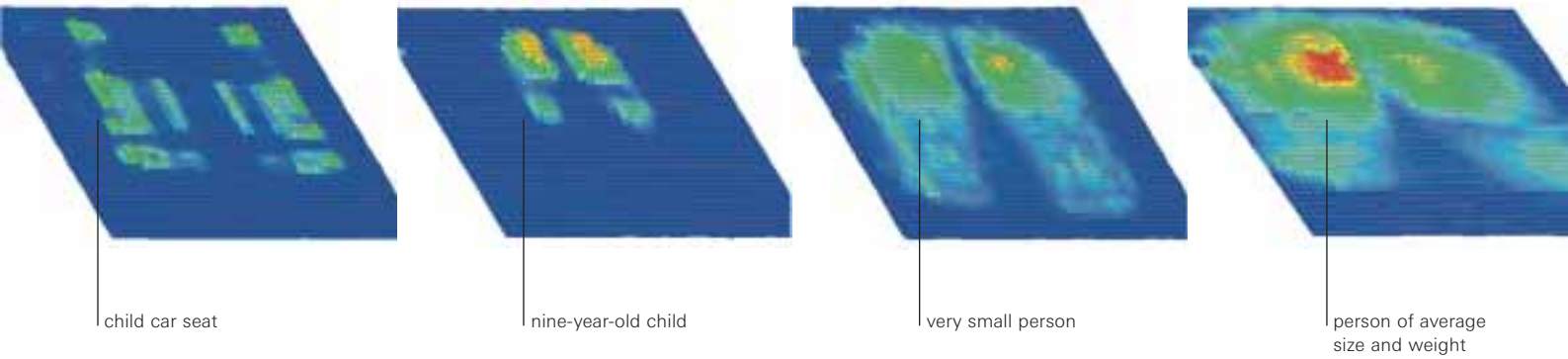
# A sense for safety

↓ Pressure profile of seat as a function of load application and distribution.




# Should a passenger airbag always open in the event of an accident? A complex question, and one that sensors in the seat upholstery help to answer

A young mother leaves the supermarket, puts her shopping in the back of her small car or roadster and places her baby in a portable child car seat on the front passenger seat, buckled in properly. Her car has no back seat, so she cannot follow the recommended practice of placing the child safety seat or booster in the rear. As she leaves the car park, however, the car in front of her stops suddenly. She reacts immediately, but a collision is unavoidable. Just a slight bump, but even such an impact may trigger the airbag, which could injure the little passenger.

**Risky situation**

Today new cars are equipped with airbag systems that protect the driver and front seat passenger in the case of an accident. But when these airbags are activated and filled with 120 (or even more) litres of gas within only 35 milliseconds – less time than a blink of the eye – there is a serious risk of injury to children, even in protective child car seats, or to anyone positioned directly in front of the dashboard. Even adult passengers can be injured by an airbag if they are not properly restrained by a safety belt. This is why, in the U.S., airbags are called Supplemental Restraint Systems (SRSs): they are designed to operate as a supplement to – not instead of – vehicle safety belts.

Suitable technical measures must be taken to avoid injuries from airbags. Systems are needed which not only detect whether the front passenger seat is occupied, but also how – and then 'decide' whether and how the airbag is to be activated in the event of a collision. BMW Group, one of the leading European manufacturers of cars for the U.S. market, has been offering a European-developed solution to this need, employing an occupant classification system, since the middle of 2003.

This system makes much greater demands on the sensing capability than the occupant detecting systems widely used in Europe, which are often based on a simple YES or NO alternative. In order to accurately ascertain how the seat is occupied, the pressure profile is measured very sensitively to determine both the size and position of the load. The Luxembourg company IEE International Electronics & Engineering has developed an Occupant Classification system (OC®) which is able to measure this pressure profile with extreme accuracy.

Such potential 'life savers' that are able to recognise who or what is occupying the front seat passenger are compulsory for all new vehicles, according to the revised U.S. regulation Federal Motor Vehicle Safety Standard (FMVSS) 208, with a transition period that extends to September 2005. The regulation requires that an airbag be deactivated if the passenger seat is occupied by a child up to 9.8 kilogrammes in a child safety car seat. On the other hand, the system must ensure that the airbag will inflate if the passenger seat is occupied by a small person up to 47.8 kilogrammes. →

← Invisible sensors in car seats regulate the activation of airbags, thus reducing possibility of injury.

**The electronic system decides**
In BMW cars manufactured for the U.S. market, the passenger seat airbag is activated only if the load on the seat satisfies certain criteria. Paul Schockmel, director strategic marketing and international relations at IEE says: "The key to occupant classification at BMW is a measuring mat developed jointly by IEE and DuPont and manufactured by us. This mat, located under the upholstery of the passenger seat, consists essentially of two DuPont™ Kapton® polyimide films sandwiching a multitude of electrical sensor cells, which emit signals of varying strength depending on the pressure applied."

"If an adult sits on the passenger seat, or a child car seat is placed on it, electrical signals are emitted: weak signals where there is little or no pressure, strong where the pressure is high. A specially developed electronic system computes the load distribution on the seat from the pattern of signals. This information enables the system to decide, in the event of an accident, whether the passenger-seat airbag should be activated or not. One of the keys to the very sensitive response is the softness and elasticity of Kapton®, which enables the mat to follow the deformation of the seat almost exactly." (See How it works.)

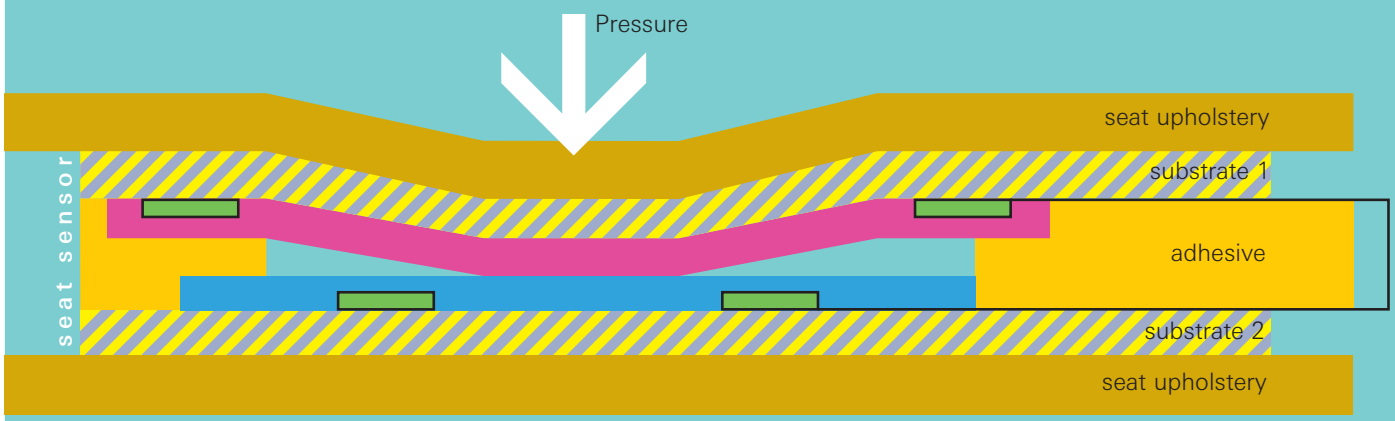
**Contributes to automotive safety**
The demand for life-saving occupant classification systems is enormous. As many as 16 million cars per year must be equipped with them from 2006 onwards in the U.S. A considerable number of them will be fitted with systems featuring Kapton® film, as not only BMW but also many other car manufacturers, such as General Motors, Hyundai and Kia, are among IEE customers.
"The success of occupant classification systems in the U.S. speaks for itself," Schockmel continues. "While in 1997 passenger-seat airbags were causing a large number of injuries and there were still eight cases of

# How it works

IEE's Force Sensor Resistor® (FSR®) technology measures the pressure profile of the load acting on the passenger seat. Key components of the OC® (Occupant Classification system) measuring mat used for this application are two sandwiched substrates consisting of thermally stabilised DuPont™ Kapton® polyimide film, on which pressure-sensitive layers and electrodes are printed. A special surface treatment ensures optimum adhesion of the layers and electrodes to the film.
The individual, locally delimited sensor cells change their electrical resistance depending upon the physical load applied to them. This data then enable the evaluation system to calculate a pressure profile and automatically correct for influences resulting from the movement of the vehicle and the occupant's changes in sitting position. The system differentiates seat occupancy according to various criteria: no occupant, child safety car seat and three categories of occupant according to size, weight and centre of gravity determined by the sitting position.

**Reliable in heat and cold**
As the Kapton® film is relatively soft and flexible, it follows the deformation of the seat exactly, permitting extremely sensitive measurement. Moreover, the behaviour of the material remains constant under extremes of temperature – from severe cold down to -40 °C to extreme summer heat up to 80 °C – even after years of constant use. Thanks to its spring-like elasticity, the material always regains its original form. Kapton® thus meets the demanding prerequisites for the extreme precision of the OC® system.

Force Sensor Resistor® (FSR®) is a registered trademark of IEE, Luxembourg




The sensor mat is integrated into the upholstery of the passenger seat.

electrodes

conductive ink

substrate 1 and 2
Kapton® polyimide film

death in 2003, not one single injury or death caused by an airbag has so far been confirmed in 2004*."
"Along with the use of occupant classification sensors, the increased awareness of parents and drivers regarding auto safety, including the best placement and protection for both children and adult passengers has certainly contributed to the substantial reduction of fatalities in the U.S.," says Michael Sanders, global director of DuPont Automotive Safety Group. "We will continue our efforts to educate people in various parts of the world and offer high-performance materials to develop innovative solutions with our partners to help improve the safety of our children, as well as drivers and adult passengers." (See Airbag evolution.)

**www.iee.lu**
**www.dupont.com/kapton**

*Source: National Center for Statistics and Analysis of the National Highway Traffic Safety Administration, USA, 1.10.2004

Occupant Classification system (OC®) is a registered trademark of IEE, Luxembourg


↑ It takes only 35 milliseconds to completely inflate a passenger-seat airbag, less than the blink of an eye.

# Airbag evolution

Standard airbag systems are unable to discern adult passengers from children riding in car seats. In addition, earlier airbag systems deployed with tremendous – some say excessive – force which, when airbags were first installed in passenger vehicles in the early 1990s, had tragic consequences for some child passengers incorrectly positioned in their immediate proximity. Subsequent airbag systems were redesigned to deploy with lesser, but still lifesaving, force.
Among the positive developments in the U.S. since 1996 is that an estimated 1700 children have been saved from injury because they were placed in rear seating positions, and the rate of airbag-related deaths among children has declined by 96 per cent. This is due in part to extensive public education, warning labels and other efforts designed to inform consumers that rear-facing infants must never be placed in the front seat of a vehicle with a passenger airbag, as a deploying airbag poses a grave risk of death or serious injury.
The U.S. Department of Transportation refers to recently developed safety devices incorporating occupant classification sensors and related technology as 'advanced airbags' (see http://www.nhtsa.dot.gov/airbags/). The media call them 'smart airbags'.

Source: Occupant Protection Division, U.S. department of Transportation/NHTSA