Paper Direct Metallizing for Decorative and Functional Applications

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Abstract

Metallized papers have been in use for over 30 years for packaging and converting applications. The main reason was the high energy costs associated with aluminium foil and the need for a more economic replacement. However, due to recent market requirements for new applications, metallized papers have entered into new markets such as holographic security and other functional uses. Paper is environmentally friendly and cost less than other flexible films.

1- Introduction

Vacuum metallized papers have been in use for over 30 years for different applications. Paper is characterised by its flexibility, low-cost production and biodegradability. Metallized paper offer good alternative to aluminium foil which is more expensive to produce and to dispose. There are many advantages of utilizing properties of paper in many applications for the following reasons:

- Low Cost for Mass Production.
- Organic Substrate; Environmentally- Friendly; Biodegradable, Recyclable.
- Flexible.
- Paper is porous and has hydrophilic cellulose fibres. This makes it suitable for many niche products including chemical sensors.
- Can be manufactured with different grades.
- Can be formed easily into different shapes.
- Can be printed with fast inkjet printing for special products.
- Paper can be Hydrophobic by special treatment.

- Dielectric constant of paper is low; suitable for embedded RFID.

Metallized papers have been in use for a wide variety of applications including Cigarette packaging either in inner or outer wrapping, metallized labels (wet glue and pressure sensitive adhesive) for alcoholic drinks, beer, food cans, soft drinks and mineral waters and also for metallized flexible packaging and inner liners. Metallized paper labels offer bright visual appeal for marketing the products. Other applications include Gift wrappings, Holograms, Candy, Chewing gum wrappings, Butter and "fast" food wrappings.

2- Advantages of Metallized Paper over Aluminium Foil Laminates

Metallized paper has many advantages over aluminium foil laminates. This can be summarized as follows:

a- Cost: metallized paper is less expensive to produce than aluminium foil laminates.

b- Capital costs of machinery to produce metallized paper are lower than the cost of large rolling mills for producing thin aluminium foil.

c- Environmentally friendly: metallized paper uses only 1/125 th of the amount of energy as compared with aluminium foil production. Also, metallized paper has a very thin layer of aluminium in the range of 30nm. Therefore, it is considered as a single ply material. This makes it easier to dispose and recycle than aluminium foil laminates.

d- Converting : metallized paper offer better performance during sheeting, embossing, die cutting and printing. This enables higher converting line speeds, greater outputs and less scrap.

Table 1 shows some of the advantages of using paper as a flexible substrate.

Table 1. Advantages of using Paper as a flexible substrate

Low Cost for Mass Production.
Organic Substrate; Environmentally- Friendly; Biodegradable, Recyclable.
Flexible.
Paper is porous, hydrophilic cellulose fibres; suitable for many products including chemical sensors.
Can be manufactured with different grades.
Can be formed easily into different shapes.
Fast inkjet printing for special products.
Paper can be Hydrophobic by special treatment.
Dielectric constant close to air; suitable for embedded RFID.

3- Global Market for Metallized Paper

The decline in key cigarette packaging sector has led to some decline in the demand of metallized paper packaging for such application. However, there is now a growing demand for metallized paper in other nontobacco sectors such as gift wrap particularly in Asia Pacific.

On the other hand, transfer-metallized boards remain a niche product. Metallized paper/board laminates offer better environmental credentials than metallized film/board or aluminium foil/board laminates.

At present, the world largest market areas for metallized paper products are Europe and North America. It is estimated they account for approximately 80% of the world production of metallized paper. However, there is a growing production of metallized paper in other parts of the world including India and China.

Specialty papers are also of growing interest to the paper industry. They are usually higher value added products attracting a premium and increased financial performance for the producer.

According to Smithers PIRA report the global volume of the specialty paper market in 2012 was 2.3 million tonnes and is forecast to grow 2% annually to reach 2.5 million tonnes by 2018.

4- Vacuum Metallizing of Paper

Vacuum Metallizing is carried out inside a vacuum web metallizer. In this process, aluminium is evaporated in a vacuum environment and allowed to condense onto a moving flexible substrate such as film or paper. The technology also allows for selective metallizing, enabling the production of security products whenever required.

There are two methods for the production of metallized paper:

a- Transfer metallized paper and paperboard.

b- Direct metallized paper and paperboard.

a- ***Transfer (Indirect) Metallizing***

This process is called transfer metallizing (or sometimes indirect metallizing) because rolls of flexible films such as polyester or polypropylene are metallized first with aluminium then the thin layer of aluminium is transferred onto the rolls of paper. The film can be re-used again for vacuum metallizing up to approximately 10 times before start producing low quality product.

The main stages of a typical indirect metallizing process are shown in Figure 1.

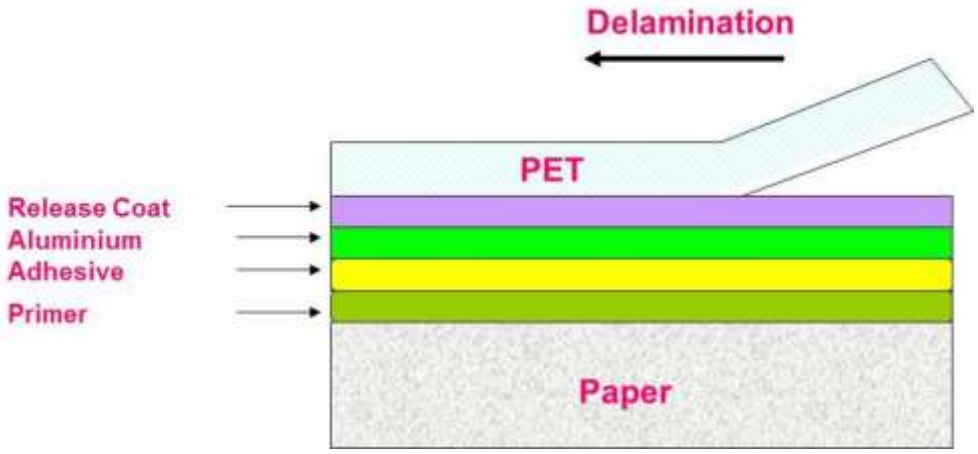

Figure 1. Transfer Metallizing Process

The main advantages of the transfer metallizing process are:

- The PET film can be re-used many times:
- No requirement for special expensive vacuum web metallizer. Very thick paper or boards will take long time to outgass in the vacuum metallizer due to moisture retention. PET film can be metallized easily. Then aluminium can be transferred onto the thick paper and the film can be re-used again. This can be done inside a standard vacuum web metallizer.

The main disadvantages of the transfer metallizing process are:

- The use of inexpensive poor quality paper results in a low quality product
- Complicated process and time consuming.
- As the polyester (or polypropylene) film deteriorates the quality of metallized paper produced deteriorates.

b- ***Direct Metallizing***

In this process flexible rolls of paper are loaded into the vacuum web metallizer. Then rolls of paper are directly metallized with aluminium in a vacuum environment. There is no need for plastic films such as PET to be used in this process (Figure 2).

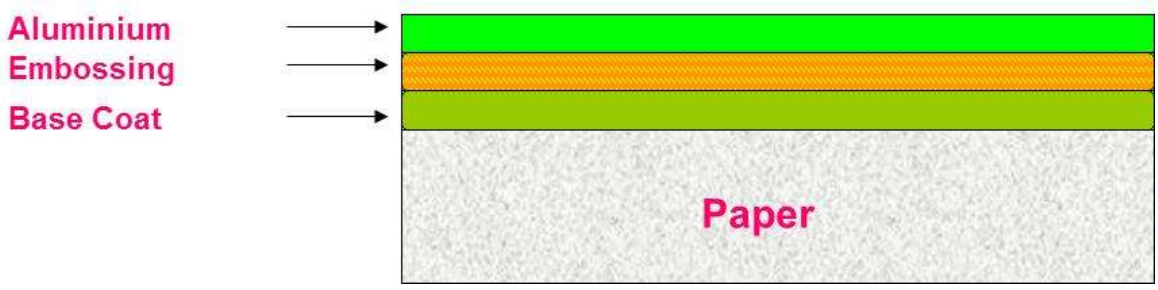

Figure 2. Direct Metallizing of Paper

Rolls of paper, usually clay coated paper, are first coated with a base lacquer in order to make the surface of the paper very smooth. This ensures a high quality gloss finish. During the base lacquer drying stage the moisture content in the paper is reduced from its natural 5-6% content to about 3 % depending upon type and the manufacturing process of the paper.

This drying process reduces the water outgassing from the paper when it is loaded inside the vacuum web metallizer. This enables the achievement of high vacuum which is required for quality metallizing.

Following metallizing, the rolls are then coated with top lacquer, or with a coloured lacquer such as gold to produce bright gold colour finish, to protect the thin aluminium layer and to enable the paper to be printed. At this stage the paper is re-moisturised in a special chambers to restore the paper's original strength and handling properties.

The main advantages of the direct process are:

- simple process giving consistent results
- lower production costs than the indirect process
- high production yield - less scrap produced
- high gloss finishes, superior quality product
- higher barrier properties
- For holographic applications: The paper can be embossed before or after metallizing.

- Security coding can be added before or after metallizing.
- Can be laser etched for security coding.

The main disadvantages of the direct metallizing process are:

- Process is most suitable for good quality paper
- Not suitable for thick paper board.

Both processes are used in Europe and North America but the vast majority of metallizing companies use the direct process for the main tobacco and label markets because of consistency of process and quality. The use of high quality paper means superior product. Figure 3 shows direct metallized paper with and without holographic embossing.

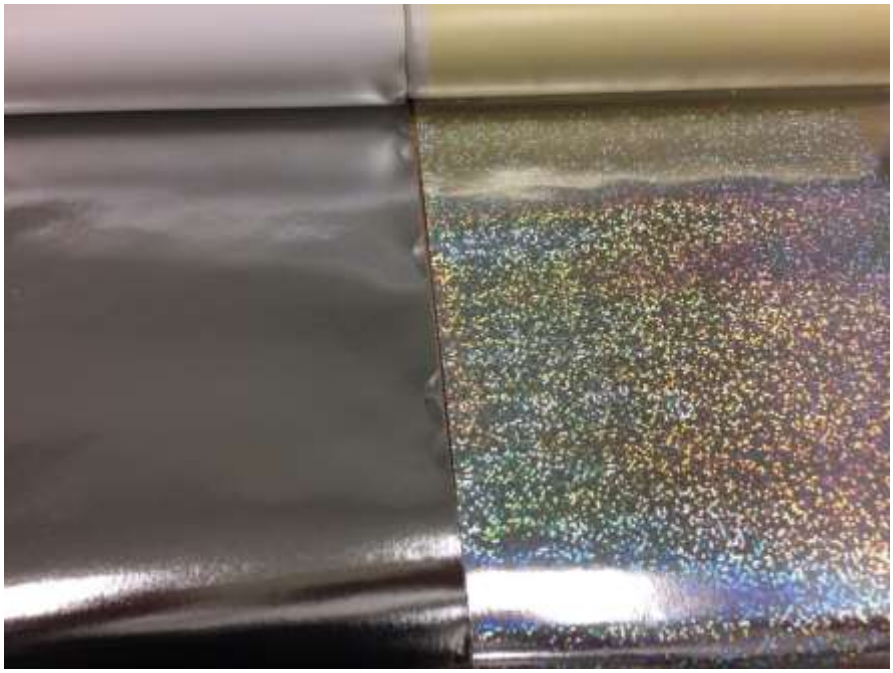

Figure 3. Direct Metallized Paper with and without holographic embossing

5- Technology of Direct Metallizing of Paper

The utilization of vacuum technology for direct metallizing of paper requires special attention in the selection of substrates and materials. The following list identifies some of the main areas to be considered in direct paper metallizing:

- ***Paper Selection*:** the paper should have good surface quality for metallizing. Papers are coated, usually with clay coating, by the paper manufacturers in line during the paper making process. Features such as stiffness, tear strength, burst strength, wet strength must be considered depending upon the application. In addition, some food wrapping such as butter and “fast” food require grease and an aroma barrier.

- ***Lacquer selection*:** paper to be metallized must be pre-lacquered despite having a 12-15 gsm clay coating. The brightness of the aluminium depends on the hardness and smoothness of the lacquered surface. Lacquer weight can be from 2-3.5gsm or as high as 6gsm. Post lacquering of the metallized aluminium provide good protection and durability. It is usually done within 48 hrs following metallizing, although some applications do not require this stage. Typical post lacquer coatings are 1.5 gsm to 2 gsm and considerations must be given to whether the material is to be printed as for labels.

- ***Lacquer coating machine***: there are many different technologies available for applying the base and top lacquer onto the paper. The machine should be able to apply a smooth and uniform coating for high quality metallized product.

- ***Selection of vacuum metallizer***: the selection of the most suitable vacuum web metallizer depends on its design to handle paper rolls. This includes the efficiency of its vacuum pumps and the winding system.

- ***Quality testing equipment***: this includes instrumentation such as moisture analyser, analytical balance, Gurley densometer, forced air oven and a gloss meter. Other instrumentation such as tear tester, Mullen tester, Cobb tester and curl tester are highly desirable.

Table 2 shows some factors that can affect the quality of direct metallizing of Paper

Table 2. Factors affecting Quality in Direct Metallizing

Paper Quality	• Surface Roughness. • Moisture Content. • Paper Thickness.
Metallizer Winding System	• Special design for paper thickness>90gsm. • Possible web breaks.
Heat of Metallization	• Coating Thickness. • Web Speed.
Vacuum Level	• High Vacuum . • Fast Pumping Speed.

6. Examples of Smart Paper

a- Paper can be used for smart security coding instead of standard Polymeric film. Figure 4a&b shows example of insertion of special coding inside metallized direct paper which can be used as a machine readable security holographic paper label for food packaging and other products.

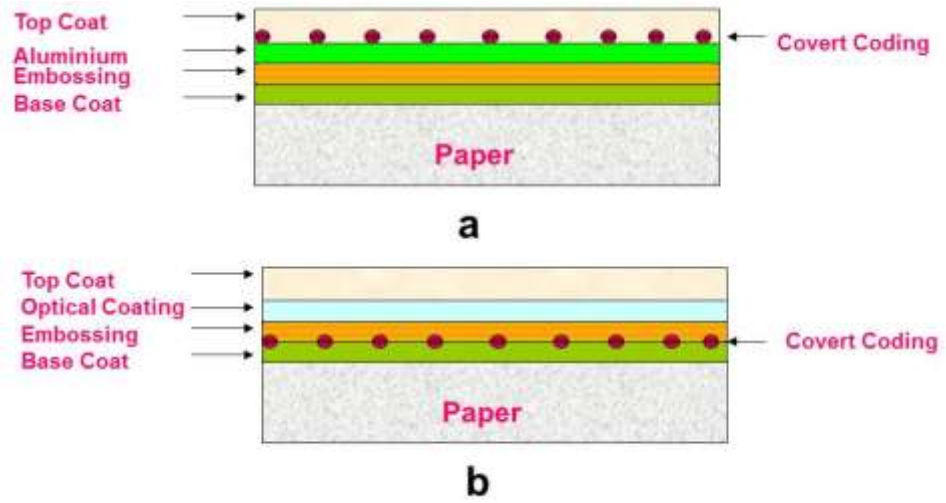

Figure 4. Machine Readable metallized Paper with Covert Coding

b- Paper Battery

The thin sheet of cellulose, which is major constituent of paper, is first infused with aligned carbon nanotubes. The nanotubes act as a cathode. This allows the storage devices to conduct electricity. A lithium metal is then laminated to act as anode. In this case, the cellulose fibres act as separators. A bio-electrolyte such as sweat, blood, urine, etc can be used to activate the battery. The battery provides a low, steady power output. The paper battery integrates all of the battery components in a single structure, making it more energy efficient and lighter.

Table 3 shows some other examples of the utilization of paper for smart applications.

Table 3. Examples of Smart Paper Applications

Bioactive Paper	Biosensors
RFID Paper Tags	UHF (860-955MHz)
Photonic Paper	Rewritable Paper Display
Electrochemical Paper	Thin Paper Battery
Electronic Devices	Paper Transistors

Conclusions

Environmental concern has increased demands for metallized paper as organic, biodegradable substrates. At present, embossed metallized holographic papers are used for packaging, security and labels. However, there is more integration of holograms with smart devices using metallized paper as a substrate. This will include more advanced technologies of embedding covert coding such as nano-materials within paper fibres or further development in paper battery.