



# Breaking barriers

**M**arket research is saying that flexible circuits are an emerging technology, the cynics will say 'they always have been and they always will be'. Just like hybrid circuits, multichip modules, mechatronics and many others, it is a technology that makes a lot of sense and has great potential, but has not always made it to the mainstream.

The advantages of flexible circuits include space and weight saving, increased circuit density, and elimination of bulky connections and wiring. But, arguably, the most potent benefit today is the opportunity to break the boundaries of conventional design and styling, particularly in the highly competitive and miniaturised world of portable electronics devices. The concept of a ribbon to wrap around and through small complex modules, providing both circuitry and wiring connections is proving irresistible. In many cases, design elegance is winning the trade off against cost.

Today flexible circuits are manufactured cost effectively in high volume, using a range of materials and processes to suit various applications. Single and double sided circuits and 3d assemblies are common and current carrying ability, trace routing and component pitch densities compete with most conventional pcb processes.

Essentially copper conductors laminated between plastic (polyester, polyethylene or polyimide) substrates, flexible circuits can take advantage of screen printing techniques and product can be supplied in sheets, on reels or on rolls. Design criteria and material choice

After many years of development, flexible circuits are emerging as a viable alternative to rigid boards.

By **Louise Joselyn.**

will depend on whether a circuit is flexed once to wrap around or inside an enclosure, or whether it will be flexed constantly during a product's lifetime.

By far the best advantages of flexible circuits are gained by replacing all circuit boards in a design with a single flex circuit. Many applications go half way, by connecting smaller boards with a flexible circuit to create 3d shapes.

Companies like IBM were playing around with flexible circuits more than 20 years ago and these have found their way into computer equipment and peripherals. The technology has always been a favourite in military and automotive markets. Today, they are used widely in the automotive, communications, industrial and medical sectors.

The automotive market is a significant user of flexible circuits, and applications continue to grow. It is an important technology for reducing the bulk and weight of wiring harnesses and looms, while reducing the number of connectors required to interconnect many automo-

Illustration: Paul Davies





tive subsystems. The ability to incorporate electronic and mechanical devices, such as sensors and accelerometers

has been a major driver for integrating further functionality into the wiring harness.

Freudenberg NOK Mechatronics acquired Delphi Deutschland's flexible circuit business last year and plans to expand the business further into the automotive sector. Called Freudenberg Mekttek, the company is the preferred supplier for Delphi and Siemens VDO, but is keen to expand into other markets.



Recent advances in automotive systems for safety, comfort and driver assistance, such as collision avoidance, parking assistance and lane departure warnings, require sensor data to be transmitted more widely around the vehicle. For example, flexible circuits are being designed into the car steering wheel and control levers for wipers and lighting, incorporating sensors

and replacing some mechanical parts. The circuits can take on highly complex 3d shapes and be wound around and through the existing design infrastructure. They provide a single, continuous, reliable interconnect between different mod-

ules, though can be integrated with traditional wiring if necessary.

Flexible circuits hosting capacitive sensors, rf circuitry and associated componentry are being used in vehicle door handles as part of a keyless entry system. Daimler-Chrysler is finding flexible circuits rugged enough to be incorporated inside the gear box control unit, for example, wrapped into the housing and in contact with oil. They are particularly suitable for mechatronic applications, vehicle manufacturers are finding.

Another fast growing automotive application is in exterior lighting systems. The combination of flexible circuits and led lighting has begun to revolutionise the styling of front and rear lighting clusters. Conventional 'boxy' lens and reflector designs are giving way to elegant curves and exotic shapes, particularly in luxury and sport car models.

US company, Multek, for example, can supply complex 3d designs with multiple steps and angles. The flexible substrate is bonded to an aluminium heatsink. The positional tolerances of the surface mount led lamps can be minimised and isolated to each aluminium plate. Plus additional smds can be mounted on the assembly.

Outside the automotive sector, the space saving and design advantages are attracting new high profile consumer

## Flexible and exotic

Printed electronics may stretch the definition of flexible circuits and may not yet be a truly emerging market, but printing electronic circuits, such as sensors, actuators, batteries, photovoltaics, capacitors and resistors, on to a thin film flexible substrate has wide potential.

Organic leds on flexible substrates are beginning to show some potential according to researchers, supporting novel lighting design opportunities, interior lighting for cars and planes, and public displays and signage. However, research continues into manufacturing large size panels more cost effectively.

applications, including flip and swivel phones, digital organisers and laptops. Samsung's SGH P-920, for example, incorporates mobile tv, still image and moving 'swivel out' video cameras, music player and 3G phone. This hinged device uses sophisticated flexible circuits to connect the displays through the special swivel mechanism and folding hinge. A critical aspect is long term reliability of the electrical connection.

Apple's second generation iPod nano takes advantage of flex circuits for the capacitive scrollwheel mechanism to achieve yet greater miniaturisation in its slimline case. 3M is a major supplier of flexible circuits in a wide range of consumer, portable, wireless and multimedia products.

When it comes to designing flexible circuits, some special considerations need to be taken into account. EDA tools that support flexible circuit design include software from Mentor Graphics and Zuken. Zuken, in particular, offers some advice, guidance and design rules for designers of flexible and flex-rigid circuitry.

Flexible circuits may once have been regarded as niche and specialist, but today the technology looks set to moving much closer to the mainstream. ☺

"(flexible circuits) ... can deliver a more elegant solution with much reduced component count."

Michael Braeuer, **Freudenberg Mekttek**

Company expert Michael Braeuer explained that, for many years, flexible circuits have been used in applications where no other solution was possible, but often very small circuit boards were favoured because they were slightly cheaper. "With electronics proliferating in the car, the benefits of flex are becoming more apparent. In particular, it can deliver a more elegant solution with much reduced component count," Braeuer said. He added that design for manufacture techniques, such as panelisation, can reduce the costs of flexible circuits considerably.