Thin film transistor and its new developments engineering essay

Engineering

S. N. Kumarasinghe. Faculty of Information Technology, University of Moratuwa. salindanayanajith@gmail. com. Abstract: The usage of mobile devices is increasing day by day. And the complexity of the mobile devices is also increasing. Therefore the display of the mobile devices should also develop in order to give good output to the user. Modern day people use Thin Film Transistors (TFT) to build mobile display devices. A thin film transistor is a special type field effect transistor by depositing a thin active semiconductor layer and the dielectric layer and metal contacts on a supporting substrate. Each pixel of TFT is controlled by one to four transistors. And it TFT has best resolution of all the flat panel technologies. Today development of TFTs are at a high level. And it is also a current research area. Because use of the TFT is very high in today's technical world. C: UsersSalindaDesktopurl. jpgKeywords: TFT, mobile display, thin film, semiconductor.

Introduction.

In past few decades, we can see huge development in computers and mobile devices. For that development, display of computers and mobile devices gives a huge impact. In old days, people use to produce computer displays using CRTs. So that they are big in size. But after arrival of LCD, LED, TFT the mobile devices and computers get very small in size. And also they give good output quality than previous CRT displays with high picture contrast, high resolution, and high colors. So that the companies which developed LCD, LED displays encouraged to develop their product more and more. So the competition among the companies get high. Every one try to produce more superior product than others. That results more advanced displays to the market. That is huge breakthrough in development of mobile device technology.[6][7]There are many ongoing researches on TFTs. Now the researchers implement TFTs which are flexible and more energy efficient. The more it get thinner, the less its energy consumption. So the researches are mainly forces on how to create thinner, low energy consummating, TFTs. They also have thin of nearly 4nms. With the flexibility and low thin, the modern displays are flexible and also transparent. Therefore the designers of new mobile phones, tablets, PDA and laptops design them as ultra-thin. Figure 1: Flexible laptop which can role. The flexible laptops are available in todays market and this is possible because of this thin film transistor technology. The increased use of thin-science is still in the Microelectronics. However, there are increasing applications in other areas such as optical and magnetic thin films device, electrochemical, protective and decorative Coatings and catalysts. [5]In early time, there were only one color TFT displays. But with the rapid growth of TFT now we can see more than 16 million color displays. This is achieved by one to four transistors per pixal. [1]C: UsersSalindaDesktopamoled_laptop. jpgFigure 2: Laptop with AMOLED. displayC: UsersSalindaDesktopReserchColor_TFT-LCD_Layout. pngFigure 2: cross-section of a display with TFT. 1 - Glass plates2/3 - Horizontal and vertical polarisers4 - RGB color mask5/6 - Vertical and Horizontal command lines7 - Rugged polymer layer8 - Spacers9 - Thin film transistors10 - Front electrode11 - Rear electrodesFegure 3: New processing methods of thin film materials and the devices. There are a variety of processes, thin film deposition technologies originating from purely physical or purely chemical processes. The main processes in the liquid phase chemical thin film techniques, chemical processes in the gas phase and glow discharge processes evaporation based methods [8]. Recently, there is a series of new procedures developed using a combination of different methods. This combination enables the control and adjustment of microstructure and properties defined more thin layers. Typical methods include for example ion-beam assisted deposition (IBAD) and plasma CVD (PECVD). Examples of new techniques for thin-film processing, which is still in development, are laser ablation (PLD) and chemical solution deposition (CSD) pulsed. Both techniques allow the preparation of complex thin film materials (complex oxides, carbides, and nitrides). Currently, the experimental efforts are increasingly computational approaches, supports address complex growth processes, saving time and money. These approaches allow for example, the description of the development of the thin film microstructure as a function of process parameters. Today TFT developers widely use AlN, ZnO, and Pb(Zr, Ti)O3, In2O3 to create TFT displays. By using various elements they achieve flexibility and transparency of the display devices. There are small elements called pixels in the display. They have one to four sub-elements which control the back light. This each sub element is controlled by underlying transistor panel. This panel as whole called as the thin film transistor (TFT) panel. When this panel is transparent, it called as transparent thin film transistor (TTFT). And to control this transistors there are command lines under the TFT panel. TFTs are the active elements, which are arranged in a matrix on the display and because of that they called as " active-matrix TFT".[2]

N-Type Organic Semiconductors

N-type materials of high performance permits the production of pn junctions and ± complementary logic circuits. Interestingly, most of the previous work on p-type organic materials such as pentacene, poly - concentrated or oligothiophenes, described in the previous section, while recently there have been serious efforts to prepare (3 alkylthiophene) materials New N-Type semiconductor. Disproportionate development of organic p-type FET (OFETs) with respect to n-type is clearly a result of the inherent instability of organic anions, particularly carbanions react with oxygen and water under operating conditions, such devices unstable mode. De Leeuw et al. have this problem indirectly by examining the stability of the n-doped (ie, reduced) and treated polymers by evaluating standard redox potentials for reactions with oxygen and water. It is concluded that although there is an optimum thermodynamic stability window can be determined based on a standard redox potential, stability of materials of n-type doping is strongly dependent on the value of the overload tension (ie, free activation energy) with the chemical processes (ie the reaction with water or oxygen). Therefore, a careful adjustment of the electron affinity of the n-type materials should be made in order to obtain thermodynamically stable devices, or passivation layers or sealing compounds should be used. Alternatively, air stability achieved by inhibition kinetics undesirable redox processes. For example, the incorporation of hydrophobic functionality can in the chemical structure of the organic semiconductor prevent ingress of water and thus a barrier ª º kinetics. The design rules for the n-type organic semiconductors are very similar to the p-type materials, except that the n-type semiconductor materials have devices using the electron injection into the LUMO. Therefore, the electron affinity of the semiconductor must be optimized so that the LUMO level (conduction band) relative to the Fermi levels of the source electrodes and drain not to limit the injection of electrons from the source the semiconductor and the semiconductor in the drain. Most work to date has taken gold electrode used as the source and drain. Gold has a work function of 5. 0 eV ~ regarding empty and as most of the n-type material, electron affinity levels ~ solid state, the energy barrier of 4. 0 eV to wait about 1 eV limit charge injection are in the semiconductor. Interestingly, this is not the case. It is known that if gold surfaces are coated with organic materials to modify the work function of the metal apparent to 1 eV, and thus facilitates the injection of charge carriers in the n-type materials. Alternatively, this apparent workfunction change can be interpreted as a thin interfacial layer electric dipole in the very fact that there is a vacuum in the displacement of metal / organic interface. This phenomenon, ultimately provides an additional element of complexity in terms of the test corresponds to the work function of the electrode in the conduction band of the semiconductor for forming ohmic contacts[11]. OTFTFegure 4: Coross section of OTFT. TFTs are transistors created using thin films, usually of silicon deposited on glass. The deposited silicon must be crystallized using laser pulses at high temperatures. For organics to compete with a-S: H, their mobility should be greater than 0. 1 cm^2/V s and their on/off current ratio of greater than 106. OTFTs active layers can be thermally evaporated and deposited at much lower temperatures (i. e. 60° C).

Some benefits of OTFTs are,

They does not require a glass substrate as amorphous as silicon does. And do not need high temperature for the manufacture process. So cost of the production is low. Can be implemented on top of a piece of plastic. And also deposition techniques could reduce costs dramatically.

And the challenges has to be when developing OTFTs are,

Workarounds for complications with photoresists. Finding suitable organic semiconductors with high enough switching times & mobility. The accommodation of the teams to research and Development of new device structures and materials new functions must be carried out continuously. Research and development has to offer equipment a high degree of flexibility in the placement of a plurality of substrates and deposition parameters in real time Tracking capability. Until recently, these facilities do not let a high performance product manufactured developing new thin film materials more boring. By using parallel processing thin combinatorial approach perform, and a significant reduction in sample Size, time and money can be savedThin film systems require direct control of the materials in atomic and molecular level, including the surface modification Deposition and patterns. Many of these techniques have improved in the last ten years, which remarkable progress in the fundamental understanding physics and chemistry of thin films, the microstructure. The evolution and properties. This progress has led to the development of new materials, enhanced applications and new device designs and functional thin film Systems. One of the most striking examples is the success Developing novel semiconductor device having Materials such as oxides and nitrides (for example, GaN).

Another typical Examples include advances in the synthesis of hard coatings based on borides, carbides and nitrides. [9]C: UsersSalindaDesktopApple iPad 3 OFFICIAL VIDEO - Retina Display_ 5 MP Camara_ A5X and More - YouTube[19-45-01]. JPGFigure 5: A pixal and it's colour element with the control transistorC: UsersSalindaDesktopApple iPad 3 OFFICIAL VIDEO - Retina Display_ 5 MP Camara_ A5X and More - YouTube[12-45-21]. JPGFigure 6: Thin film transistor panel with connection lines. There is huge variety of thin-film transistor deposition processes and technologies. It originate from purely physical process or purely chemical processes. More important thin film processes are based on liquid phase chemical techniques, glow discharge processes, gas phase chemical processes and evaporation methods. Recently, new processes which are utilize the combination of different processes have been developed. So by this combination more defined and controllable tailoring of thin films microstructure can be generated. Ion beam assisted deposition and plasma enhanced are some typical processes examples. Pulsed laser ablation and chemical solution deposition are still developing processing techniques. By both this techniques can synthesis complex thin film materials like complex oxides, nitrides, and carbide. The computational approaches are highly support to address complex growth processes which saves big amount of time and money. So this approaches allows evolution of thin film microstructure's description as a function of processing parameters. The history of TFT goes back to 1960's. The first solid-state amplifier which is ever planted was the thin film transistor. But until quite recent time there were no practical application. And in in 1970's it came for a solution as flat display panel's large integrated circuit. That time they were built by using amorphous silicon (a-Si) with the doping of boron (B) or phosphorus (P). Because the boron (B) or phosphorus (P) impurities it gives the ability of control the electrical characteristics of a-Si semiconductor. And in early 1980's researchers show that TFT technology can use to implement active matrices. And by using that, it is possible to drive a liquid crystal displays (LCD). This finding highly accelerate the development of thin flat panel displays. And the CRTs was replaced by TFT LCDs very rapidly. In 1983, Sharp released full color 3 inch LCD prototype and in 1988 they developed 14 inch display. And after that the mass production of TFTs was started. [4]After 1990s research on low temperature poly-Si TFTs became more popular. Implementation of these technologies and the highest level of technological perfection, was helped to explore new technologies which launched with the aim of creating new types of high-performance TFTs. The present is considered as the time to explore deeply in this area. By that in future, there will be perfect TFT technologies by applying various TFT materials such as semiconductors. There is no doubt that future of TFT is clear. But LED technology is also going with TFT technology. Lots of research going on both technologies. No one can predict which will be the most powerful technology in the future.[4]There are few types of TFT panels we can see in the present. They are,

1) TN panels (Twisted Nematic).

Most current type is this panel. This comes as 17in panels. This is one of the early stage TFT technology. But it's still very popular because of its lower cost and ability of delivering fast pixel response time is very good for modern gamers. Today many modern displays are marketing on response time. But it has some disadvantages of this technology. This panels have poor viewing angles of 130 to140 degree relative to other types of TFTs. To address this issue TN panels improved as ‘ TN+film’ technology, where a special film a layer is added. But vertical viewing angles are still bad. Even a modern TN panel has huge color shifts and even colour inversions when watching from below or above. TN panels use 18-bit color. So they deliver law saturated colors. This makes them less suitable for photo editing and multimedia applications.[3]

2) MVA panels

Fujitsu developed MVA (Multi-domain Vertical Alignment) panels. Now there are many manufacturers who also building MVA panels. They also using this technique to develop MVA panels. MVA panels and their derivatives have much deeper blacks. So that they has better contrast ratios than TN panels. And also with wider viewing angles and support 24-bit color rendering, which support up to 16. 7million colors. So that, their cost is often relatively higher than other types. Originally this has slower response times, but now MVA panels are approaching the reaction times of TN panels because of ‘ overdrive’ technologies which supply greater than normal voltages to the liquid crystals.[3]

New trends in Thin Film Transistors.

1) Spray Painting method to produce Organic Thin-Film Transistors

Figure 7: Spray Painting method of TFT. In electronics industry Silicon is the iconic material, which is the basic material for memory chips and most

microprocessors. Billions of small computer elements can be crammed into very small area by using Silicon as a substanceElectronics industry is finding a novel organic materials which can use for purposes which Silicon can't use like bend and fold. So most of the researches predict that organic semiconductors allows the production of low-cost video displays which could be sprayed onto a suitable surface just like paint spraying. " At this stage, there is no established best material or manufacturing process for creating low-cost, large-area electronics," says Calvin Chan, an electrical engineer at NIST. He also said that, " What our team has done is to translate a classic material deposition method, spray painting, to a way of manufacturing cheap electronic devices." Calvin Chan and his team's work showed that the commonly using organic transistor material such as poly(3-hexylthiophene), or P3HT and spray-on transistor materials are working more similar way. Because transistors aren’t very deep. When sprayed them onto a flat surface, transistor effects happen at its lower surface and when it has the substrate it works fine.

2) Smallest silicon-based thin-film transistors

Smallest silicon base thin film transistors ever made was produced by Schiltron's technology. Its 35 nm channel thickness and 48 nm gate length. They used a double gate design which provides provides tight electrostatic interaction to control short channel effects which resulting lower erase voltages, thinner tunnel oxides, and higher endurance than current nitride-based NAND designs. Schiltron technologys was introduced to engineering audiences first, at the IEEE International Electron Devices Meeting (IEDM) in San Francisco which was in December to eliciting positive reviews. " Our memory design is feasible for the sub-50 nm technology node, and solves the usual critical problems associated with thin film transistors and charge trap flash." said Andrew J. Walker, Founder and current president of Schiltron. So this new transistors can be used with many products including TFT, alternative for NAND Flash memory. So the more the transistor get smaller the more display get thinner. So that is a big advantage for producers who develop displays using TFT.

3) Making Amorphous Silicon Thin Film Transistors on PEN Films

Teonix® PEN filmFigure 8: Teonex® PEN films. FDC researchers, have developed a way to make high-performance amorphous Si thin film transistors on planarized Teonex® PEN films. They integrated 3. 8-in QVGA arrays of transistors with Vizplex-100™ to fabricate glassless high-performance flexible display which has thickness of only 375 micrometers. This display is quite rugged and readily can survive severe vibration and impact. The company also release some videos of tests performed at their General Dynamics’ labs. The FDC method uses a patented technology to temporarily fix flattened Teonex PEN film (DuPont Teijin) to a rigid support with a specially developed adhesive. Amorphous silicon circuits and then madeconventional flat panel production lines. Although exposure of the film to temperatures as high as 200 ° C attached (392 F) during the production process, there was substantially no distortion plastic substrate. The film finished with the transistor array substrate using a mechanical force, which is soft enough to allow for automation of the process. The FDC thin film transistors are reported using the latest semiconductor and dielectric deposition process on a gate Teonex PEN. The high temperatures allow the fabrication of transistors with high on-off ratio, costs more below the threshold, and - most importantly - more bias-stress stability. These performance characteristics directly at a higher density of pixels for higher resolution, a large number of gray levels to improve image quality. The capability to produce high quality grapes of thin-film transistors with minor defects is to cater supported by the use of flattened DTF Teonex PEN, developed the visualization needs of demanding applications. The PEN Teonex temporarily attached with flattened layer restoration provides a smooth enough and free enough to allow manufacturing error of the micrometer-scale electronics.

4) First paper interstrate thin film transistors.

Today, there is increasing interest in the utilization of biopolymers for minimum cost electronic applications. Since cellulose is the great Earth biopolymer, some international teams also have reported using this paper as a physical support (support) of electronic devices. But no one had used the paper as an inter-tered component of a FET. In a new entry, scientists Cenimat/I3N - A research group led by Elvira Formatunato and Rodrigo Martins coordinated - a sheet of plain paper as the dielectric layer oxide FET. The research team that devices on both sides of the paper web. Thus, the paper acts simultaneously as substrate and as an electrical insulator. " It's a two in one" says Elvira Fortunato. Also showed overcome performance amorphous silicon TFT, and rival with state of the art thin film transistor electrical characterization of the devices, the FET hybrid. These results suggest promising new disposable electronic devices, such as paper displays, smart tags, smart packaging, bio-applications, RFID labels, among others.

5) New Molecular Thin Film Transistors works with Low Voltages.

Organic electronics is carried out under performance and cost-sensitive applications. One of the main problems of traditional organic thin film transistors (TFT) is the high-voltage operation, often more than 20V. In order to reduce the operating voltage and thereby the power consumption of integrated circuits are required in organic TFT, gate dielectrics new ultrafine. Infineon has a new molecular TFT for high mobility organic semiconductor (pentacene) and one (2. 5 nm), molecular self-assembly monolayer ultrathin developed (SAM) gate dielectric. This advancement in the field of organic dielectric gate transistors transistors were made at 1 V, the display of a subthreshold swing as low as 100 mV / decade. For a transistor with a channel length of 5 microns was measured 0. 01µS/µm slope - the greatest slope reported an organic semiconductor device today.

6) Low Cost Manufacturing method to create Thin Film Transistors using Carbon Nanotubes

Nano-Proprietary, Inc., through its subsidiary, announced Applied Nanotech, Inc. (ANI), today announced that it is a low-cost method for the production of thin-film transistors with monolayers of well-dispersed single wall carbon nanotubes developed. Monolayer random network of single-walled carbon nanotubes in a solution at room temperature by a method which is compatible with polymeric substrates, based on a large area flexible microelectronic deposited. Thin film transistors constructed in silicon oxide, but other dielectric materials are also useful. Mobility performance of these transistors, even at this early stage of magnitude better than amorphous silicon, or organic semiconductor materials transistor. In addition, this new type of transistor to provide a significant contribution to improvement of the sensitivity of the sensor based on carbon nanotubes ANI, transistors with the internal amplification of the sensor detection signals.

7) AMOLED

C: UsersSalindaDesktoppantalla-amoled. jpgFigure 9: AMOLD Cross sectionActive Matrix LED (Light Emitting diode) is one of display technology which use in mobile devices and televisions. OLED is a specific type of the thin-film display technology where organic compounds form the electroluminescent material, and active matrix is the technology to address the pixels. AMOLED is an advancement of OLED technology, this has same characteristics as OLED. In fact, the similarities beyond outnumber the differences. OLED, at its core, it is a simple light emitting diode's luminescence is provided with a film of organic compounds, in contrast to the opposite conventional inorganic materials. By the electric current running through the electrodes in an OLED, this can emit light which can be used in a variety of devices, such as from flashlights to computers. The basic principle of operation in AMOLED is electro-luminescence. Electro-luminescent (EL) has a visual appearance and electrical phenomenon in which a material emitting light in response to the passage of an electric current or a strong electric field. This is different from black body light emission from heat, chemical reaction, sound or other mechanical means. AMOLED has more control over color expression of it. Because it only gives pure colors as output when electric current stimulates a pixels. The primary color matrix set as red, green and blue pixels which are imposed directly to a printed circuited board. Each and every AMOLED element is arranged in a special micro cavity structure which is designed to fully reduce ambient light interference, which also improves overall color contrast. The thickness of the organic layer is calculated and manufactured to produce the maximum light which can give to a color picture. Furthermore, the colors are refined with a special type of filter and purified without using traditional polarizer to give outstanding color purity. Figure 10: AMOLD Cross section

Discussion

Multimedia devices are most useful tool in human activities. So people tend to use all in one devices which can perform many tasks in single device. To perform many multimedia tasks in one device display is very important. With a sufficient display size dew tasks can be integrate into single screen. With the TFT technology people can implement display devices with enough size high colors and high resolution. Therefore it is very useful to search and study such aria. And also this aria has high impact on most other research arias such as flat panel displays, TFT arrays in solar cells, etc. And also this thin film transistor are using in new display production method which called as AMLED. Almost all the current mobile phones and tablet pcs use this type of display. This has best color variations and high contrast. AMOLED is also a good aria for research in the future.

Conclusion

In summary, this review paper reviews on what are the major limitations and drawbacks of the traditional display devices. And what are the major effective methods to fabricate TFTs nad materials use to fabricate TFTs. Also about current technologies that are need to develop TFTs. And applications TFTs And finaly what are the limitations and drawbacks of TFTs. TFTs are promise to make electronic viewing more fitting for the purpose and universal as they are low in energy consumption. TFT is so revolutionary that in the field of displays. Today, TFT technology is widely use in next generation component for big size displays and flat panel displays which are expected to become a main technology in the production of flexible displays.

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