SOLID STATE DEVICES

Progress Still Rapid

from our Solid State Physics Correspondent

INTRODUCING his technical paper at the Third European Solid State Device Research Conference in Munich on September 21, G. H. Schwuttke (IBM) informally sounded the keynote of the conference when he reflected on the rate of development and cost improvement in solid state device technology. He said that, if the motor car had developed with the same rapidity, our vehicles would now cost £100 and travel at 10,000 miles an hour. His point was that demands on the performance of materials have become severe as device dimensions and rates of operation have changed by the orders of magnitude implied in his example. The strongest demands have been in purity, perfection and fineness of structure in the intricate patterns of interwoven solid phases which go to make up a solid state device.

Compared with earlier conferences perhaps the greatest difference was the upsurge of contributions on means of forming arrays of metal-oxide-silicon structures, using techniques such as ion implantation and growth of epitaxial silicon films. For example, F. F. Fang and H. Rupprecht (IBM) investigated the ultimate switching speed for a chain of MOS gates, using all the 'tricks' of implantation techniques. They achieved delay times as low as 0.1 nanosecond and standby power drains as low as 2 nanowatts from all-n-channel arrays. R. de Werdt and I. A. den Boer (Phillips) described improvements imparted by implantation to the already sophisticated LOCOS methods for making complementary-symmetry MOS circuits. Three papers were also given by investigators from Siemens on complex circuits made from silicon on sapphire; this medium will eventually allow even faster switching times by reducing capacitances but control of the film properties is still primitive.

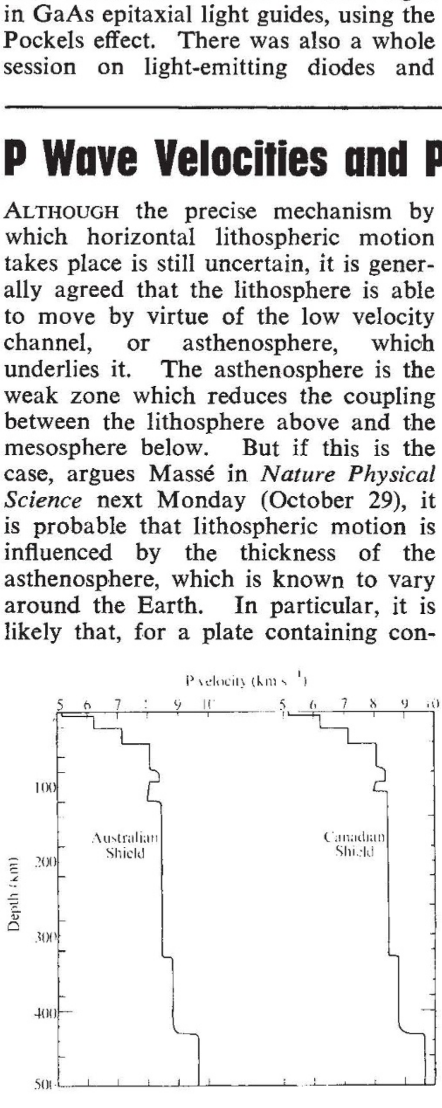
Working alongside the people developing metal-insulator-semiconductor devices, some physicists have been trying to understand charge transport and buildup in the MIS oxide layer: G. Sixt (Institut für Festkörperphysik) and A. G. Holmes-Siedle (University of Reading) described how independently they have used high-energy light in different ways to characterise charge profiles in bombarded insulators. The floating gate MOS memory has also been improved by ingenious use of charge injection into insulators. Eschewing light, J. Verwey (Phillips) has used junction avalanche effect to inject holes across the silicon dioxide layer; H. Card has used Poole–Frenkel conduction through silicon nitride for the same purpose. M. A. Green and J. Shewchun (McMaster University, Ontario) have also used oxide transport and they demonstrated a useful range of operating modes for their MIS tunnel diode, first discussed last year; in many respects, this device can mimic a p–n junction but the problems of forming a metallurgical junction are avoided.

In the junction device field, it is clear that much still has to be found out about the way in which the p–n junction operates, especially when used at the limit of its performance. At high currents, minority carrier injection levels are such that new forms of recombination occur. An example is impact recombination, which is an Auger effect. In this regime, the ratio of diffusivity to mobility deviates from the conventional Einstein relation; N. G. Nilsson (Royal Institute of Technology, Stockholm) has developed a suitably generalised Einstein relation, and K. Roy and K. H. Glöckner (AEG Telefunken) and J. Cornu and M. Lietz (Brown Boveri) have investigated this phenomenon in high voltage P–I–N diodes. Work on gallium arsenide devices continues to be intensive; for example, in the information handling area, H. Kleinknecht (RCA) reported 70% modulation of He–Ne laser light in GaAs epitaxial light guides, using the Pockels effect. There was also a whole session on light-emitting diodes and another on Gunn devices. It is clear that, for the sake of smoothing technological progress, more has to be found out about the physics of the III–V compounds, including their band-to-band transitions, mechanisms of degradation under stress and the defect structures of real crystals. As mentioned, device performance is increasing rapidly. Schottky-barrier field-effect transistors in GaAs can operate in the millimetre wave region and P. A. Kirkby and G. H. B. Thompson (STL) have achieved an output of 40 W mm^{-1} from heterostructure lasers.

Opto-electronic devices probably provided the peak of interest for the conference. J. Carnes (RCA) gave a riveting survey talk on charge-coupled devices and announced a 160 by 128 imaging array which could act as a pickup device for television display while accommodating the usual interlace delays; the publicity release talks about a camera the size of a cigarette packet. For the first time, liquid-crystal displays were admitted into an otherwise purely 'solid state' conference. This is reasonable on several grounds, not the least being the general opinion expressed by speakers that reflective liquid crystal arrays will probably carve out a large share of the display device market.

P Wave Velocities and Plate Motions

ALTHOUGH the precise mechanism by which horizontal lithospheric motion takes place is still uncertain, it is generally agreed that the lithosphere is able to move by virtue of the low velocity channel, or asthenosphere, which underlies it. The asthenosphere is the weak zone which reduces the coupling between the lithosphere above and the mesosphere below. But if this is the case, argues Massé in *Nature Physical Science* next Monday (October 29), it is probable that lithospheric motion is influenced by the thickness of the asthenosphere, which is known to vary around the Earth. In particular, it is likely that, for a plate containing continent, the greatest resistance to motion will occur beneath the shield regions where the low velocity channel is thinnest. This, in turn, implies that the rate of movement of a plate which includes a continent may also be influenced largely by the thickness and nature of the low velocity channel beneath the shield.



But is there any evidence to support such a view? Much more needs to be known about the lithospheric driving force before final conclusions may be drawn; but in the meantime Massé notes that a comparison between the Canadian and Australian shields gives general support to his hypothesis. The P wave velocities in the low velocity zones beneath these areas are equal (see diagram) implying similar physical constitutions for the two zones. But the thicknesses of the zones are different, and so are the drift rates of their respective continents. In numerical terms, the thickness of the low velocity channel below the Canadian shield is only 0.5 times that of the channel beneath the Australian shield and, according to Minster *et al.* (*Eos*, **54**, 238; 1973), the absolute drift rate of North America is only 0.4 times that of Australia. Thus although the analysis is limited to a simple comparison, the relevant parameters are certainly consistent with Massé's hypothesis.