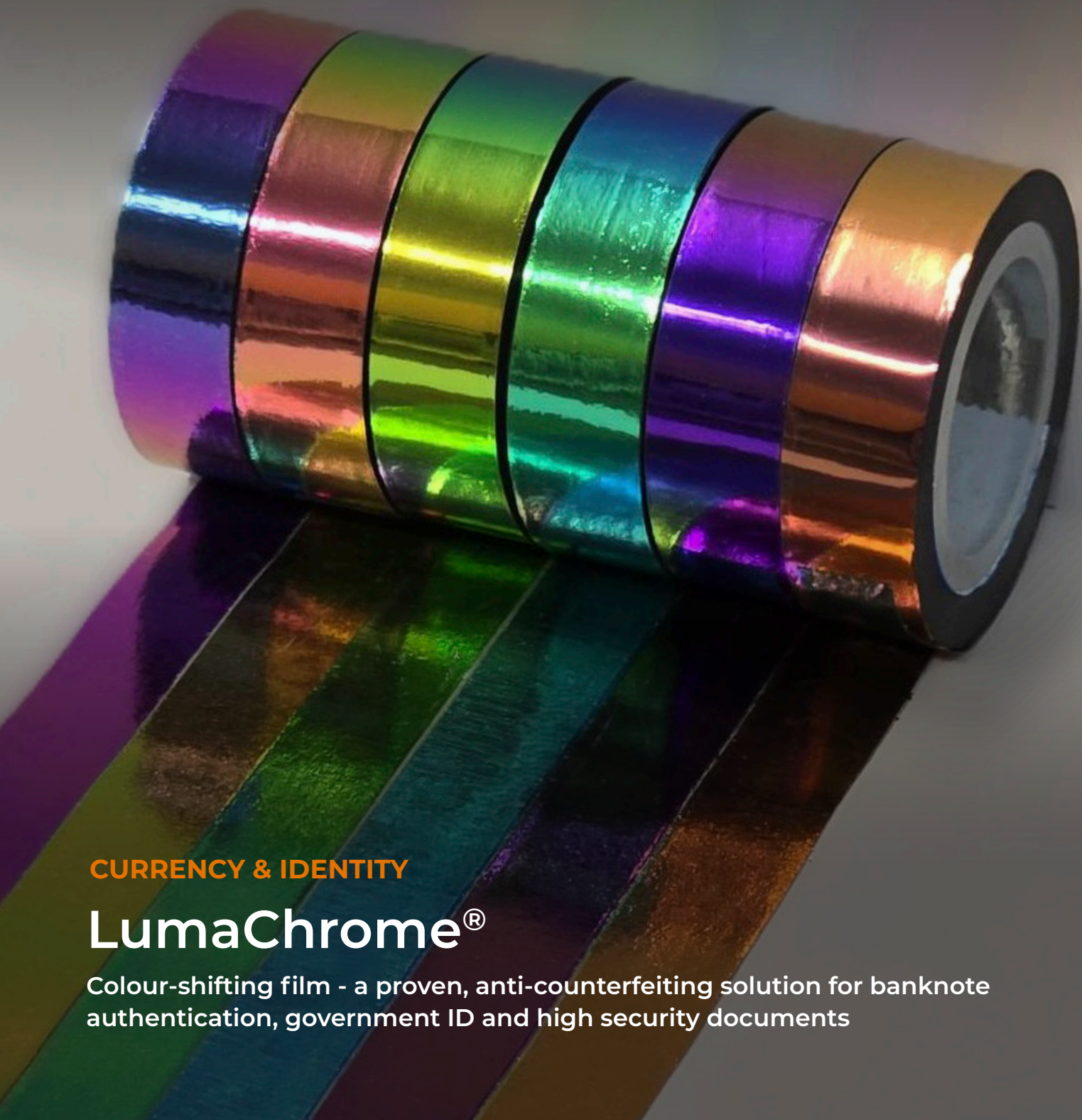


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**Authentix**<sup>®</sup>  
The Authority in Authentication



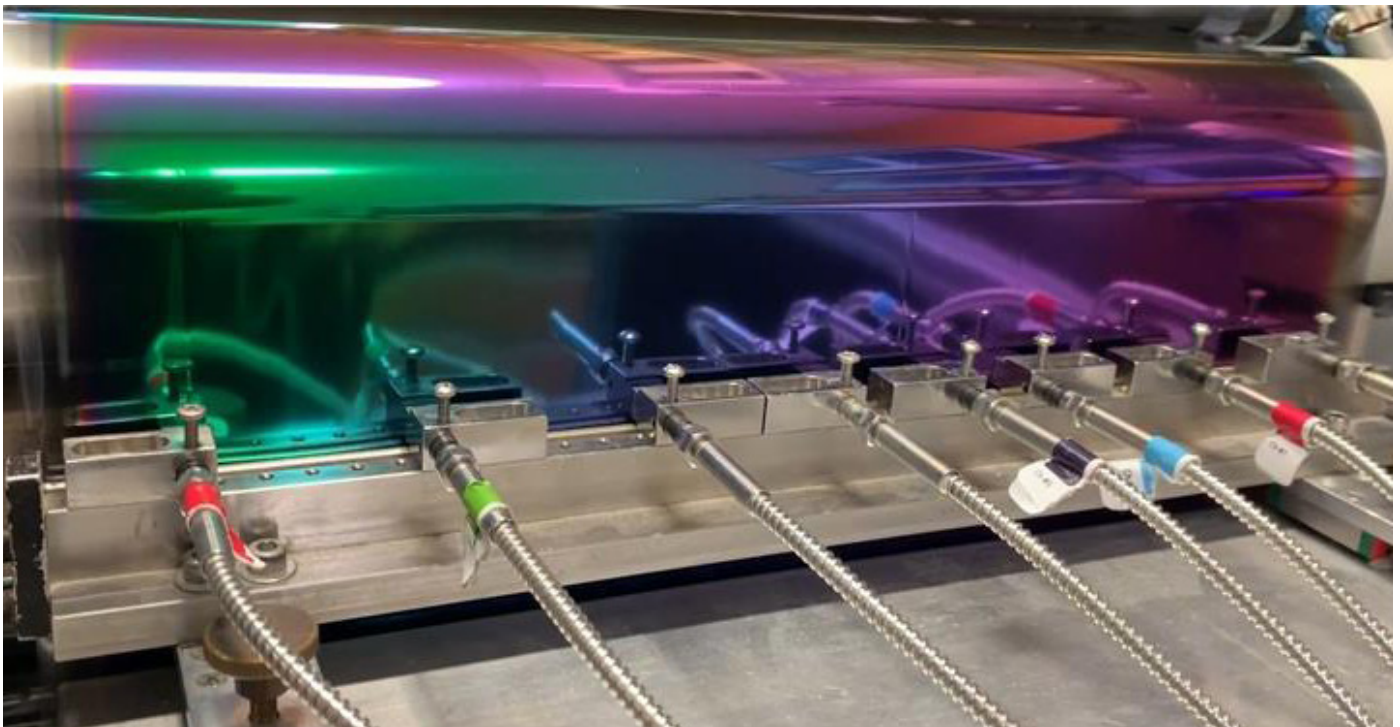
**CURRENCY & IDENTITY**

**LumaChrome**<sup>®</sup>

Colour-shifting film - a proven, anti-counterfeiting solution for banknote authentication, government ID and high security documents

## OVERVIEW

This paper introduces the Authentix LumaChrome® optical thin film, based on the optical interference characteristics of deposited thin films for high production manufacturing. LumaChrome has been used to authenticate banknotes for over 20 years, this colour-shifting film changes from one colour to another distinct colour when tilting the film yielding an intuitive and easy to use solution which is extremely difficult to replicate. Availability in multiple formats from a security patch for government ID cards to full thread insertion into banknotes, LumaChrome is a highly versatile and powerful tool for securing documents and products. The techniques and processes used to create the visually stimulating colour-shifting films, while not novel, employ extremely complex machinery and processing techniques. With the ability to create several standard colour-shifts over a wide range of saturation levels, Authentix can create a lasting security feature that experiences virtually no degradation over the lifetime of the substrate.





## INTRODUCTION & BACKGROUND

LumaChrome colour-shifting film has been employed in the banknote and government market space for more than two decades. Branded as an Optical Security Device (OSD), the technology was first developed by the bank of Canada in conjunction with The National Research Council of Canada. Looking for a way to combat the ever-growing banknote counterfeit industry, a new technology was needed. Founded on the science of how light behaves, scientists developed a way to control light using ultra-thin layered optical interference structures combined in such a way that the light reflected back to the observer was controlled to a specific wavelength (colour). The first iteration of this technology appeared on the Birds of Canada note series as a metallic patch, which shifted colour from gold at normal incidence to green when tilted.



Figure 1: Birds of Canada 100-dollar denomination displaying a colour-shift OSD patch in the upper left corner

A subsequent adaptation of the technology appeared as a colour-shifting, de-metallized thread in the Canadian Journey series notes. The ability to de-metallize and use the technology to show numerical characters with multiple colour-shifting options, proved the adaptability of the technology and its strong applications in the secured documents industry. Since then, LumaChrome's technology has been

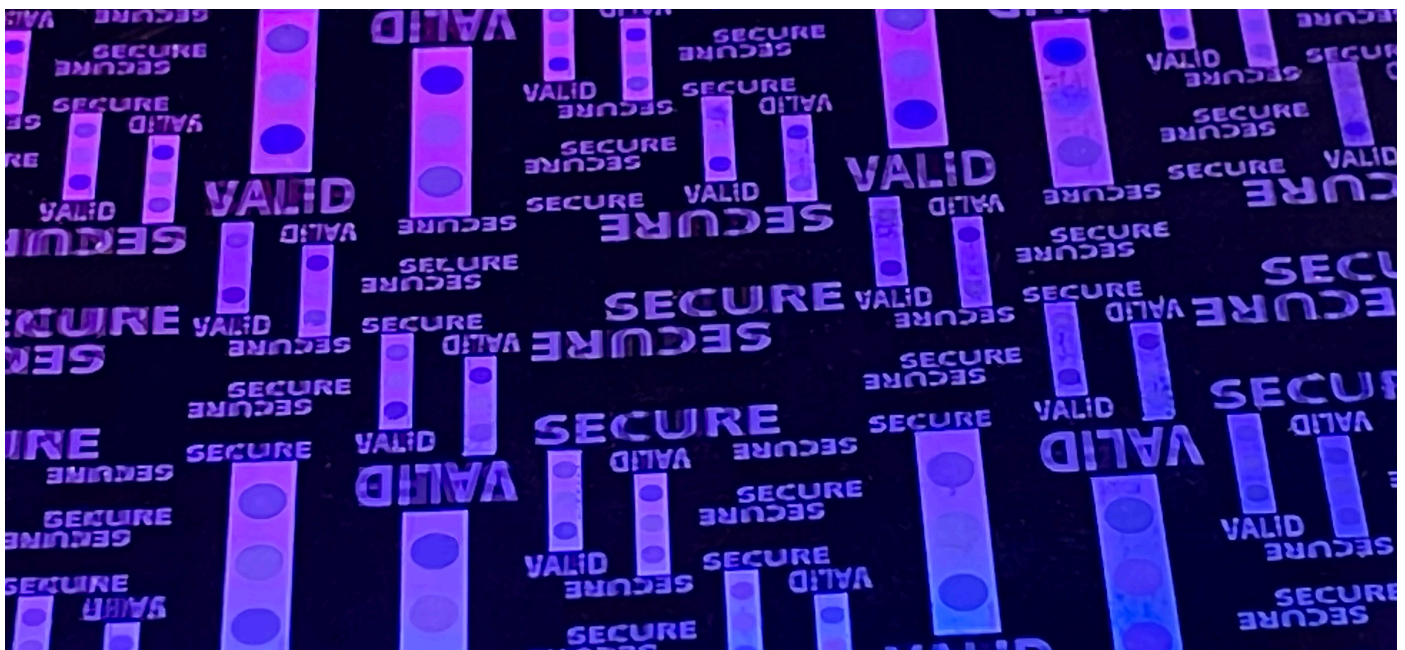


considered a standard in document and security authentication space for more than two decades and adopted by more than 10 countries. The unique combination of layered thin film materials provides for striking colour transitions that are extremely difficult to reproduce, requiring a high degree of knowledge in thin film optics and sophisticated production process and equipment.

## CHARACTERISTICS OF COLOUR-SHIFTING FILM

Colour-shifting film offers simple and impactful authentication through an observed change in colour from one angle to another. The perceived change in hue and chroma of the feature can be varied by varying the thickness of the one or more of the filter's layers. Very bright and highly saturated colours can be achieved in this manner as can controlling the individual layer thicknesses to obtain specific brightness levels and chroma values.

LumaChrome film is made from highly durable and resistant materials. These materials are difficult to process, have an extremely long shelf life and requiring large facilities and sophisticated, customized machinery to produce. When deposited in a specific manner, the materials combine to create a resulting low-profile film that has high durability.



## HOW THIS TECHNOLOGY WORKS AND ITS ADVANTAGES

LumaChrome is based on the optical interference characteristics of thin films made by physical vapour deposition (PVD) methods in a large-scale production environment. The techniques and processes used to create the visually stunning colour-shifting effects require complex machinery and processing techniques to produce films with nanoscale uniformity and precision across wide webs of security foil materials. The result is a security feature that acts as an intuitive authentication device by way of a vivid shift from one colour to another distinct colour, through tilting of the film relative to the user. With the ability to create many varied colour-shifts over a wide range of saturation levels, LumaChrome can create customized security features that undergo virtually no degradation over the lifetime of the substrate.

LumaChrome thin film optical filters are made by depositing very thin layers of high-purity metals with specific and well-known optical properties onto a substrate, such as optical grade PET. There are two types of optical filters: (1) metal-dielectric and (2) all-dielectric.

Metal-dielectric films typically consist of three layers, a semitransparent metal layer, a dielectric layer, and a reflector layer, as in Figure 2. In combination, these layers manipulate the incident white light to reflect a specific colour (or wavelength), control brightness and saturation in the eyes of the user.

The top layer (at only 5-10 nm thickness) is a metal layer which acts to control the amount of light reflected from the top surface and the amount of light transmitted to the underlying layers. The central layer (up to hundreds of nanometers) selectively controls which wavelength of light undergoes constructive or destructive interference. This is determined based on the index of refraction and thickness of the layer to match the resonance of a given wavelength. The bottom layer is a reflector layer and is usually a high purity metal of tens of nanometers thickness. It reflects maximum light back through the filter promoting interference effects. Metal-dielectric filters are best suited for reflection type security features, considering they are not transparent.





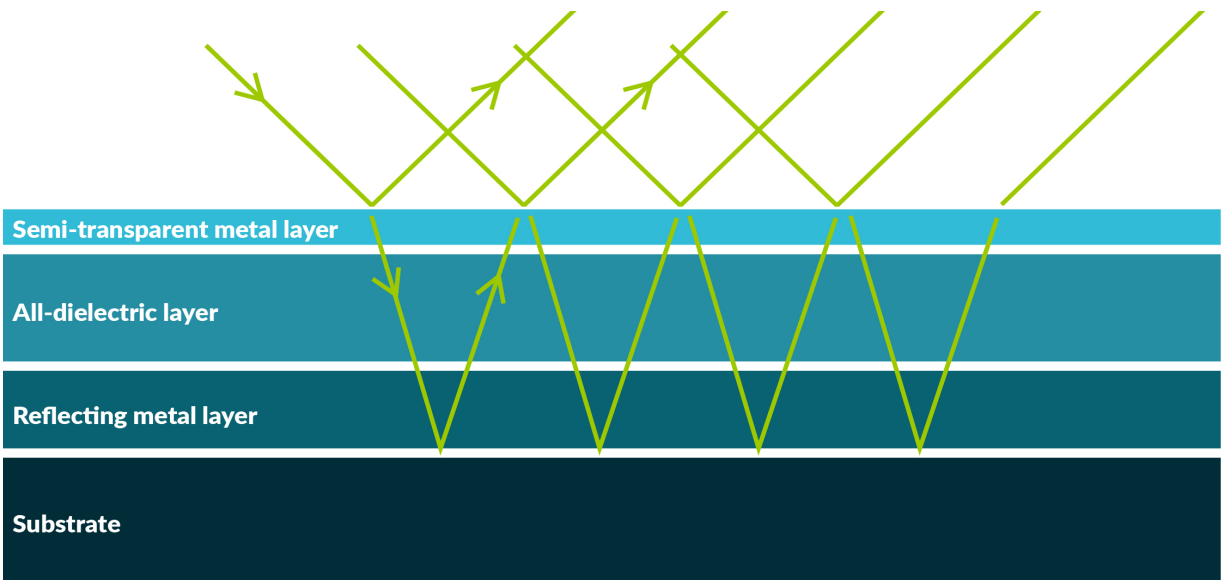


Figure 2: Cross section of LumaChrome metal-dielectric colour-shifting film

In all-dielectric films, alternating layers of high and low refractive index materials are employed to control the wavelength (colour) of light which undergoes interference, and either is reflected or transmitted through the device. This version of LumaChrome can provide security features for use in transmission and/or reflection authentication. Depending on the desired outcome, multiple layers may be used to tune the filter to achieve specific colour properties.

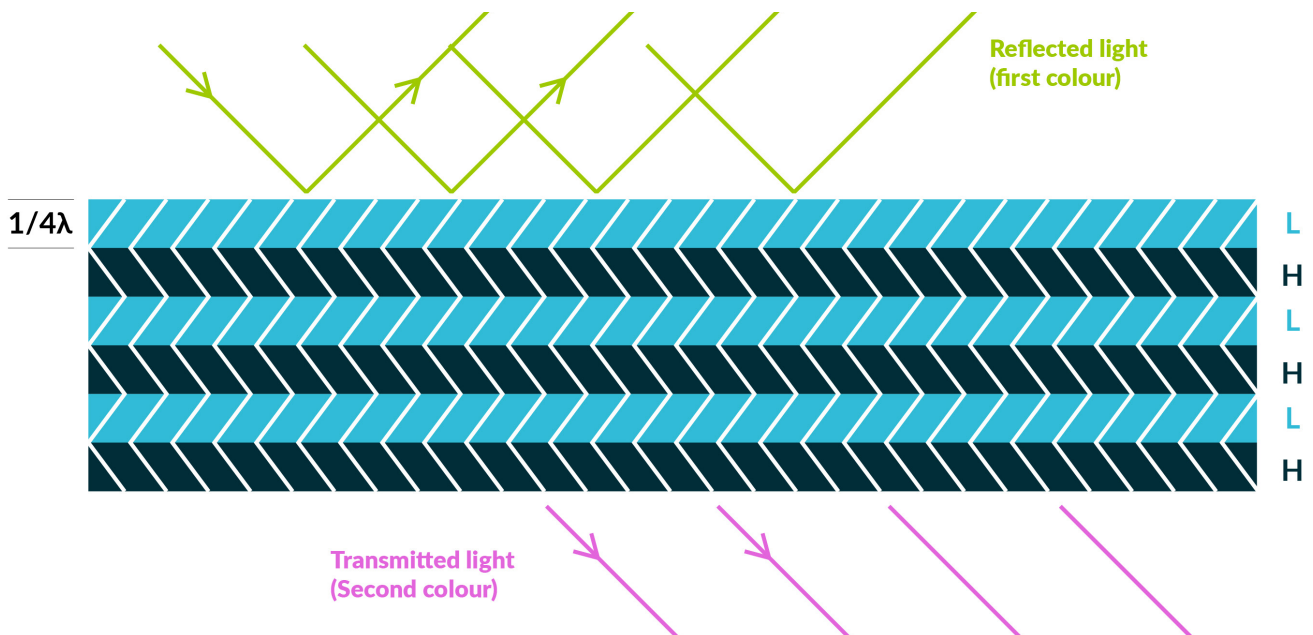


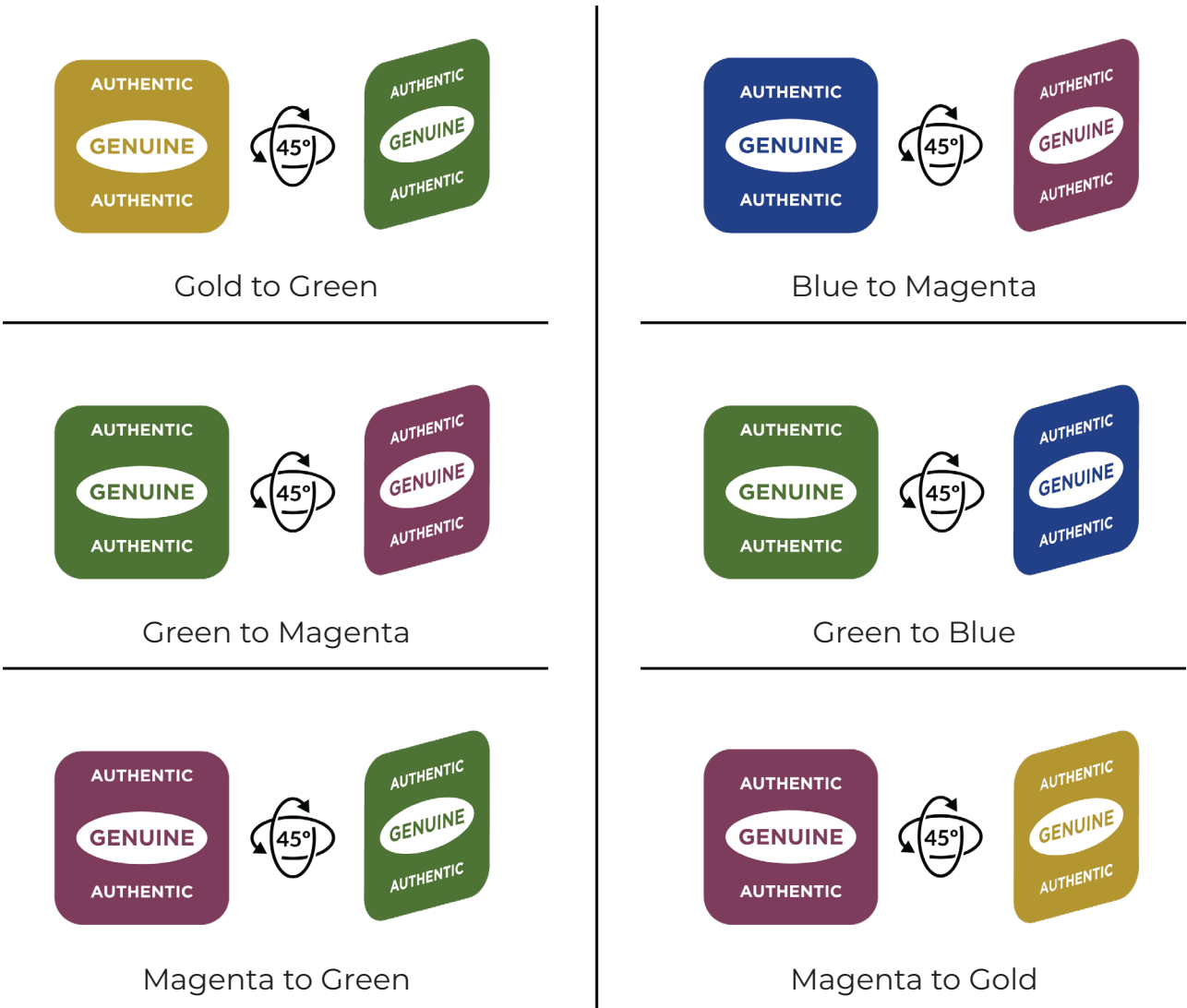
Figure 3: Cross section of LumaChrome all-dielectric colour-shifting film



In both examples above, the total thickness of each device can be under 1.5um, not considering a substrate carrier. Utilizing specific application methods, when applied to a substrate, these types of features are almost indistinguishable to the touch from the substrate surface, making them very difficult to reproduce and easily authenticated against a counterfeit version.

To summarize, this overt Level 1 feature is designed to exhibit a crisp colour transition or ‘flip’ when the viewing angle is changed.

LumaChrome colour pairs include:



## PRODUCTION CAPABILITIES

Authentix utilizes advanced thin film modelling technology as a blueprint, to determine optical constraints, expected layer thicknesses, colour gamut, and other important CIE colour space characteristics of the film. Without a highly skilled understanding of optics, this modelling of LumaChrome thin film technology would be left to the impossible methodology of trial an error.

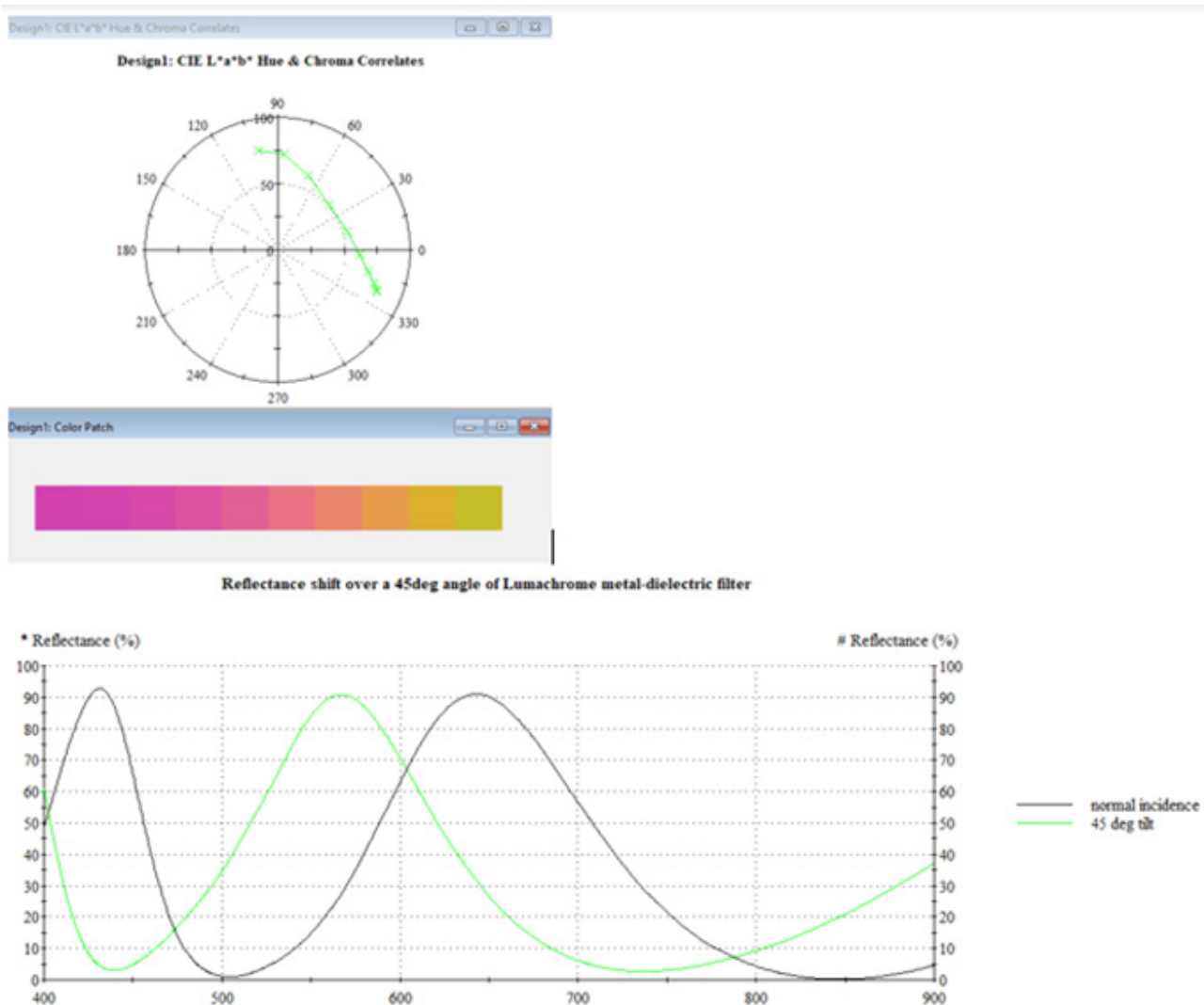


Figure 4: LumaChrome thin film modelling software

a) CIE  $L^*a^*b^*$  reflectance colour coordinates for magenta to green 3-layer LumaChrome filter, with peak position at 645 nm on normal incidence. (b) Expected reflectance colour-shift model for 3-layer LumaChrome magenta to green, with peak position at 645 nm on normal incidence. (c) Reflectance plot of LumaChrome filter, with peak position at 645 nm (magenta) on normal incidence, and 550 nm (green) at 50°.

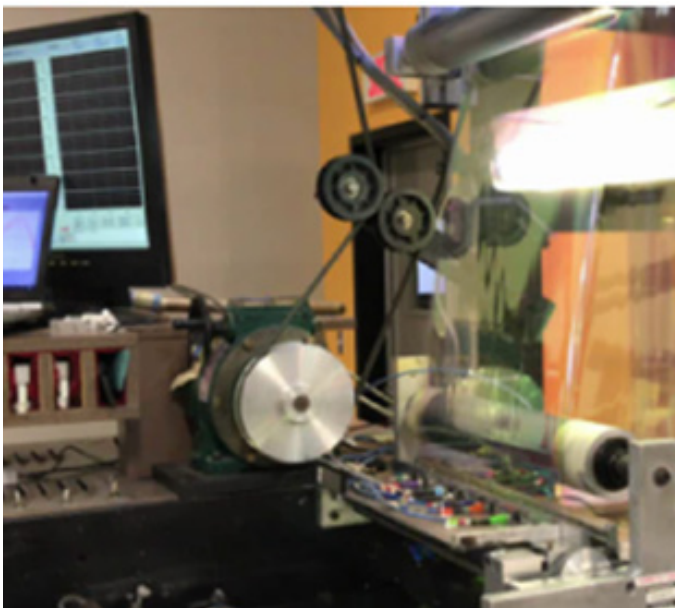






*Figure 5: Complex thin film roll coater used to manufacture LumaChrome*

To support high volume production of LumaChrome, Authentix utilizes large roll-to-roll optical thin film deposition coaters in high secure production facilities. With the ability to operate up to four separate deposition zones simultaneously, Authentix has the unique ability produce highly customizable films, very cost effectively.



*Figure 6: Quality control inspection equipment to ensure product conformance to specifications*

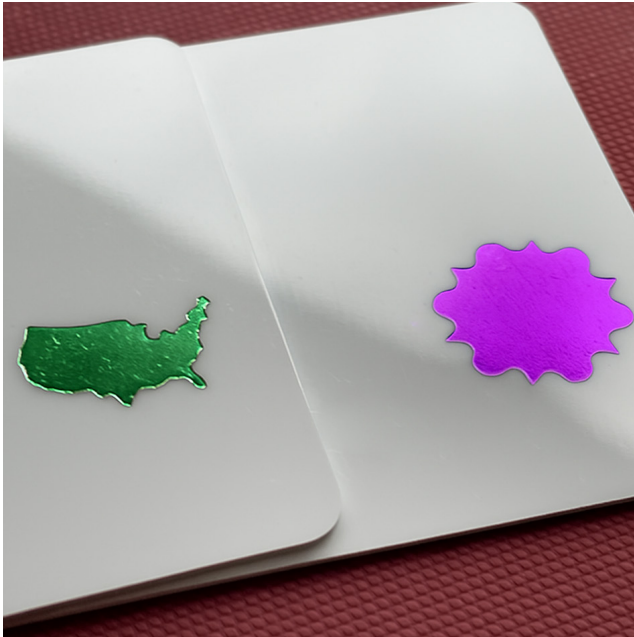
Conversion capabilities of LumaChrome enables us to perform high speed inspection of each roll produced, editing out gross defects, pinholes and colour abnormalities to ensure perfect conformance to client specifications.



## EXISTING AND UPCOMING FORMATS

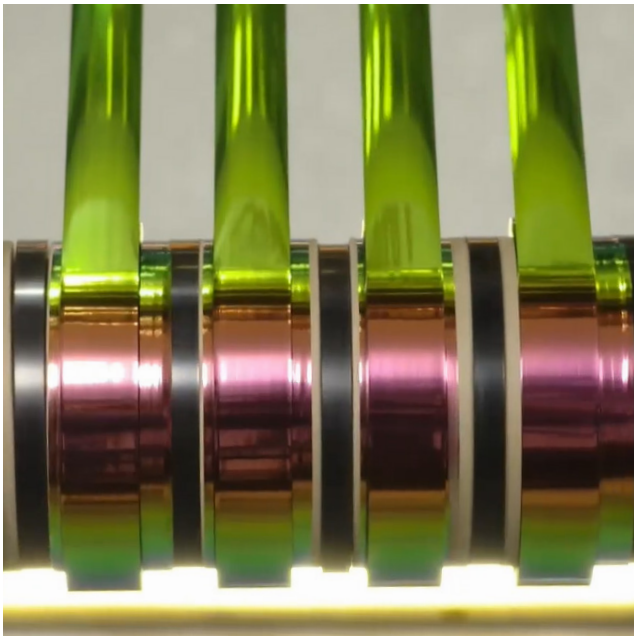
LumaChrome as a metal-dielectric or all-dielectric film is available in multiple formats to meet customer demand and specific security application needs.

### Patch Application



Patch is available in both in all-dielectric and metal-dielectric LumaChrome arrangements. Patch application can be in the form of a simple shape or die-stamped to a specific customer image/logo. As a metal-dielectric, this type of feature can be de-metallized to customer requirements to introduce numerical and other characters. This type of feature can allow for under/over printing.

### Stripe Application

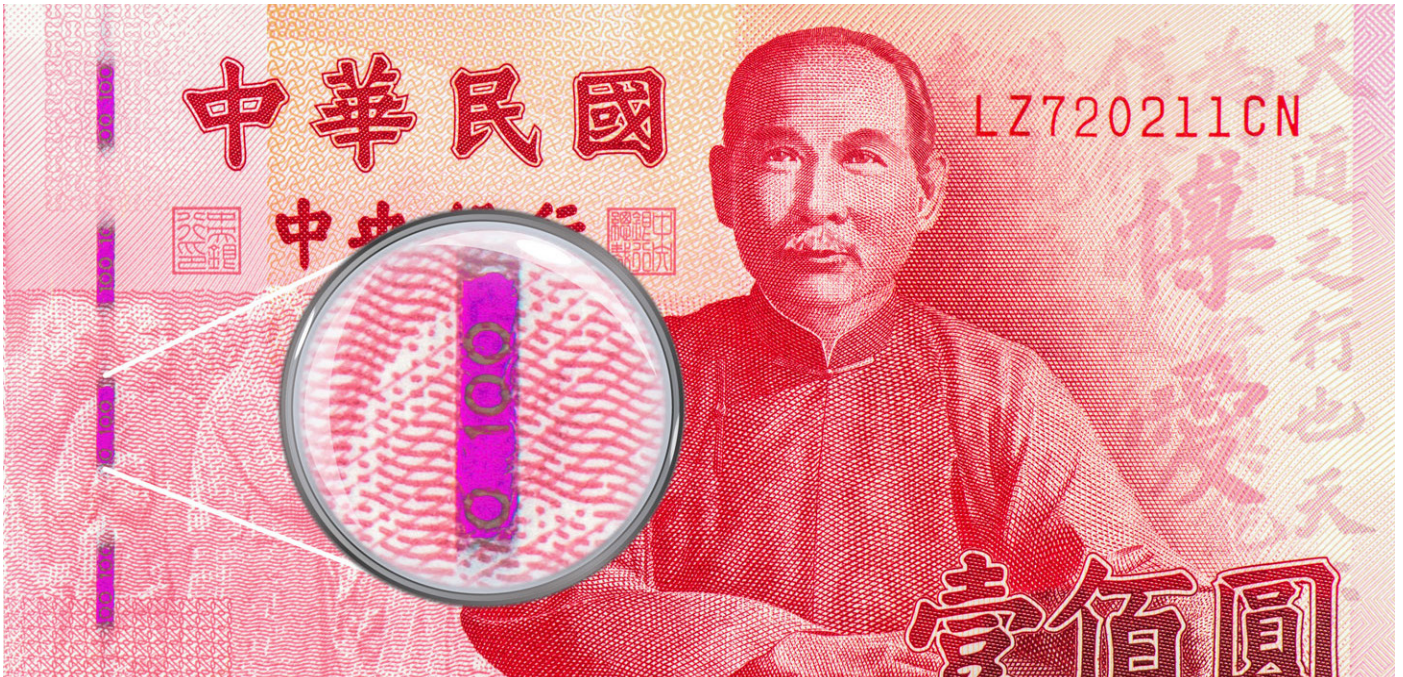


Stripe is available in both all-dielectric and metal-dielectric LumaChrome arrangements. Stripe application offers large feature area for greater feature coverage of the substrate. Sections within the feature area can be configured for de-metallization, windowed, and allow for under/overprinting.





## Thread Application



Available both in all-dielectric and metal-dielectric LumaChrome arrangements. Thread application is designed to retain the carrier substrate. The complete film is slit down into ribbons of a few millimeters wide and woven into the substrate.

## Windowed Application

Typically reserved for all-dielectric LumaChrome. A windowed feature to provide for a first colour-shift in reflection and a second colour-shift in transmission. This type of feature is ideal for polymer and other optically clear substrates.





## FUTURE FORMATS

Future LumaChrome formats are being explored as possible combinatorial features with our nanotechnology-based platform, to create next generation optical security devices.



## CONCLUSION

Authentix proven LumaChrome thin film platform of colour-shifting technologies, have been a staple to the secured documents industry for years, offering vibrant colour-shifting effects that are robust, complex to produce and that are available in many formats to meet customer demands. LumaChrome is a perfect solution for protecting banknotes and government documents and ensuring the worldwide economy and individual identities are secure.

Published on: July 30 2025



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# The Most **Reliable** Banknote **Security** in the Industry