# Nano-Media: Multi-Channel Full Color Image with Embedded Covert Information Display

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(a) (b) (c) (d)

**Figure 1***: The Nano-Media concept (a) SEM image of the pixelated substrate (b) Microscopic image of the ICL (c) Full color images displayed by the Nano-Media after aligning (a) and (b) taken by a camera (d) Covert QR Code stored on the Nano-Media and is read by a camera using an IR edge-pass filter (Inverted).*

## 1 Introduction and Motivation

Nano-structures represent a class of materials with nano-scale features which can be engineered to manipulate light beyond the limit of diffraction. By tuning the structure geometries and material compositions, nano-structures can act as color pixels which have wide applications in imaging and display devices [Yokogawa et al. 2012].

Producing a color image using nano-structures can be very time consuming and is currently a major challenge in applying nano-structures in displaying visual information. Usually, high resolution nano-patterning techniques, such as electron-beam lithography, are used to generate nano-structures according to the desired color image onto a substrate, and the nano-structures are replicated thereafter using nano-imprint lithography technique. Despite the breakthroughs in the nano-fabrication technology in recent years, the entire fabrication process still remains slow and expensive, because each color image would require a new nano-pattern being generated.

In the technology presented in this poster, called ‘Nano-Media’, we provide an alternative solution to the existing challenges, which allows any color image to be rapidly printed using nano-structures as pixels.

## 2 Technical Approach

A Nano-Media is mainly comprised of a pixelated nano-substrate (cf. figure 1a) and an intensity control layer (ICL) (cf. figure 1b) on its top. The pixelated nano-substrate is patterned with nano-structures arranged into a mosaic of red, green and blue primary colors for displaying visible colors and infrared pixels for embedding covert information. To produce an image, the ICL is patterned into a grayscale mask, based on the desired color image.


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By aligning the ICL with the nano-substrate, the color sub-pixel’s intensities are tuned achieving any given color, similar to the liquid crystal in a color LCD screen (cf. figure 1c). The unique characteristic of the presented technology is that the nano-structures are universal for any image to be displayed and only the ICL needs to be patterned for the desired color images. Using such an approach, the complexity in patterning nano-structures is significantly reduced into the micro-scale patterning of ICL itself. This technology can take the full advantages of using nano-structures as pixels and apply them practically in printing color images.

As a proof of concept, we fabricated a nano-substrate in the size of 4 mm x 3 mm. In fact, using nano-imprint technique, master replication, master recombination and roll-to-roll process, the nano-substrate can be readily fabricated in the scale of several square meters or even much larger. The sub-pixel has a size of 10 µm x 10 µm and each pixel has a size of 20 µm x 20 µm. Therefore, the fabricated nano-substrate allows for a color image to be produced with 1270 PPI resolution. It should be note that, by engineering the nano-structures, the size of the sub-pixels can potentially reach less than 1 µm and still maintains the color properties, which implies a possible resolution of 12,700 PPI. Using this technology, both overt and covert information can be stored and displayed with Nano-Media as shown in figure 1c and figure 1d.

Nano-Media is an enabling technology that can integrate nanotechnology into the information display and storage. It can be used in anti-counterfeiting labels, optical storage and general publishing media such as a magazine.

## References

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