Evolution of light sensor integration

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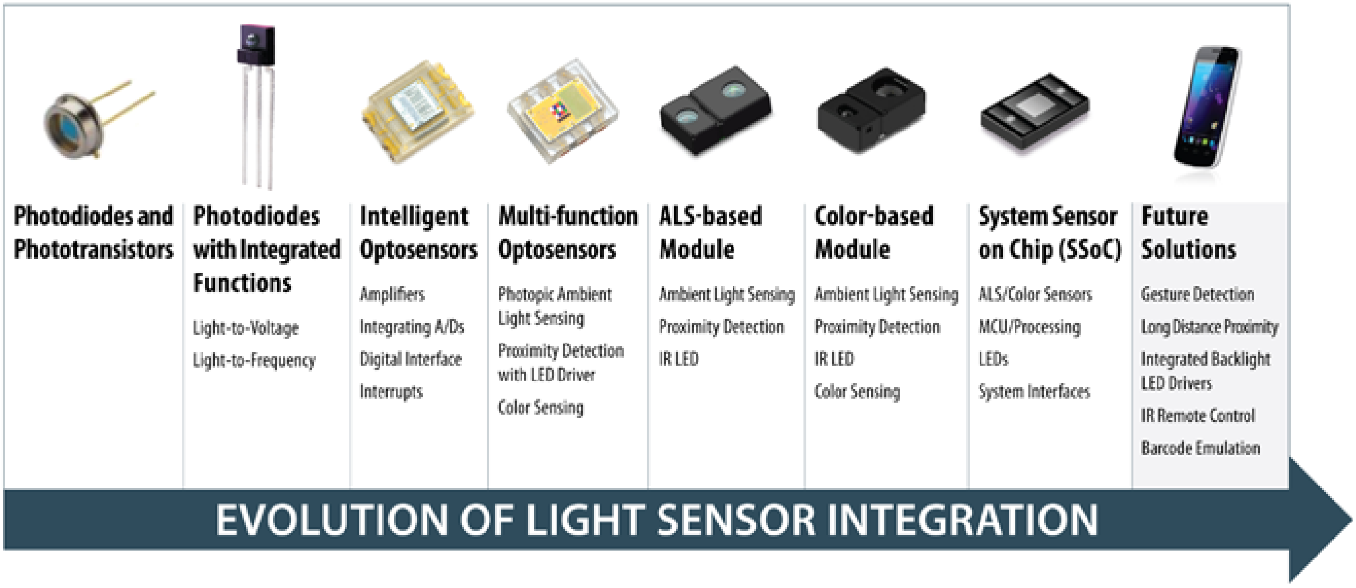
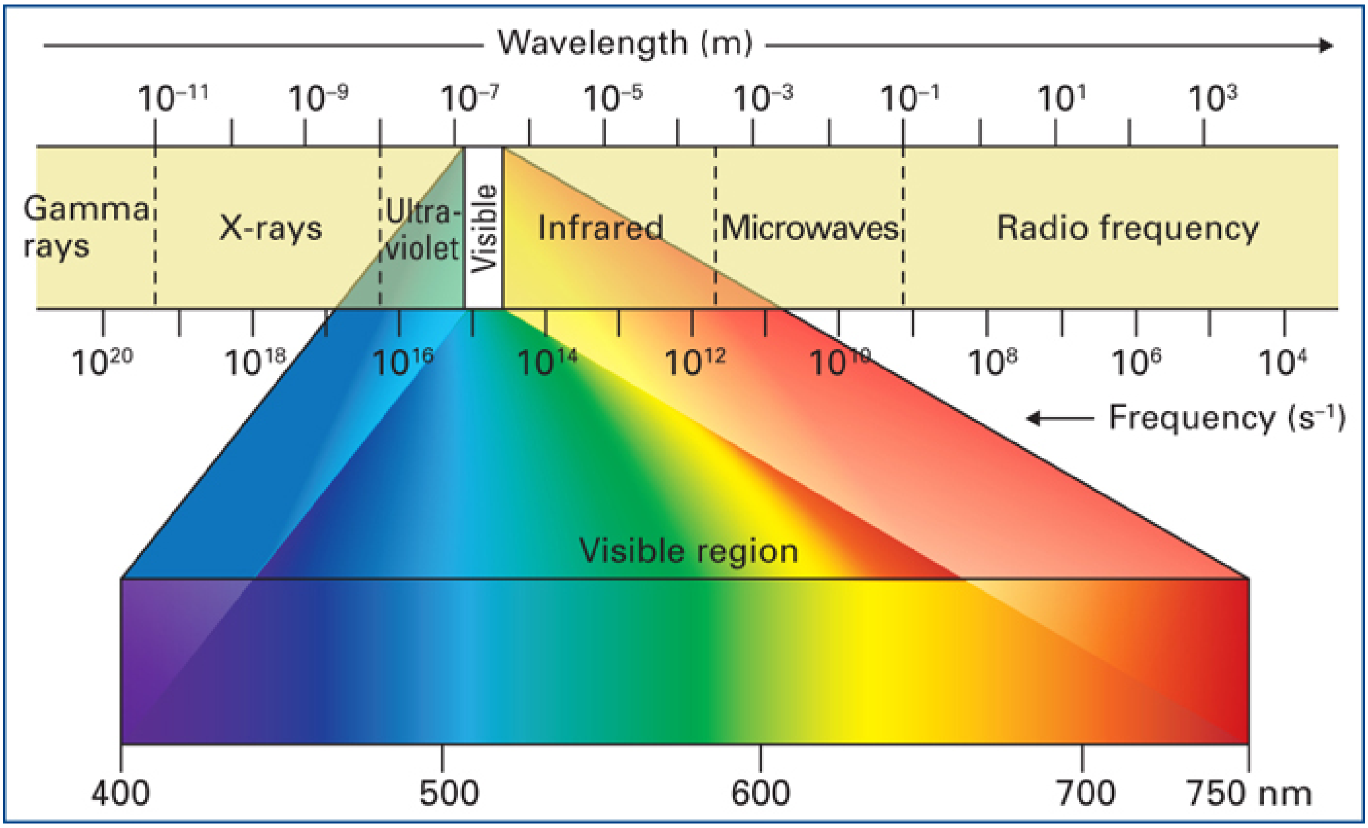
Light sensing technology, in the form of photodiodes and phototransistors, was invented around the 1950s. Since the inception of the first optosensors, the devices have gradually found their place in commercial and industrial applications, but their adoption was limited due to the size, cost and overall performance. This has changed over the last decade with tremendous strides being made in performance, integration and cost improvements of light sensors, along with their proliferation into high-volume consumer applications.

Before the turn of the century, light-sensor technology was mainly composed of simple photodiodes and photo transistors. Industry pioneers such as ams developed many ground-breaking products which extended the capabilities of these simple devices. Amplifiers and translation circuitry were integrated to realize light-to-voltage and light-to-frequency devices. These advancements improved key attributes such as speed and sensitivity. The improved characteristics opened up new applications, including consumer and commercial printers. The devices were soon adapted to include color filters which allowed individual red, green and blue color sensing.



Intelligent optosensors
Intelligent optosensors then emerged, which further extended the functionality with integrating A/Ds, interrupts, and digital interfaces such as SMBus and I2C. The interrupt capability and digital interfaces enabled these devices to be easily used in microcontroller and processor-based systems. It also enabled more sophisticated processing and applications of light sensor data. In addition, these devices became very proficient in photopic sensing, which is the ability of silicon photodiodes to sense light in a way which emulates the human eye.

Developing a photopic light sensor, one that senses light like the human eye, in a commercially-viable device is not easy and has become the subject of many innovative patents and design techniques. The fundamental challenge is that typical silicon light sensors are sensitive to light in the 300-1100nm wavelength band, whereas the human eye only responds to light in the 390-700 nm wavelength range.



Research and development teams have focused on photopic light sensors, given the tremendous benefits and value they bring to display-based products. These sensors enable automatic adjustment of display brightness based on the lighting environment to conserve energy, extend battery life and simply improve the user viewing experience.

Creating a photopic sensor requires eliminating the sensing of the ultraviolet (UV) and infrared (IR) light sources through packaging or on-chip filtering. Alternatively, the sensing effects of the UV and IR light sources can be subtracted from the resulting light intensity (lux) calculations. A photopic light sensor can be created by adding a photopic filter and/or UV and IR blocking filters to the package or silicon. However, these solutions may not be cost-effective for high-volume production.

Multi-function optosensors
Intelligent optosensors evolved to multi-function devices with the added ability to measure red, green and blue colors. Color sensing allows reflective or transmissive color, light color temperature and basic ambient light measurements. These enable a broad range of applications including printing, gas/fluid analysis, consumer electronics, solid-state and general lighting, health/fitness products and consumer electronics.

The proliferation of cell phones and demand for better user experiences are driving a high adoption rate of ambient light sensing in touchscreen smartphones. In addition, touchscreen smartphones require proximity detection to disable the touchscreen and display backlight during a call. The multi-function optosensors now also include proximity detection functionality with an IR sensor and IR LED driver circuitry. These proximity detection solutions require an IR LED to complete the solution. IR proximity detection is an ideal solution since the IR light wavelength chosen (usually around 850 nm) easily passes through dark glass and opaque materials and is not visible by the human eye. The layout and positioning of the sensor and IR LED can be easily adapted to the specific design objectives, phone mechanical design, and glass characteristics.

The IR sensor in some cases has also been used to measure the IR component of the ambient light and then subtract this from the lux calculation, resulting in a more accurate light intensity measurement. Over time, the multi-function optosensors have become more intelligent with the integration capabilities to improve the accuracy of the photopic and color sensor through the use of more advanced sensing, error-compensation circuits, and package and on-chip filtering.

Light sensor modules
Smartphone shipments, as a percentage of overall handsets shipments, continue accelerated growth. The increasing volume demands and requirements for an optimized ambient light sensing (ALS) and proximity detection solution enabled the development of ambient light sensing-based modules. These modules include a multi-function optosensor in addition to the IR LED, all contained within a module. The module often includes optics to further optimize the ALS and proximity detection performance based on typical phone mechanical design and the display glass characteristics. In addition, the proximity detection in the module solution can be calibrated at the device level, which eliminates the need for end-product calibration as required if a discrete sensor and IR LED are used in the design.

The high-volume and growth of handset shipments have also been a driving force for suppliers in advancing the capabilities, reducing component costs, and enabling manufacturing operations to produce devices in excess of 10M units per month. Coincidentally, there is no room for any compromise in component quality, reliability and performance. This creates very demanding metrics for component manufacturers, and demands precise execution in manufacturing to maintain the highest levels of quality and reliability.

The need to measure the lighting environment beyond just ALS (or broad spectrum light) has driven the adoption of color sensors for use in display-based products. Color sensors can now perform the essential function of an ALS device to determine the light intensity of the environment as well as color temperature. The need for color sensors has driven integration, allowing devices which have integrated color sensors (for ALS and light color measurement), IR proximity sensors, and IR LED all within an optical module. In addition, color sensors now enable the ability to adjust and optimize the display color based upon the ambient light intensity and color temperature, further improving the user viewing experience.

Future outlook
It’s anticipated that sensor solutions will further evolve ALS or color-based modules to include native processing capabilities through integration of a microcontroller (MCU) or processor, multiple optical sensors/LEDs, and a variety of interfaces optimized for the target application. Sensor System on Chip (SSoC) solutions will provide unique sensing and computation capabilities for the medical, health and fitness markets. The availability of these highly integrated SSoC solutions will

enable smaller and more feature-rich devices for applications such as heart-rate monitoring, pulse-oximetry and other health/fitness related products.

As the industry volume-driving platforms such as the smartphone and tablets evolve, demand for display management optimization to lower cost, reduce size, improve performance and improve the user experience will continue to drive further integration of intelligent light sensor capabilities.

Advanced functionality such as gesture detection for improved user interface, mobile couponing via bar-code emulation, and heart-rate monitoring for medical/fitness applications are becoming a must-have in smartphones and other consumer products.

The applications for these sensors will continue to expand as designers find new creative ways to exploit the integration of light sensors and apply the capabilities to a myriad of applications in the industrial, commercial, consumer, automotive and medical/fitness space.