Novel filter mosaic for hand-held multispectral applications

Technology and application.
A custom filter mosaic and companion illumination system has been designed for use within a handheld clinical device. The spectral characteristics of the mosaic and illumination system were designed to detect erythema and bruising, especially in persons with darkly pigmented skin. The mosaic is configured to be compatible with existing CMOS sensors, a design feature consistent with our targeted price point of $500 cost of goods.

The technology has other potential applications in biomedical and industrial imaging, including:
- spectral imaging of wounds to detect bioburden, infection, or necrosis
- spectral imaging of skin to quantify pathology including jaundice, dermatitis
- field imaging of produce to quickly identify bruises or discoloration
- monitoring poultry and plant disease in agriculture
- quality control during assembly (e.g. semi conductor, pharmacy)

Description.
A novel custom filter mosaic has been successfully designed and fabricated using lithography and vacuum multi layer film technologies. The filter incorporates four different wavelengths within the visual to near-infrared range each having a narrow bandwidth of 20nm or less. This design permits a multi-spectral image to be acquired in a single exposure, thereby providing overwhelming convenience in multi spectral imaging acquisition.

The filter design was based those used within CMOS technology. CMOS offers adequate technical performance at low cost and is easily integrated with board-level electronics. CMOS cameras utilize a color filter array, i.e. Bayer filter, consisting filters arranged in a 4 element mosaic. These filters have a wide band transmission profile to permit reconstruction of colored images. In contrast, our mosaic uses narrow band filters tuned specifically to chromophores of interest.

A schematic design is shown below and illustrates a narrow band spectral response synched to four defined wavelengths. The initial versions of the device focus on spectra related to bilirubin, hemoglobin and water.

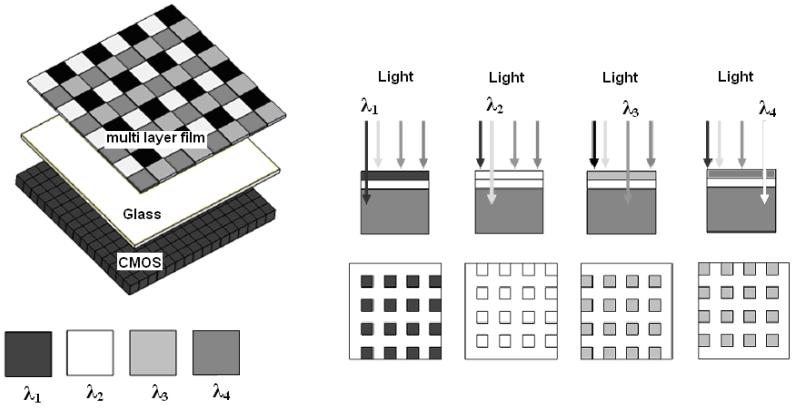
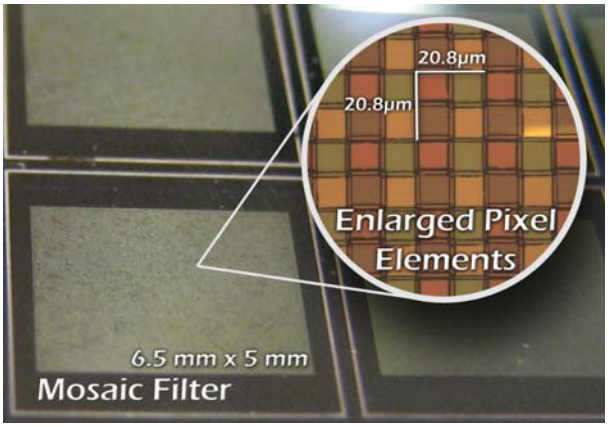
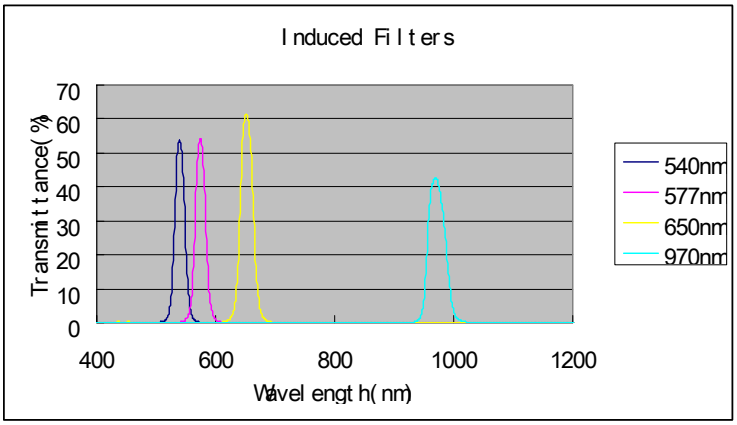


Figure 1 Four element color filter array

A micrograph section of the prototype mosaic filter is shown below on the left and indicates the size of the filter and its elements. Subsequent improvements to the fabrication process have reduced the gap between filters to 1 µm - 2 µm. The figure on the right illustrates the transmittance of light through the narrow filters in the array

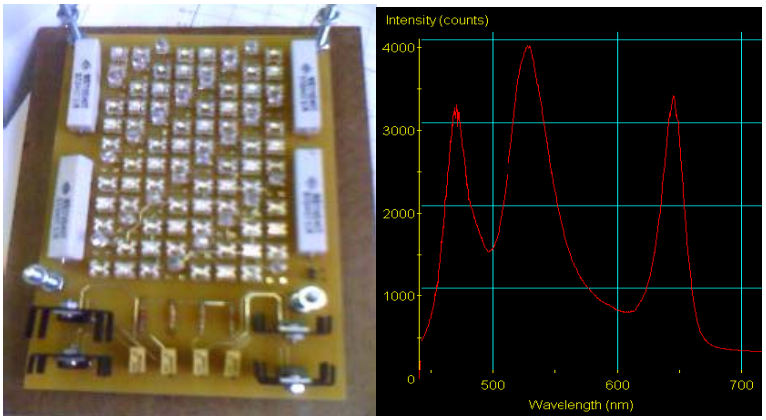




Illumination system. One challenge in creating a clinical multispectral instrument is the variable ambient lighting conditions. For the mosaic filter to work properly, the clinical target must be bathed in light that contains the spectra of interest. In addition, lighting requirements must be compatible with the portability requirements of a handheld device. Specifically, we desired a battery-operated device that can be carried in a lab coat, so size and weight were important considerations.

To overcome these potential barriers, we designed and fabricated a LED-based illumination. LEDs are low cost, have low power requirements and permit the light source to be tuned for the application- in this case- tuned to the wavelengths of interest. The design used as test bed can work at a nominal voltage of 13.5V, 1.7A with a maximum power consumption of 23W and 600 lux peak illumination and 405 lux as average at a distance of 45cm. The next design iteration will operate at 5V & 5W which will meet the requirement s for a handheld detector.

The prototype design is shown below with its spectral response that indicates its ability to bathe the target with light covering the spectrum of interest. The 940 nm LED is not shown due to the limitations of the spectrometer used to test the illumination system.



Prototype LED illumination system and an illustrated spectral power distribution.

Improvement over existing options

Barriers to incorporating multi-spectral imaging in many industries include cost and portability. Moreover, current multispectral imaging applications require either multiple exposures or extensive post-processing.

The new mosaic filter overcomes these barriers so applications in many industries are possible. The cost and size of this technology permits the development of small handheld multispectral devices at affordable costs. The real-time imaging process permits the design of devices capable of working in the field or at the point of care.

This multispectral technology was designed as a point of care clinical tool- specifically to assess bruising and erythema. While these entities have medical and forensic applications, other industries should benefit from this multi-spectral technology including produce meat inspection and quality control in manufacturing.

Breakthrough Points

The use of a custom filter array overlaying a CMOS sensor represents a novel approach to multi spectral imaging. Compared to other multi spectral technologies (multi prisms, optical-acoustic crystal and others), the design provides simple, low cost instrumentation that has many potential multi spectral imaging applications which require a handheld detector.

The primary commercial benefits of the new technology are cost and size. This technology can be used to create small handheld multispectral devices at affordable costs. The real-time imaging process permits the design of devices capable of working in the field or at the point of care.

For additional information about this technology, contact Lauren MacLanahan, Office of Technology Licensing, at 404.894.6900