Currency and the Never-Ending Battle

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Abstract:

Banknotes as a medium of exchange for goods and services have been used throughout the world for the last two hundred years. During this time banknotes have been refined to provide ever increasing security against counterfeiting. Enhancements such as special substrates, Intaglio printing, planchets, watermarks, portraits, colored fibers, and guilloche patterns have been employed. More recently, holograms, laser perforation, optically variable devices, and security threads have been added to the banknotes as further deterrents as counterfeiters have become more adapt at using new technologies to simulate the older features. Some examples of these anti-counterfeit features are discussed as well as some counterfeit notes.

New technologies are being created that are just now being introduced to the banknote community. These include combination optical devices such as Chromagrams®, oriented optically variable devices, de-metallized optically variable threads and virtual image devices. These devices are shown and described.

Introduction:

The question that might be asked is whether or not AIMCAL is relevant to the production of currency. The answer is an unequivocal “Yes.”

The substrate of banknotes is most often based on fibers-to-roll converting of cotton (75%) and 25% linen (flax) fibers into large roll stock for subsequent printing and the addition of other security devices. However, over thirty countries including Australia, New Zealand, Kuwait, and Haiti are using special polypropylene roll stock for polymeric based currency. During the manufacture of the “paper” currency, holograms and security threads are added or inserted for each banknote. Holograms require rolls of embossed plastic film with a release layer. The PET/Release is typically 12.5 microns thick and has been vacuum coated with opaque aluminum which may further be processed in roll form using a demetallization process involving chemical resists and etchants all in register with the holographic or diffractive design. Several vacuum companies are considering an oil demet process in registration with the hologram to make the demet hologram all in line.

Security threads are being used more and more in currency, particularly those that are optically variable and have demetallization. A good example of such a security thread can be seen in the recently issued (2006) Indonesia 50,000 Rupiah, the 2004 Canadian 20 Dollar or the 2006 India 100 Rupee (Fig.1). Not only is advanced roll coating required to produce these color shifting threads but these threads are also laminated to protect the optical coating. Following the lamination step, "high tech" slitting of these rolls to narrow multiple ribbons (2-5mm wide), for 1000's of feet, wound up like on a fishing reel is required.

Thread

Fig. 1. 100 Rupee India Banknote (2007) Showing Color Shifting Thread

Other security features must also be developed in a roll to roll format since that is the only practical way to mass produce and attach such devices to banknotes.

The last step in the manufacture of banknotes is the printing step. Although the main security printing is based on Intaglio or rotary screen printing of sheeted paper, other presses use roll to roll silk screen or lithographic presses.

It is evident then that the manufacture of modern bank notes requires either access to polyester vendors or OPP vendors and also to equipment manufacturers of various roll to roll webs. So industrial metallizers, coaters and laminators are all used to manufacture paper currency!

Currency Essentials:

Folding currency, i.e. banknotes, is used world-wide for trade and services. Banknotes will always be a part of commerce because they assure anonymity to their users. Unlike credit and debit cards, banknotes have no tracking of spending patterns and address privacy concerns. In the past paper currency was backed by gold and silver – no more. Faith in the value of banknotes rests on the fact that such "paper" represents value based on the credit worthiness of the issuing governing body. The value of the banknotes also implies that they are genuine. Thus, over the years, governments have put out considerable effort to make banknotes difficult to counterfeit. At the same time, consumers must be able to readily determine if their banknotes are genuine or fake. So banknote designers have employed various means to allow the average person to easily recognize banknote features. All this must be accomplished at production speeds since billions of banknotes must be made and yet made at reasonable cost, typically at US $50-$60.00 per one thousand notes.

Early Currency:

Folding paper actually started in the Tang dynasty (618-907A.D.) around 800A.D.[1] Paper money was used to relieve the weight of silver or gold when money had to be transported long distances. At its destination the paper money was reconverted back into its equivalent value of silver or gold. This money was called “flying cash” since it often blew away in the wind. It was not until the 1600’s that paper currency was used in the West, no doubt from examination of Chinese currency brought westward by travelers from Asia.

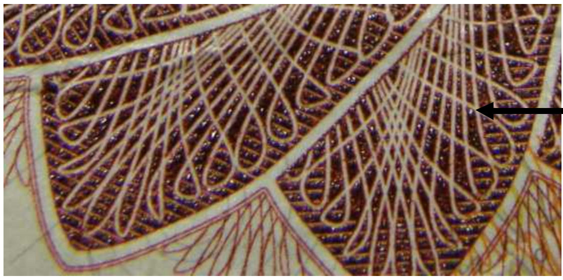
In Colonial times of America, currency was introduced by Benjamin Franklin and he used images of leaves to prevent counterfeiting. This was accomplished by pressing leaves into plaster, allowing the plaster to dry, removing the leaf, and then oiling the plaster to make the negative image with more plaster. Lead metal poured into the mold produced a printing plate with the image of the leaf.[2] The images were also ones people could remember. Since photography and computer scanners were unknown at the time, counterfeiters had a hard time duplicating the images since leaves are not all the same. However, presumably they could be simulated using similar leaves as their template once Frankin’s method was discovered. To make counterfeiters pause in their trade, the penalty of counterfeiting was stamped onto the currency – “To Counterfeit is Death!”

It was during the Civil War of the United States that counterfeiting flourished. Every bank issued its own currency between the years of 1860-1864. Banknotes of this era used intricate engravings of various scenes and images of faces to deter counterfeiting. Not only were there many notes from different banks but each state issued their own notes. At this time banknote plates were engraved by skilled artisans that made counterfeiting difficult. However, one only had to find a co-conspirator who knew the trade and you were in the counterfeiting business. In fact, a man by the name of Samuel Curtis Upham known as the “king of counterfeiters,” based in Philadelphia, used his skills to produce about one million fake ($15 million worth) Confederacy notes.[3] These fake notes helped debase the South’s currency.

Now it is quite difficult to tell a real note from a counterfeit note from the Civil war era. To make matters worse, in the 1950’s facsimiles of Confederate notes could be found in Cheerios cereal boxes and in the period, 1960-1965, facsimiles were produced to commemorate the Civil War as well as for promotional items by the Topps and A.B.C. gum companies.[4]

Modern Currency:

Form the early 1800's to the present, banknotes authenticity was based on intricate graphics including guilloche patterns (Fig. 2), various colored ink combinations, serial numbers and signatures. Graphics have included birds, animals, ships, trains, planes, scenes of agriculture, famous people, and many other types of subjects.[5] However, with the advent of color copiers, scanners and computers, printing by itself was no longer a deterrent to counterfeiting. Thus, the era of optical security devices was introduced, including reflective thread, planchettes, watermarks, micro-printing, laser perforation, holograms, optically variable inks, zero order diffraction, and scrambled indicia devices. Information on these devices can be found in references 6-7. All these devices are added to the banknote paper so as to defeat digital copying.



Guilloche (Spiro graph) pattern

Fig. 2.Guilloche pattern taken from 100 Kroner (Denmark) banknote

Substrate for banknotes as indicated has ranged from paper to cotton/linen to plastic. The latter materials allow for greater durability than paper in washing and handling. Polymeric banknotes can enable features such as transmission holograms and scrambled indicia devices that can not be created in "paper" banknotes. However, polymer banknotes do suffer from set folds and appear to have more difficulty in maintaining print adhesion.

Future Currency:

In spite of all the progress in making the currency more resistant to counterfeiting, even more sophisticated technology is required since counterfeiters are becoming more technologically capable. They have large sums of money from other illegal activities to fund their counterfeiting and have access to commercial sources of holograms, color shifting pigments and even equipment to make banknote simulations.

Several new concepts have been recently announced that are either just entering the currency market or are in trials. One concept that has been recognized by the Committee on Technologies to Deter Currency Counterfeiting is the use of hybrid technologies.[8] Hybrid technology is a combination of optical devices that take the same real estate area on a banknote. Such layering of technologies requires multiple skills to replicate the feature which should make counterfeiting more difficult. At the same time, the optical device must be readily understood and remembered. An example of such a device is shown in figure 3. This device is a hologram that changes its image as it is tilted but its diffractive colors have been modified by a thin film interference device. One can easily remember its image as it is a well known figure of sculpture i.e. Venus de Milo.

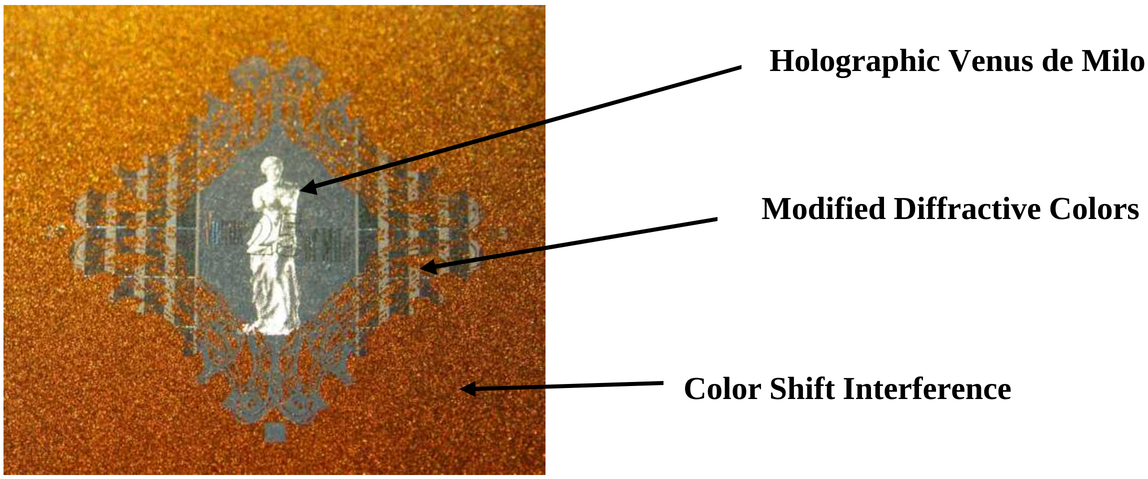


Fig. 3. Hybrid Device of Holographic and Thin Film Interference Elements

Several other novel concepts have also been introduced into the marketplace. Unison™, also known as Motion™ technology, is a micro-optic security film based on a micron scale (24 micron) array of geometric aspheric lenses that results in virtual images floating either above, below or in the plane of the substrate.[9-10] The image moves orthogonally to the direction of tilt which is counterintuitive. This is accomplished by placing the lens array slightly offset over another piece of embossed film in which small areas have been pigmented and where other areas are highly reflective.

Three dimensional images can also be produced by laser ablation of a thin film coated on the back side of 60 micron glass spheres embedded into a polymeric matrix. The laser ablation causes a dot in the film. If the focal plane relative to the glass sheeting is moved in x, y, and z directions, a complex stick image is created behind the “fly–like” lens array and is seen by the human eye either above, in, or behind the surface of the glass sheeting. Both depth and parallax is observed (Fig.4).[11-12]

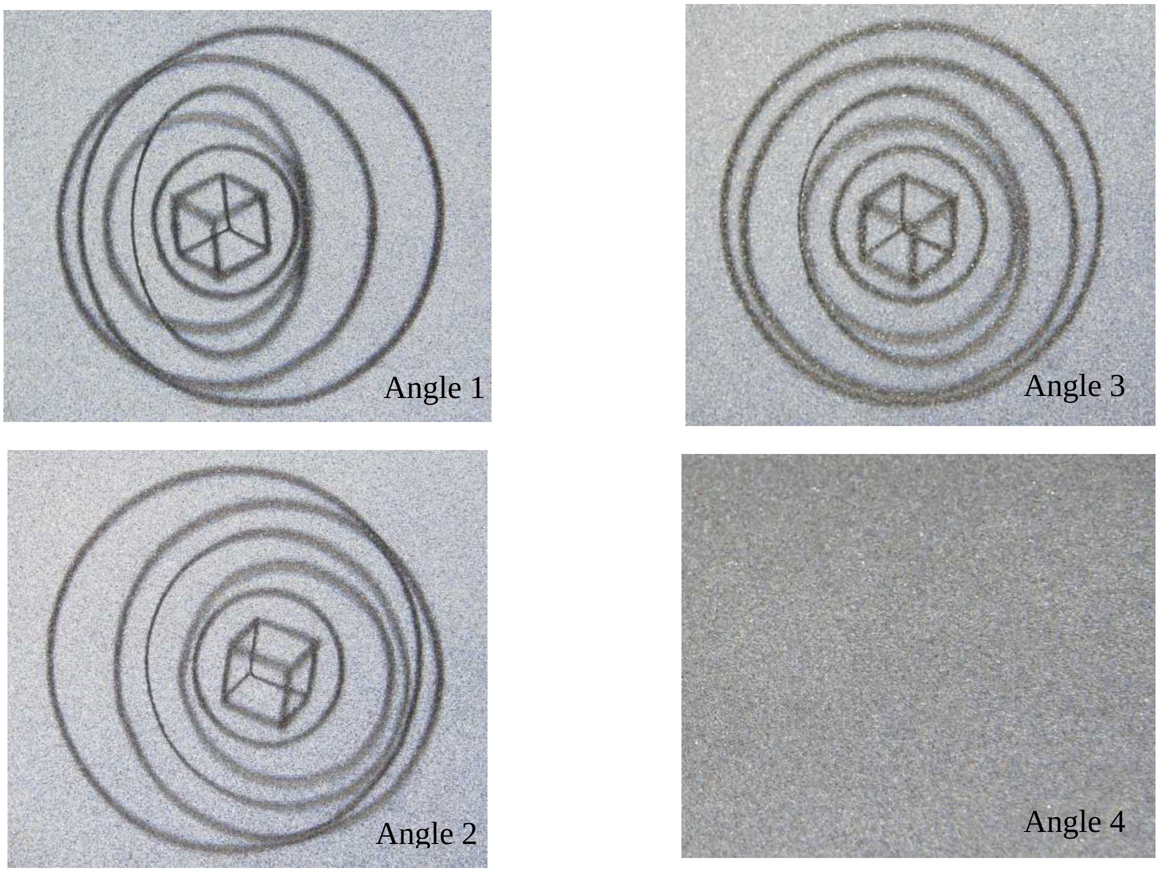


Fig. 4. 3D Floating Virtual Images above an Array of Glass Beads

Another fascinating device is based on an array of OVD mirrors oriented in different positions within a polymeric matrix.[14] Due to differences in spatial reflections, an image may appear to move across the image plane or float above or below another object as one moves his head or tilts the device side-to-side or front-to-back. An example of this optical phenomenon is shown in Fig. 5.

Fig. 5. Hologram satellite moving over the “rim of a crater” as the angle of view changes.

Conclusions:

To protect the integrity of currency, governments have had to resort to increasing levels of technology to prevent banknotes from being copied, simulated or even originated on equipment that parallels the authorized process. As technology has increased so has the sophistication of the counterfeiter. This counterfeiting has in turn driven the production of banknotes by governments and national banks to a product that is not only pleasing to the eye but is highly resistant to forging.

As banknotes continue to evolve, more and more AIMCAL technologies will be required!

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