high temperature deposition techniques. Nevertheless research is being continued at several laboratories and progress may be expected.

Very interesting MO effects have been found in metallic, artificially layered structures.[23,24] This is a new field but the possibility for "atomic engineering" in these materials may provide yet unknown and unexpected phenomena.

7. Summary and Outlook

In this article we have discussed materials for MO recording and their application in rewritable recording systems. After a long period of intensive research the RE-TM alloys can be adjusted to satisfy all the requirements for suitable MO materials. This has been made possible by new insights in the physics of the recording processes, combined with advanced preparation techniques. The requirement of direct overwrite, which is expected to be essential for practical applications, will have an impact on further developments in the RE-TM alloy system. Lorentz microscopy pictures show that extremely small domains can be written in a controlled way in these materials allowing for very high recording densities. Unfortunately the resolution during readout is limited by the spatial extent of the laser spot which is about 1 μm at the present wavelength of 800 nm.

The main disadvantage of the present materials is their moderate MO performance and chemical instability. Although some practical solutions to these problems have been found, these drawbacks are the driving force in the search for completely new classes of materials. Magnetic oxides and metallic multilayers offer some interesting prospects here. All these efforts are worth pursuing, because MO recording may develop as the future recording technology, combining the advantages of both magnetic and optical recording.

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Research News

A Novel Monolithic Thin-Film Electroluminescent Device with Extrinsic Memory

Flat display panels are a part of many portable consumer products. Their visual performance is inferior to that of cathodic ray tubes: the luminance of liquid crystal displays (LCDs), the leading flat display technology, is very low, and, in the conventional line-by-line addressing mode, their contrast decreases with increasing panel size. Electroluminescent (EL) display devices are an interesting alternative to LCDs. Figure 1 shows the structure of a standard thin-film(TF) EL device. The active ZnS-Mn layer is sandwiched between two dielectric Y_2O_3 layers.[1,2] Electroluminescence is excited by an alternating field of some 10^6 V cm^{-1}, applied between the metallic and the transparent electrode.

In principle the visual performance of emissive display panels is independent of screen complexity and addressing mode. In practice, the average luminance decreases with

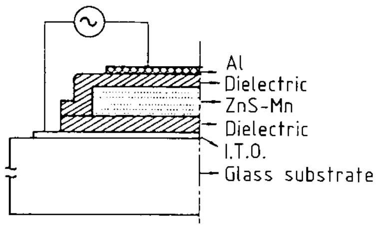

Fig. 1. Cross section of a standard TFEL structure (schematic). See also [7].

increasing screen size: in the line-by-line addressing mode, the time during which each pixel is excited is reduced to T/N, where the period T is determined by the operating frequency of the panel and N is the number of lines. This decrease in luminance can be compensated for by higher excitation currents, but the current density supported by the thin-film electrodes is limited. This practical limitation of screen size and complexity in EL panels can be overcome with the use of memory devices. An EL device with memory shows bistable behavior and remains in the ON or OFF state until the device is switched. Thus, for a static image on a display screen, no periodic refreshing of the screen is required. Standard ZnS-Mn EL devices have been shown to exhibit intrinsic bistability,[3] but the hysteresis margin is low and fades with aging of the device. Moreover, high EL efficiency and a large hysteresis margin cannot be obtained simultaneously. Consequently, this intrinsic memory effect cannot be used in display panels.

EL devices with extrinsic memory were proposed thirty years ago by *Kazan*.[4] The memory effect is produced by electrical coupling between a photoconductive (PC) layer and the EL device. A TFPCEL device can be switched ON either electrically (excitation of the EL layer) or optically (excitation of the PC layer). Due to the optical emission of the EL layer, the PC layer becomes photoconductive. The device remains thus in the ON state until the ac voltage which excites electroluminescence is switched OFF.

The first TFPCEL devices were developed ten years ago.[5] The photoconductive CdS layer was deposited on a separate transparent substrate, thus requiring an additional interconnecting step in producing a display panel. Moreover, due to the ohmic behavior of CdS layers, the dark switching voltage is inconveniently large and difficult to control. Electrical switching of such a TFPCEL display panel would be practically impossible.

Two french physicists, *P. Thioulouse* of the Centre National d'Etudes des Télécommunications (CNET, Bagneux) and *I. Solomon* of the Ecole Polytechnique (Palaiseau) have developed a device which solves both problems:[6-8] the TFEL device and PC layer are integrated on the same substrate, and the whole device can be switched ON electrically.

The original feature of this device is the choice of the PC-layer material, an amorphous hydrogenated silicon-carbon alloy (a-$Si_{1-x}C_x$:H), which can be deposited with high reproducibility in a conventional glow-discharge plasma reactor. Figure 2 shows the structure of the new TFPCEL device. Stoichiometric Ta_2O_5 is deposited by reactive magnetron sputtering on the ITO-coated glass substrate. Chlorine-free ZnS–Mn is deposited by electron beam evaporation. The photoconductive a-$Si_{1-x}C_x$:H layer has $n^{\oplus}$-i-$n^{\oplus}$ structure and can be grown in a single run. Due to carrier-injection from the $n^{\oplus}$ into the i-layer, the dark conductivity of the i-layer is strongly non-ohmic and governed by the density of states at the Fermi-level which can be adjusted by variation of the carbon content.[9]

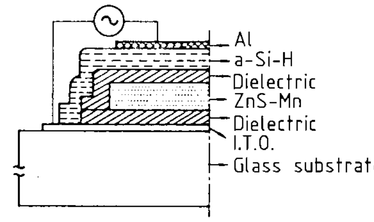

Fig. 2. Cross section of the new TFPCEL device (schematic). The photoconductive a-$Si_{1-x}C_x$:H layer has $n^{\oplus}$-i-$n^{\oplus}$ structure; its dark conductivity is therefore governed by space-charge limited conduction. This non-linear current–voltage characteristic favors electrical switching of the device [7].

The new device exhibits a combination of properties very favorable for application in display panels with high resolution: electrical switching is possible (Fig. 3) with a memory margin sufficiently large for large-size panel applications; the picture elements (pixels) have very sharp edges without the need for an additional photolithographic step; luminance (about 650 cd m^{-2}) and contrast are high, whereas the sensitivity of the PC layer to ambient light is rather low and can be adjusted by a proper choice of deposition conditions. No degradation of the memory effect was observed after more than 2000 hours of opera-

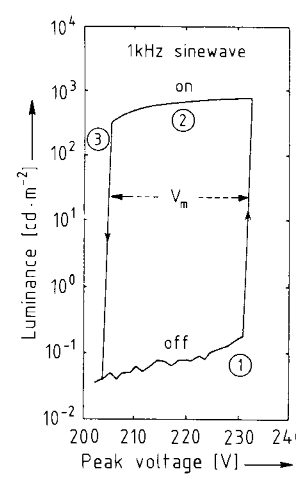

Fig. 3. Luminance vs. voltage characteristics of the new TFPCEL device operated in the dark with a 1 kHz sine waveform. The device is switched ON electrically (1) and remains in the ON (emitting) state (2) until the peak-to-peak voltage is decreased below the threshold value (3). The memory margin V_m is of the order of 25 V [7].

tion. The device is monolithic, and the addition of the PC layer to the conventional TFEL device requires only one additional step: the deposition of an amorphous silicon alloy using a well-known industrial deposition technique. The simplicity of the new device is an important difference to LCD panels driven by a-Si:H thin-film transistors, a very complex technology. The new TFPCEL structure, although still a prototype, clearly has the potential for use in highly complex display panels, and its high switching speed is compatible with TV applications.

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Conference Reports

Intermetallic Phases

The first German symposium on intermetallics ("Intermetallische Phasen: Grundlagen—Einsatzmöglichkeiten—Herstellung") was held on November 24–25 in Bad Nauheim as a joint meeting of the Deutsche Gesellschaft für Metallkunde (DGM) and the Verein Deutscher Eisenhüttenleute (VDEh). It was attended by materials scientists and engineers—nearly half of them from industry—mostly from Germany, Switzerland and Austria. The symposium was composed of four main sessions:

- fundamentals
- structural materials for high-temperature applications and lightweight materials
- functional materials
- processing technology

and three workshop discussions dealing with the production of engine parts, the boundary conditions for intermetallic materials research, and the prospects of intermetallics for high-temperature applications. The aim was to bring together the various groups in research institutes and industry which are studying intermetallic phases, or are interested in applying intermetallics, in order to review the present situation, to assess the prospects and to define tasks for the future. In this symposium only invited lectures were given, and proceedings are not published.

The introductory lecture was given by *H. J. Engell* (Max-Planck-Institut für Eisenforschung, Düsseldorf) who explained that intermetallic phases occupy a position intermediate between metallic alloys and ceramics with respect to atom bonding and crystal structure. This results in the particular properties of intermetallics which make them promising for high-temperature applications and as functional materials. *E. Parthé* (Univ. of Geneva) discussed the crystal structures of intermetallics and showed that complex crystal structures—e.g. those of the Laves phases—result from the stacking of simple basic structures, planes or columns, which allows the prediction of new structures. The first paper by *J. Hünecke* and *H. Wever* (Tech. Univ. of Berlin) discussed constitutional disorder and its temperature dependence with respect to the β'-Hume-Rothery phases and the $B8_2$ phases NiSb and Ni_3Sn_2. The second paper by *J. Hünecke, H. Wever* and *G. Frohberg* outlined the diffusion mechanisms in intermetallics and applied the analysis to phases of types B2, DO_3, $B8_2$, $L1_2$ and A15. The session on fundamentals was concluded by a review by *P. A. Beaven* (GKSS-Forschungszentrum, Geesthacht) on the possibilities for the ductilization of intermetallics, and in particular the effects of composition, i.e. stoichiometry, macroalloying, microalloying, and of processing were discussed.

The session on structural materials for high-temperature applications was led off by an introductory lecture by *G. Sauthoff* (Max-Planck-Institut für Eisenforschung, Düsseldorf). First an overview was given on the criteria for the selection of phases for high-temperature applications, and on the nickel aluminides and titanium aluminides which are already a subject of materials developments, and are now beginning to be introduced commercially in the USA and Japan. Then some less common phases were described which are of special interest for applications at temperatures above 1000°C and are a subject of current research. Figure 1 shows some examples.

The oxidation and hot gas corrosion behavior was reviewed by *L. Singheiser* (Asea Brown Bovery, Mannheim). In particular the effects of alloying elements, of impurities