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FOLDABLE AND PORTABLE TECHNOLOGY: A STUDY ON INVENTION, EVOLUTION AND IMPLEMENTATION

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ABSTRACT

Various electronic devices, especially hand-held computing devices, have become popular as portable computers, personal organizers and as wireless communication devices such electronic devices are often used as portable devices, the size, that is the length and the width, of the casing parts have to be reduced to a minimum. Hence there comes a technology of foldable devices. This paper is a simple approach to high-performance, stretchable, and foldable integrated circuits that combine to form an electronic device. The invention and development in this technology provides a foldable electronic device which is more comfortable to use which is a foldable display device including a case that stably supports a flexible display panel for improving user convenience. Basically these days users prefer devices as a mobile phone and a portable, cellular phone battery charger using solar energy using the sun, a primary source of energy is discussed as a part of content. Foldable technology is growing day by day and the recent product that is available in the market is a present invention relates to an electronic piano including a roll-up keyboard. The described technology is described more fully hereinafter with reference to the accompanying diagrams and figures providing a perspective view to the technology of portable and foldable devices. It basically only includes the proposed or the implemented ideas of such devices.

Keywords: electronic devices, integrated circuits, foldable display, solar charger, roll-up keyboard.

I.INTRODUCTION

Researchers have developed a method for fabricating silicon-based electronics that can be stretched and folded without damage, circumventing the problem of extreme fragility that ultra-thin flexible silicon materials traditionally face. Most of the flexible electronics being developed today are based on polymer materials, but polymers have inferior semiconducting properties compared to silicon. Also, unlike silicon, most polymers are not fully compatible with the standard fabrication processes used in today's semiconductor industry. If silicon can prove to be mechanically robust enough to endure the stretching and bending required by flexible electronics, it would potentially offer an ideal material for realizing commercial flexible electronics on a large scale. For example, tiny smartphones that wrap around wrists, and flexible displays that fold out as large as a television or photovoltaic cells and reconfigurable antennas that conform to the roofs and trunks of our cars. None of the flexible electronics now under development would match the billions of transistors that now fit on silicon chips, or their billions of on-off cycles per second.

On what basically any electronic device is based on is an Integrated Circuit. Thus the realization of electronics with performance equal to established technologies that use rigid semiconductor wafers, but in lightweight, foldable, and stretchable formats would enable many new applications.

II.STRETCHABLE AND FOLDABLE SILICON INTEGRATED CIRCUITS

High-performance, single crystalline silicon complementary metal-oxide semiconductor (Si-CMOS) integrated circuits (ICs) that are reversibly foldable and stretchable. These systems combine high-quality electronic materials, such as aligned arrays of silicon Nano ribbons, with ultrathin and elastomeric substrates, in multilayer neutral mechanical plane designs and with "wavy" structural layouts. High-performance n- and p-channel metal-oxide semiconductor field effect transistors (MOSFETs), CMOS logic gates, ring oscillators, and differential amplifiers, all with electrical properties as good as analogous systems built on conventional silicon-on-insulator (SOI) wafers, demonstrate the concepts. Analytical and finite element method (FEM) simulation of the mechanics, together with circuit simulations, reveals the key physics. We implement single crystalline silicon because it provides excellent electronic properties, including high electron and holes mobility. Commodity bulk silicon wafers, for cost-sensitive applications, or SOI wafers provide the source of the ultrathin pieces of Si that are required. Vacuum-evaporated materials such as Nano crystalline Si (19), which also enable high performance, might offer further advantages in cost. The same approaches to stretchable and foldable integrated circuits reported here can be used with these and other related classes of materials. The strategies reported here are important not only for the Si-CMOS circuits that they enable but also for their straightforward scalability to much more highly integrated systems with other diverse classes of electronic materials whose intrinsic brittle, fragile mechanical properties would otherwise preclude their use in such applications.

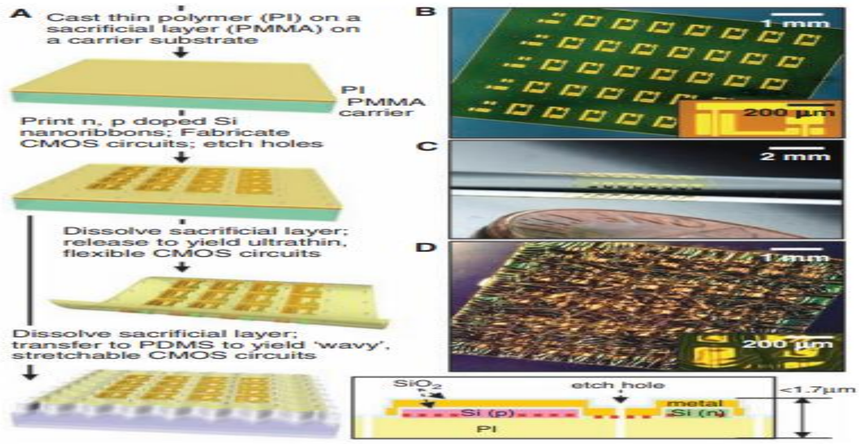

Figure 1

Figure 1 schematically summarizes the key steps for forming ultrathin, foldable, and stretchable circuits and presents optical images of representative systems at different stages of the process. The procedure begins with spin-casting a sacrificial layer of polymethylmethacrylate) (PMMA) (~100 nm) followed by a thin, substrate layer of polyimide (PI) (~1.2 mm) on a Si wafer that serves as a temporary carrier (see supporting online material). A transfer printing process with a poly(dimethylsiloxane) (PDMS) stamp (20, 21) delivers to the surface of the PI organized arrays of n- and p-doped Si Nano-ribbons (Fig. 1B, inset) with integrated contacts, separately formed from n-type source wafers. Automated stages specially designed for this printing enable multilayer registration with ~2 mm accuracy (12). Depositing and patterning SiO2 (~50 nm) for gate dielectrics and interconnect crossovers, and Cr/Au (5/145 nm) for source, drain, and gate electrodes and interconnects yield fully integrated Si-CMOS circuits with performance comparable to similar systems formed on SOI wafers (fig. S1). Figure 1C shows an image of an array of Si-CMOS inverters and isolated n- and p-channel MOSFETs (n-MOSFETs and p-MOSFETs, respectively) formed in this manner, still on the carrier substrate. In the next step, reactive ion etching forms a square array of small holes (~50 mm diameters, separated by 800 mm) that extend through the non-functional regions of the circuits and the thin PI layer into the underlying PMMA. Immersion in acetone dissolves the PMMA by flow of solvent through the etch holes to release ultrathin, flexible circuits in a manner that does not degrade the properties of the devices.

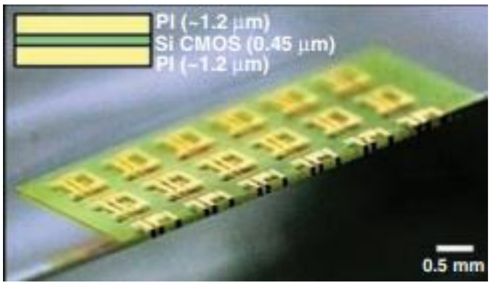

Figure 2: Image of a foldable ultrathin Si-CMOS circuit

There are two primary reasons for this behaviour. The first derives from elementary bending mechanics in thin films, where the surface strains are determined by the film thickness, t, divided by twice the radius of curvature associated with the bending, r (22). Films with t = 1.7 mm can be bent to r as small as ~85 mm before the surface strains reach a typical fracture strain (~1% in tension) for the classes of high-performance inorganic electronic materials used here. A second and more subtle feature emerges from full analysis of the bending mechanics in the material stacks of the circuits. The results indicate that the neutral mechanical plane, which defines the position through the thickness of the structure where strains are zero for arbitrarily small r\, lies in the electronic device layers Two disadvantages of such circuits are their lack of ability to strech and, for certain applications, their low flexural rigidity. These limitations can be circumvented by implementing extensions of concepts that achieve stretchable, wavy configurations of sheets and ribbons of silicon and gallium arsenide (15, 16).This gives rise to the building up of the various electronic devices as it makes easy for the manufacturer to design a device that has a foldable technology inbuilt and the basic requirement of any foldable device is the foldable display device that can be unfolded and folded.

III.FOLDABLE DISPLAY DEVICE

Foldable display devices typically use a bendable and flexible display. The foldable display device can be portable while folded and will have a relatively large screen than the portable dimensions belie while unfolded. Therefore, fold able display devices can be used not only as mobile equipment such as mobile phones, ultra-mobile PCs, electronic books, and the like but can also be embodied in various other applications including as a television, a computer monitor, and the like. This is basically A flexible OLED that is based on a flexible substrate which can be plastic, metal or flexible glass. The plastic and metal panels will be light, thin and very durable - in fact they will be virtually shatter-proof.

The flexible display panel includes a flexible film Such as a plastic film, and displays an image using an organic light-emitting diode (OLED) and a pixel circuit arranged on the flexible film. The first range of devices that use flexible OLED displays are not really flexible from the user perspective. The device maker bends the displays, or curves it - but the final user is not able to actually bend the device. Besides the beautiful designs, a flexible OLED has several advantages especially in mobile devices - the displays are lighter, thinner and more durable compared to glass based displays. Second generation flexible OLED devices may indeed be flexible to the final user. Finally, when the technology is ready, we may see OLED panels that you can fold, bend or stretch. This may create all sorts of exciting designs that will enable large displays to be placed in a mobile device and only be opened when required. The first ranges of devices that use flexible OLED displays are not really flexible from the user perspective. The device maker bends the displays, or curves it - but the final user is not able to actually bend the device. Besides the beautiful designs, a flexible OLED has several advantages especially in mobile devices - the displays are lighter, thinner and more durable compared to glass based displays. Second generation flexible OLED devices may indeed be flexible to the final user. Finally, when the technology is ready, we may see OLED panels that you can fold, bend or stretch. This may create all sorts of exciting designs that will enable large displays to be placed in a mobile device and only be opened when required.

Figure 3: OLED

Foldable display devices are generally provided with a case which supports the flexible display panel. The case is typically formed to support a bottom side of the flexible display panel, having a folded area between lateral plane areas thereof. For example, the case includes a plane portion corresponding to the lateral plane areas and a convex curved portion corresponding to the folded area and connected to the lateral plane portions by a hinge.

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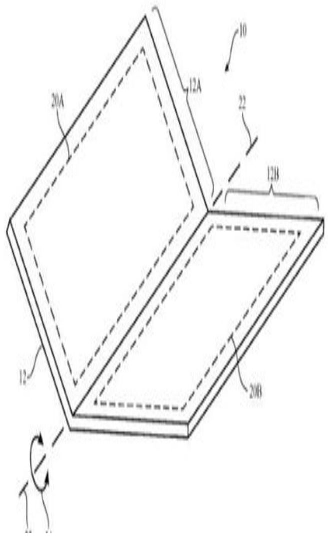
When the foldable display device is folded, the curved portion becomes convex and surrounds the folded area of the flexible display panel to support the flexible display panel. However, when the foldable display device is unfolded, the curved portion has a convex protrusion on the opposite side of the flexible display panel. Thus, when the foldable display device is unfolded, the externally convex curved portion protrudes away from the display panel, and thus, cannot support the flat folded area. That is, the folded area and the curved portion of the flexible display panel maintain a separation from each other, and accordingly, the convenience to the user can be adversely impacted.

One inventive aspect is a foldable display device including a case which can stably Support a flexible display panel, thereby improving the convenience of the device to a user. Another aspect is a foldable display device including: a flexible display panel including a folded area between lateral plane areas thereof a pair of front cases Surrounding a front circumference of the flexible display panel; a pair of bottom cases coupled with the pair of front cases to house the flexible display panel; and a biaxial hinge member mounted to the bottom case in the folded area to connect the pair of front cases to respective rotation points.

Another aspect is a display device including a pair of supports disposed between the flexible display panel and the bottom case in the plane areas and supporting the flexible display panel by being mounted to the pair of front cases by a pair of hinges.



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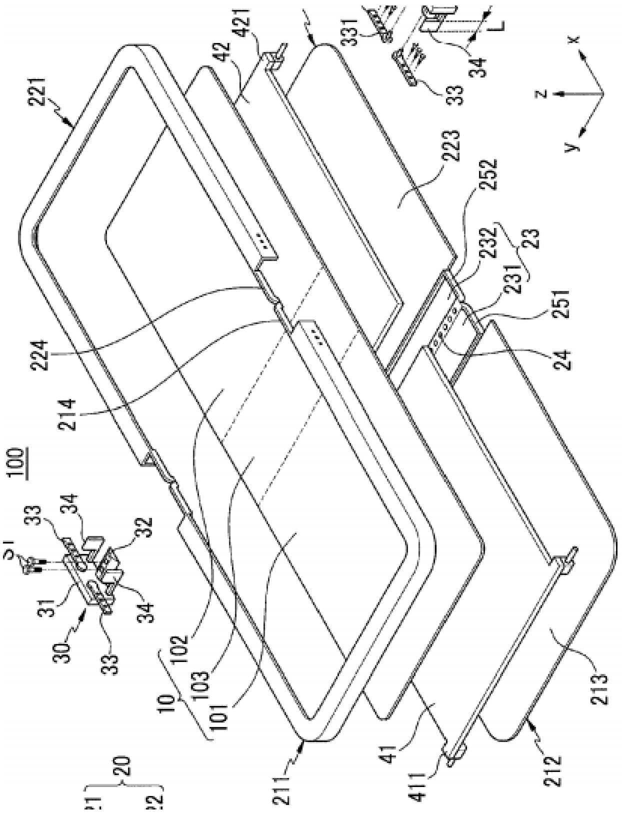


Figure 4: Foldable display Device

(From a patent)

The flexible display panel includes a flexible film Such as a plastic film, and displays an image using an organic light-emitting diode (OLED) and a pixel circuit arranged on the flexible film.

A cover window is provided on the outside of the flexible display panel where an image is displayed. The cover window can be formed of a transparent hard material to transmit the image of the flexible display panel and to protect the flexible display panel against external impact. A touch panel (not shown) that senses the touching operation of a user may be disposed between the flexible display panel and the cover window. The flexible display panel, the touch panel, and the cover window form a display module. Thus, in the present exemplary embodiment, the flexible dis play panel can include a display module. In the foldable display device, the flexible display panel includes plane areas and provided at both sides thereof and a foldable area (hereinafter to be inter changeably used with a folded area) formed between the plane areas. The case includes a first case and a second case respectively corresponding to the one side plane area and the other side plane area. The first and second cases are coupled in the foldable area to house the flexible display panel. The first case houses the one side plane area and the second case houses the other side plane area. The rotation points of each of the first and second cases and are connected to each other in the foldable area by the biaxial hinge member. In addition, the first case includes a first front case and a first bottom case. The first front case surrounds substantially the entire circumference (or perimeter) of the plane area of the flexible display panel, and the first bottom case is coupled to the first front case to house the plane area. The second case includes a second front case and a second bottom case . The second front case surrounds the entire circumference of the plane area of the flexible display panel , and the second bottom case is coupled to the second front case to house the plane area. The biaxial hinge members are arranged corresponding to lateral sides of the foldable area of the flexible display panel, and one side biaxial hinge member is mounted to the first and second bottom cases and the other side biaxial hinge member is connected to the respective rotation points of the first and second front cases. For example, the first and second bottom cases include plane portions formed in lateral sides to correspond to the plane areas and a curved portion connects the plane portions. The curved portion is connected to the plane portions, and is partitioned into two half-curved portions. The two half-curved portions are connected to a hinge portion in order to be folded or unfolded. When the foldable display device is unfolded, the plane areas and of the flexible display panel are supported by the plane portions of the first and second bottom Substrates, and simultaneously the foldable area is unfolded and thus supported by the hinge portion. The biaxial hinge member includes bodies, installation portions installed in the first and second bottom cases and connection portions connected to the first and second front cases. Alternatively, the connection portions may be connected to the first and second bottom bases. The connection portions may also be connected to both of the front cases and the bottom cases. In some embodiments, the bodies are disposed in external sides of the first and second bottom cases, and the installation portions are protruded into the bodies and installed to the hinge portion by screws. The installation portions are disposed in the outer sides of the hinge portion and fixed by the screws. The connection portions are separated from the installation portion and rotatable coupled to holes of the bodies by a hinge, and inserted into the first and second front cases and thus connected by screws. The connection portions rotate around the external circumference of the hinge in the shape of a circle. The foldable display device may further include a first Support and a second Support Supporting the flexible display panel in the folded or unfolded state. The first and second Supports can further stably support the flexible display panel in the display device. For example, the first support is disposed between the flexible display panel and the first bottom case and rotatable mounted to the first front case by a hinge in the plane area. The second support is disposed between the flexible display panel and the second bottom case and rotatable mounted to the second front case by a hinge in the plane area. Thus, when the foldable display device is unfolded, the first and second Supports respectively support the flexible display panel while respectively turning with respect to the hinges. As described, opposite ends of the hinges of the first and second supports should be supported to stabilize operation of the first and second supports that support the flexible display panel while turning. For this purpose, the biaxial hinge member may be provided with a control piece. The control piece is formed in one side of the connection portion in an inner side of the body to closely attach the first and second supports to the flexible display panel. In addition, an end of the control piece is curved along the rotation direction of the first and second Supports to minimize friction from contact when rotating with the first and second Supports. The control piece has a step structure to prevent interruption of the rotation of the connection portion in an inner side of the body, and has a length L set along a width direction of the first and second supports outside of the rotation area of the connection portion. The half-curved portions of the first and second bottom cases further comprise first curved protrusion portions protruding from the ends thereof. The first curved protrusion portions house the control piece that rotatable supports the circular circumference of the connection portion in the hinge side in the inner side of the half-curved portions. The first and second front cases further include second curved protrusion portions formed protruding from the ends of the first and second front cases to correspond to the first curved protrusion portions. The second curved protruding portions house the first curved protrusion portions and the control piece. This configuration supports the rotation of the connection portion around the hinge in the inner side of the half-curved portions.

With a present day foldable device and a solar charger, you could find yourself connected to the office and doing most things you would normally do at your computer.

IV.PORTABLE CELL PHONE BATTERY CHARGER USING SOLAR ENERGY

A portable, cellular phone battery charger using solar energy as the primary source of power and including two separate as Solar panels and a battery/Switch containing unit. The two panels are hinged connected together, and the battery/Switch containing unit is hinged connected to the back Side of one of the panels. The assembly is pivotal between a retracted configuration in which the three component parts lie in parallel planes, and a deployed configuration in which the two Solar panels lie in one plane and the battery/Switch unit lies in another plane angularly intersecting the Solar panel plane. The device is Selectively operable in three different modes, namely, a first mode in which the Solar panels are connected to charge or power a cell phone; a Second node in which the Solar panels are connected to charge the devices internal battery, and a third mode in which the internal battery is used to charge or power a phone coupled to the device.

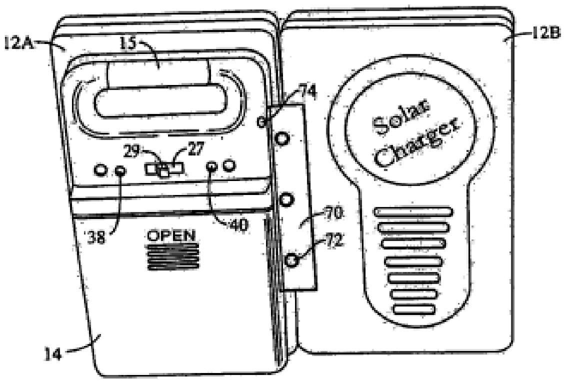


FIG. 5 is a block diagram schematically illustrating an exemplary cellular phone battery charging device

A Solar energy collecting component including at least two Solar panels pivotally connected together and rotatable relative to each other between a retracted configuration and a deployed configuration; a housing that is pivotally connected to Said Solar energy collecting component; a battery charger component disposed in the housing component including a rechargeable battery being electrically connectable to Said Solar panel, and an output jack being electrically connectable to Said battery and Said telephone to be recharged; a Switching component disposed in the housing, the Switching component comprising a multiple mode Switch and associated electrical Signal connecting circuitry, Said Switch and Said circuitry being selectively operable between a first mode, a Second mode, and a third mode, Said first mode connecting Said Solar energy collecting component to Said output jack for providing electrical power to Said telephone connected thereto, Said Second mode connecting Said Solar energy collecting component to Said rechargeable battery for providing recharging electrical power thereto, and Said third mode connecting Said rechargeable battery to Said output jack for providing electrical power to Said telephone connected thereto.

One advantage of this configuration is that non rechargeable batteries can be installed in the device and used to charge a cellular phone battery. For example, in case of emergency where no other chargers are available and where the environment has insufficient light to actuate the Solar panels. re-chargeable batteries in the device, and taking care to see that the batteries are periodically charged using the Solar panels

V.ROLL-UP ELECTRONIC PIANO

The roll-up electronic piano com prises a keyboard including piezoelectric material and a controller with a Sound chip that controls and amplifies electrical piezoelectric Signals. The roll-up electronic piano is easy to carry due to its ultra-light weight and Small size. Particularly, the roll-up electronic piano produces a similar tone to that of a real piano.

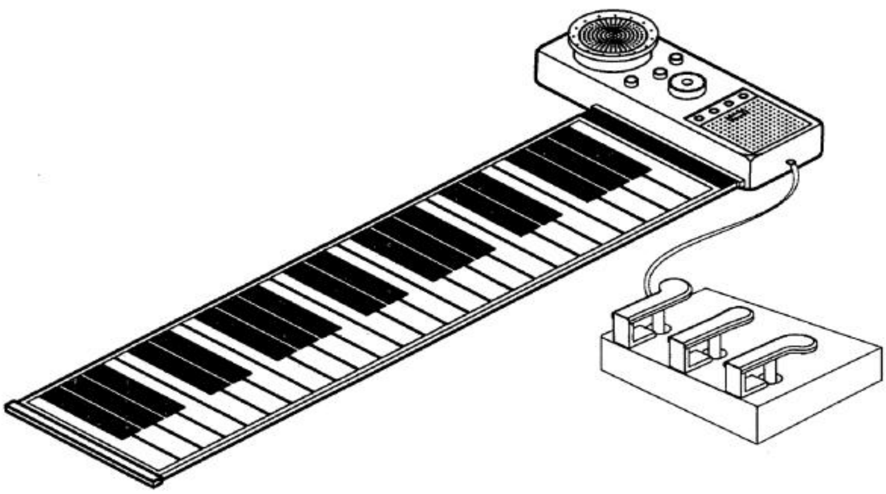
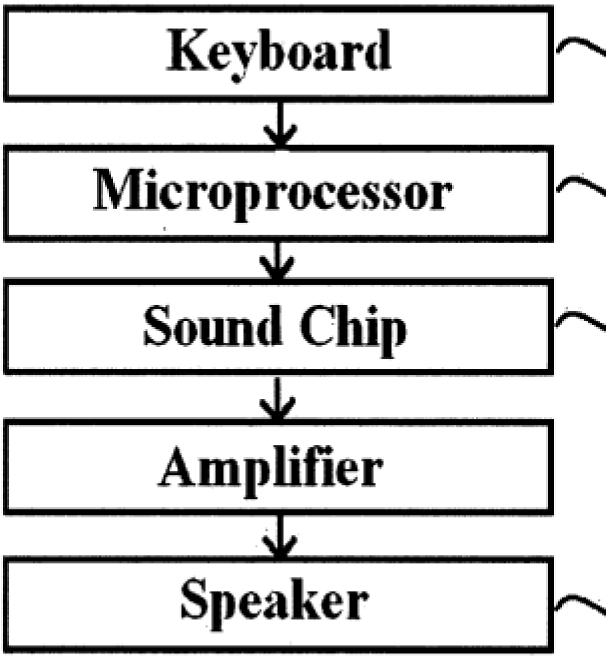


Figure 6: Roll up electronic piano

The electronic piano according to the present invention may comprise a border member that includes a piezoelectric material capable of performing on/off functions, a keyboard whose cover is made of a Silicon material and is capable of being folded/unfolded, and a control part that controls and amplifies piezoelectric

Signals, which can be separated from the keyboard, and can perform wire/ wireless Send/receive functions. The electronic piano is portable and foldable, has a Small size and is relatively lightweight, and can be connected to a computer. It is an object of the present invention is to provide a roll-up electronic piano having a Small size attributable, at least in part, to a foldable keyboard. The electronic piano can produce Sounds according to the Strength and the duration of pressure in pressing a key and can embody a similar tone to that of a real piano by preventing the vibrato effect. Still further, the electronic piano can be controlled through wired or wireless communications and be played even in a narrow Space because it includes a removable Structure capable of separating the keyboard from the control part, and can be used conveniently in a music class for children and Students due to its Small size and lightweight.

The keyboard of the electronic piano according to the present invention produces a Signal by electromotive force through a piezoelectric polymer film Such as poly vinylidene fluoride (hereinafter referred to as “PVDF") or a piezoelectric fibre when a user presses a key of the key board. The piezoelectric polymer film generates a Voltage according to the Strength and the duration of impact. The generated Signals are controlled and amplified in the control part with a Sound chip and thereafter directed to a Speaker. The keyboard comprises a coupling member for connection with the control part. The coupling member is made of flexible material that can mechanically withstand Strains produced by folding and unfolding operations. In addition, white keys and black keys of the keyboard are designed in accordance with the Standard configuration of a real piano. Inside the keyboard is a piezoelectric polymer film Such as PVDF or a piezoelectric fibre that generates a piezoelectric electromotive force corresponding to each key of the keyboard. The covering of the keyboard, except the coupling member, is made of flexible rubber. Therefore, the electronic piano of the present invention can be easily rolled up and is portable. The control part comprises an electronic circuit design including a microprocessor and a Sound chip. The roll-up electronic piano according to the present invention can be played effectively in a narrow Space because it includes a function controlling the number of octaves of the keyboard thereby eliminating the inconvenience of detaching the keyboard. When the electronic piano is divided into the control part and the keyboard, Signals according to a change in Voltage generated from the key board is transformed to a digital Signal and the digital Signal along with a unique ID value (a unique number of an apparatus) are transmitted to the control part. The control part identifies the ID value received and generates Sounds according to the digital Signals received. The roll-up electronic piano according to the present invention may be connected to peripheral devices Such as a personal computer that can Store and reproduce a record of playing as music file by transforming analog Signals into digital signals.



A keyboard outputs a Signal attributable to an electromotive force using poly vinylidene fluoride (PVDF) or a piezoelectric fibre with piezoelectric characteristics based on the Strength and duration of pressure exerted by a user. That is, while an electric current is applied into the PVDF, the PVDF generates a Voltage according to the Strength and the duration of the pressure. The outputted Signal is amplified in the control part having a Sound chip and then, Sound comes out through a speaker. The Sound chip may provide hundreds of tones. the sound chip according to the present invention can provide the same Sound effect as a real piano. The various magnitudes of Sound generated when a key of a real piano is pressed at various pressures are logged and the logged data is compared to a Voltage from the piezoelectric material, which is generated when a key of keyboard of the electronic piano is pressed. Then, the logged data corresponding to the Voltage is Stored in the Sound chip to generate the same magnitude of Sound with that of the real piano. Inside the keyboard, the piezoelectric material perceives pressure, which is enclosed by a conducting pattern film, and an insulator is formed to enclose the conducting pattern film.

When a user presses a key of the keyboard, pressure is applied to the silicon rubber and the pressure is transmitted to the shock-absorbing member. The shock-absorbing member does not transmit the pressure to the insulator if the pressure is less than a predetermined value. That is, in case of merely placing a finger on the keyboard the shock-absorbing member, made of a soft material, absorbs the pressure to Suppress the generation of a Sound. In addition, the Shock absorbing member may be formed in various densities and thicknesses to simulate the touch of a real piano. If the shock-absorbing member is excessively thin or soft, the keyboard may reduce the simulated feeling of pressing a key of a real piano. If the shock-absorbing member is excessively thick, the keyboard may not be easily rolled up. If the shock-absorbing member is excessively hard, more pressure may be required to press the key than for a real piano. Thus, the shock-absorbing member (18) should be made of a material with an adequate density and thickness.

The covering of the keyboard is made of a flexible rubber, preferably, silicon rubber so that the keyboard can be rolled up. Silicon rubber has good heat resistance, cold resistance, and moisture resistance. In addition, a pattern imprinted on the surface of the silicon rubber stands well. The present invention includes reforming the Surface of the Silicon rubber to facilitate mounting portions of the Silicon rubber to one another. The shape of a keyboard is printed on the upper plate of the keyboard covering. Here, another advantage of the reformed silicon rubber with fine grooves is that when white keys and black keys are printed on the upper plate of the keyboard covering, the number of printing Sequences can be markedly reduced because ink can easily infiltrate into the silicon rubber through the fine grooves plurality of protrusions made of insulating material are formed at a lower Surface of an upper PCB to maintain a distance between the upper and a lower PCB when a key of the keyboard is depressed. When a key is depressed, pressure is first applied to the keyboard covering made of silicon rubber and transferred to a shock-absorbing member. If the pressure is less than an adequate value, the shock-absorbing member may not transfer the pressure received to the insulator. That is, if a user lightly touches the keyboard with his/her finger, the Shock-absorbing member made of a Soft material absorbs the pressure to suppress the generation of Sound. If the pressure transmitted to the shock-absorbing member is more than an adequate value, the pressure is transferred to the insulator and the PCB in sequence. The upper and lower PCBs are connected to the sound chip through a metal interconnection for each key. The PCBs can maintain flexibility and elasticity during repeated folding and unfolding operations and generate Sound by an electric current that flows when the upper PCB comes in contact with the lower PCB.

VI.CONCLUSION

Foldable technology is growing day by day and the recent products that are available are developed and evolved day by day. The fabricating silicon-based electronics On which any electronic device is based presents the basic requirement of the Foldable technology. The foldable device and the portable charger using solar as the foem of energy ensures that the technology is widely used and technically and sustainably developed. In India yet the devices are not in use but the entertainment device or the piano is discussed in the paper is readily available on amazon for sale. Thus it includes the recent innovations and the static development.

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