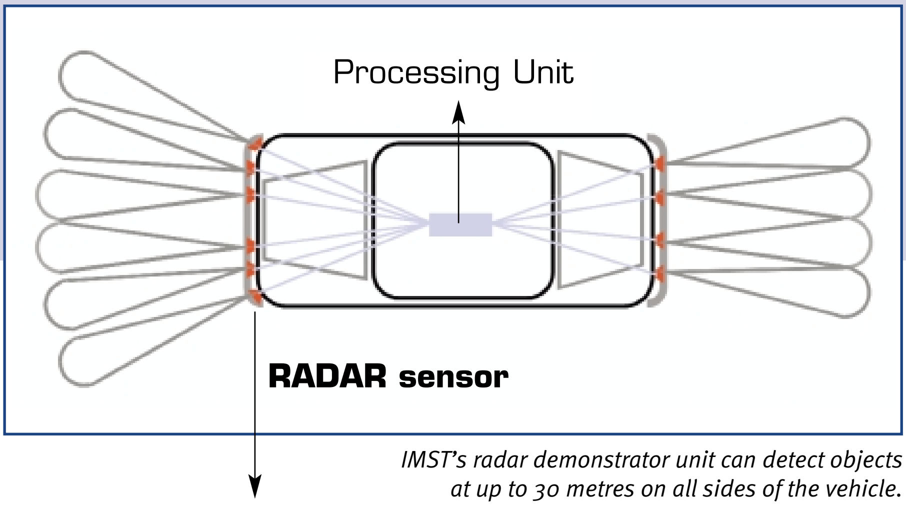
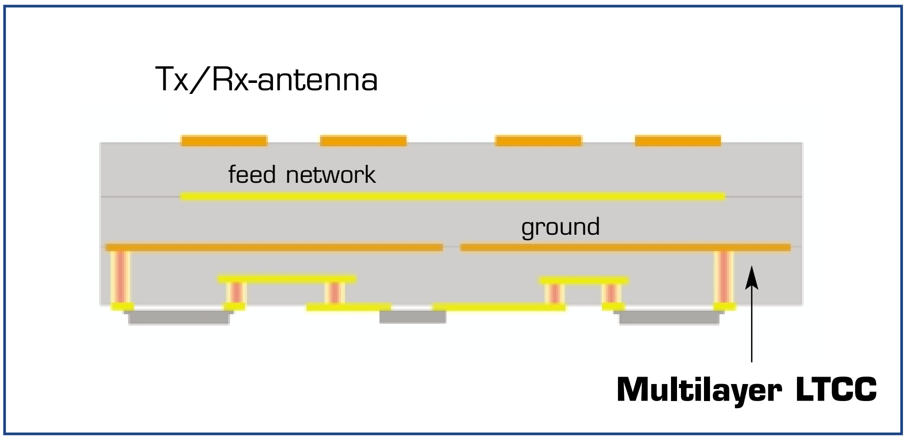
24 GHz radar sensor uses Green Tape™ LTCC technology to detect the proximity of objects

The compact dimensions of the radar sensor unit are made possible through the use of DuPont LTCC technology.

➥ One of the largest costs in modern society is accounted for by automobile accidents. Not only were more than 93,000 people killed in road accidents worldwide in 1998, according to Eurostat, but a large number of people were injured and a tremendous amount of money was spent on car repairs. It has been calculated that about 50 per cent of all intersection, head-on and rear-end collisions could be avoided by earlier driver reactions, corresponding to a potential saving of 340 billion euros (about US$ 408 billion), and that around 94 per cent of all traffic accidents could also be avoided by collision warning systems and automatic vehicle interventions, saving around 640 billion euros (about US$ 768 billion). Since the early nineties, car engineers have been searching to develop suitable devices for collision avoidance, although the cost of such a device has, for many years, been out of reach for automotive applications.



IMST's radar demonstrator unit can detect objects at up to 30 metres on all sides of the vehicle.



Build-up of the radar sensor's multilayer RF circuit made with the DuPont 951 Green Tape™ LTCC system.

This article covers a special 24 GHz Frequency Modulated Continuous Wave (FMCW) radar demonstrator unit for measuring the distance and velocity of objects, which has been developed by IMST GmbH, of Germany, with the close technical assistance of DuPont Microcircuit Materials (MCM).

A new concept

Many electronic solutions are available to today's car industry for radar sensors, most of which are based on pulse methods, whereas the sensor featured in this article is based on the FMCW principle of operation. The carrier signal of the radar is frequency modulated in linear ramps. The sensor receives and transmits simultaneously, and the frequency difference Δf between the transmitted and received signal (e.g. between two objects) is proportional to the time difference of the two signals. The time difference of the two signals is in turn proportional to the distance between the transmitter and the reflecting object, thus determining very accurately, through the frequency difference Δf, the distance between the two objects.

IMST GmbH, based in Kamp-Lintfort, near Düsseldorf, Germany, is an experienced development service provider for mobile radio systems and microelectronics and is a high-tech workbench for both the private and the public sectors. The company has a highly qualified staff of about 120 scientists and engineers, and creates tailor-made solutions for wireless radio applications. Low Temperature Co-fired Ceramic (LTCC) is considered to be one of the favourite substrate technologies for RF and microwave applications. Accurate 3-D modelling tools and a prototyping line are available to develop ambitious LTCC solutions.

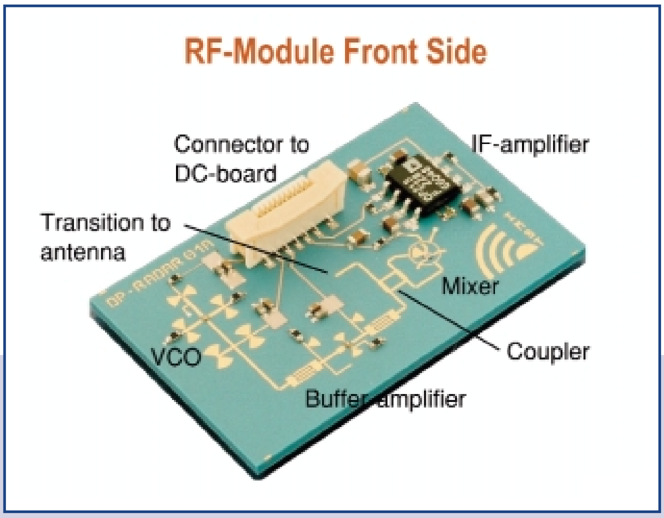
The radar sensor device is a further demonstration of the suitability of LTCC for use in automotive driver-assist systems. The unit allows the detection of objects up to 30 metres on all sides of the vehicle, making possible such safety-related functions as collision avoidance, pre-crash warning, blind-spot detection and parking assistance. It would also be suitable for numerous industrial applications, where the detection of distance and speed are important.

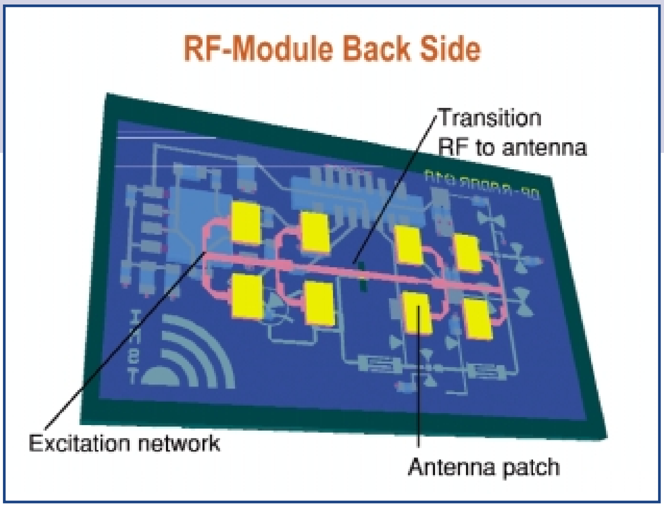
The prime driver in the development process was cost reduction compared to conventional interconnection technologies. The demonstrator unit was designed and built in-house by IMST, which has a well-equipped laboratory, that includes a clean room and an LTCC prototyping facility. A 5-layer LTCC construction was chosen using the DuPont 951 Green Tape™ materials system as the preferred substrate technology, meeting the particular design requirements for the demonstrator. The multilayer ceramic comprises the patch antenna on one side and the HF front-end on the other side, as can be seen in the illustrations. The conductors and passive components are applied by screen printing. The materials used are 254 µm thickness 951 AX tape, 6146 Ag as the solderable top conductor, 5742 Au as the top bondable conductor and for the antenna pads, 6141 Ag for the vias and 6145 Ag for the antenna feed lines. The process used is a standard LTCC process, with all metallisations, including the top conductor, co-fired together.

The module is assembled with cost-effective single semiconductor devices, avoiding the use of expensive monolithic integrated circuits (MMICs). The HF front-end with the integrated patch antenna measures only 3.4 x 2.1 cm. Signal conversion and signal processing are currently undertaken on an external board, which is USB-connected to a PC that evaluates and visualises the data. A graphical surface offers numerous possibilities to alter the sensor configuration and the processing parameters.

For automotive applications, in particular, LTCC-based ceramic circuits are hermetic, offering field-proven reliability and superior robustness in harsh environments. They exhibit high thermal conductivity, low weight, small size and resistance to vibration and temperature cycling.

The radar demonstrator unit is a first step towards a commercial product and IMST is offering further development activities for specific custom applications and specifications, with technical back-up from DuPont, as necessary. The unit was featured at the FISITA show in Barcelona, Spain, in May of this year, and at the SMT/ES&S/Hybrid show in Nuremberg, Germany, in June. It will also be shown at the Convergence exhibition in Detroit, the United States, in October 2004.





Front and rear sides of the radio frequency module.

For further information, visit http://www.ltcc.de