SOLID STATE

Optical Circuits

from a Correspondent

ALMOST everyone has felt the impact of miniaturization in electronic circuits. TVs and radios have become portable and now calculating machines are following. This has been achieved almost entirely by the replacement of the vacuum tube by the transistor and, for the more complex circuits, by the packing of many hundreds or thousands of transistors onto one silicon chip. Nowadays, a computer can be put on a single integrated circuit. The next stage of development in integrated circuitry will almost certainly be the partial changeover to the use of optical signals for transferring data, but again in very small integrated devices. The chief reason is the better speed of operation which can be obtained when information is impressed on a light beam, rather than on a bar of semiconductor. For this reason, we are already witnessing the use of laser links between distant computers (and soon between satellites in space), whereas land lines consisting of bunches of optical fibres could ultimately replace our present telephone cables, endowing vastly greater carrying capacity to the country's communication system. Apart from the speed and flexibility of optical information processing, however, two other major technical needs may be fulfilled by optical methods, namely the need for more compact storage of information and the need for an all-solid-state camera. Thus, "Optoelectronics" is a field of research which should be watched closely by those with interests in wide-band data transmission, information processing and imaging.

One recent step which should be noted is the making of an integrated optical photodetector. This device is capable of having a laser signal piped along its surface for any reasonable distance, then be deflected into a lower layer, where it is converted into an electrical signal. Whereas the concept is clearly not novel, the realization of the concept has been achieved rather neatly and very economically. The light guide is a sputtered glass film, bounded on one surface by air and on the other by thermally grown silicon dioxide, formed by oxidation of a silicon surface, out of which the sensing photodiode is formed. The authors, D. B. Ostrowsky, R. Poirier, L. M. Reiber and C. Deverdun, in *Appl. Phys. Letts.*, **22** (9), 463 ; 1973, describe the use of the ordinary materials of silicon technology for making such a thin-film light guide having quite a high efficiency. Because the structure of the device is amenable to all the tricks of miniaturization and complex pattern generation by photolithography, very complex information processing circuitry could be developed rather rapidly in this system of materials. Thus, within a few years of the development of a thin-film light guide by Tien and Ulrich (*J. opt. Soc. Am.*, **60**, 1325 ; 1970), an easily fabricated, integral optical-electrical circuit element has been demonstrated.

The efficiencies are as follows: losses in the sputtered glass film, which has a refractive index of 1.46 and is 1 μm thick, are 0.8 dB per cm from all sources, of which 0.1 dB per cm is unavoidable leakage loss into the substrate. The guide-diode coupling achieved was 80%. Even using a crude grating, made of photoresist, to couple a laser beam into the thin film, good laser-film coupling was achieved. The rise-time of the diode signal was limited by the capacitance of the diode but could reasonably be reduced to 15×10^{-12} s—a very low value for silicon which is possible because the photodiode can be made very small in this application. This, in turn, being because a very energy-dense optical signal is being transmitted.

Thus, this new device demonstrates some of the basic advantages of using light rather than electrical current as a medium by which to process signals. Optical integrated circuits, coupled to holographic information stores, may in a few years make our present pocket-sized computers look very cumbrous and indeed senile.

ASTHENOSPHERE

Three Possible Models

from our Geomagnetism Correspondent

THE general properties of the low velocity zone in the Earth's upper mantle are now quite well known. Depending upon the region, the top of the zone lies between 50 and 100 km beneath the surface and the bottom lies between 100 and 200 km, although in spite of this variability both the upper and lower boundaries appear to be sharp, with each transition taking place in less than 10 km. The velocity drop which gives its name to the zone is about 3–6% and according to Anderson *et al.* (*J. geophys. Res.*, **70**, 1991 ; 1965) is rather more pronounced for S waves than for P waves. This difference in behaviour can apparently be related partly to the fact that the attenuation is greater for shear waves than for compressional waves and is a useful reminder that the low velocity zone is also a high attenuation zone, the increased attenuation also being a few per cent.

As Gueguen and Mercier (*Phys. Earth planet. Int.*, **7**, 39 ; 1973) now point out, it follows from this that, although explanations for low velocity and high attenuation have often been considered independently, valid physical or chemical models for the low velocity-high attenuation zone (LVHAZ) must

Experimental and Theoretical Aerosols

How aerosols are formed is a question which is still causing a great deal of discussion and the flow of publications on the subject is still increasing. In next Monday's *Nature Physical Science* (July 23) two aspects of the science of aerosols are given an airing. First Kiang, Stauffer and Mohnen present a theoretical interpretation of the way in which aerosols are formed. In another communication, which deals with an aspect of the experimental side of aerosol physics, Dahneke summarizes recent developments in aerosol beam spectrometry.

Kiang and colleagues point out that there have been many studies both of the chemical reactions which occur in the liquid phase of droplets and of the role of chemical reactions preceding the phase transitions. But none of these studies has given any consideration to the physical processes which take place in the formation of aerosols. Kiang *et al.* have applied themselves to investigating the nucleation process but they also call attention to the possible chemical reactions involved in the formation of $(NH_4)_2SO_4$. They conclude that water vapour plays an important part in heteromolecular nucleation in that it can change the rate of nucleation by several orders of magnitude. Perhaps it is no surprise that the calculations reveal that gaseous substances with the lowest volatility will nucleate first, but Kiang and his team point out that the critically sized droplets so formed will act as a surface for heteromolecular condensation. The significance of this work is that the theory developed can be used for the formation of aerosols in urban atmospheres, the stratosphere and also in the atmospheres of planets.

The surprising aspect of Dahneke's review of aerosol beam spectrometry is that evaporation does not seem to pose a serious problem in the measurement of moist aerosols. The reason, quite simply, is that the particles are substantially cooled in the adiabatically expanding nozzle-jet flow and this, coupled with evaporative cooling, retards further evaporation. Thus, these spectrometers may prove to be widely useful in measuring aerodynamic size distributions, compound size/composition, size/radioactivity and size/charge distribution of aerosols. They can also be used in sorting the sizes of airborne particles, powdered and industrial powders and dusts.