Pattern Metallization: Selective Deposition of Metals on Polymer Films for Functional Applications

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Extended Abstract

Selectively Metallized Films have been used in various applications. Most everybody has seen the mass mailed envelopes, using a metallized PET or oPP film with a clear window for the address. And most everybody has already devoured a food item, that was heated in a microwave using a susceptor laminated to a paper board, whereas the susceptor had a pattern to it.

Most of these patterns were created by pattern etching. There are two different approaches for this, and both start out with a fully metallized film. The first technology prints a protective coat over the areas that are supposed to stay metallized. In a subsequent step the film then is exposed to a caustic bath, that etches away the aluminum that is still exposed. The film then is washed in order to remove the caustics. The second method prints a concentrated caustic solution right onto the areas that need to be etched. The caustics then dissolve the aluminum, and like in the first step, the film is then washed and cleaned before further processing. Either method represents an additional production step, and both methods have to deal with the leftover: Caustics with dissolved aluminum, which needs to be disposed of according to EPA rules.

An alternative to this method has been around for some time now, but has to date not found widespread application: In Chamber Selective Metallization. Here the pattern is created by preventing the aluminum from depositing in the areas that are supposed to stay clean. This is achieved by applying a thin film of oil onto the areas that are not supposed to be metallized. The thin layer of oil fulfills two functions: 1. It creates an area with low surface energy, which prevents the aluminum from attaching, and 2. when exposed to the heat of the evaporator, it also starts evaporating itself, creating a gas stream in the opposed direction to the aluminum, further preventing the metal from depositing. Although this technology has been around for some time the only major application so far is the use in patterned capacitor films. One of the reasons for this might be the type of oil being used so far, which is not fully FDA compliant. Since there typically is a small

residue of oil left on the film, the concern with the majority of the applications that aim towards food packaging is the exposure of the packaged food to the pattern oil. Finding the right oil is not a simple task, as it needs to fulfill several requirements: Besides being FDA compliant, preferably not only for food contact, but even as a food additive, it needs to be vacuum compliant, needs to have the right viscosity under the conditions under which it is being used, and it needs to have just the right evaporation behavior that it only leaves a minor residue on the pattern metallized film.

In term of the residue there was, initially, major concern about the compatibility with further processing, especially with lamination. It was found, however, that the oil has either no or only minimum impact on several types of adhesives. Full compatibility with specific adhesives however should be tested prior.

The main advantage of in chamber patterning is the reduction in production cost, as it completely eliminates one process step. In addition, it eliminates the environmental issues with the leftover caustic solutions.

It was also found that much finer print resolutions can be achieved with in-chamber metallization. Print resolutions up to 300 lpi are achievable, and create numerous opportunities for creative and decorative applications.

Applications and Markets

Applications and Markets can be divided into two major segments: Decorative and Functional Applications.

Decorative applications are mostly in the packaging field. The following areas expressed high interest and are currently being qualified:

a. Metal pigment replacement. Here the patterned metal is used to enhance print designs and layouts. So far either metal pigments or demetallized films have been used in these areas. Metal pigments typically do not achieve the luster and reflectivity a metallized layer offers. In addition many printers like to stay away from metal pigments, as they are not only expensive, but considered abrasive to the printing machines as well. Over demetallization the pattern metallization offers a price and an environmental advantage.
b. Functional Packages: Here the patterned metal is used to create functions in the package such as windows, strips etc. Again some of these applications have been served by demetallized film, so the pattern metallizing offers the appropriate advantages.
c. Print Design Enhancements: Metallized film is already used to enhance print designs. Currently those areas that are not supposed to have shiny appearance are printed over with heavy opaque inks. Printers and converters expressed that it will be of advantage if such areas don’t have metal to begin with, which will save on the cost of inks and printing.

d. Holographic applications: Since micro embossed holographic films rely on a reflective layer it is possible to create holographic designs with holographic appearance such as a rainbow hologram in only selected areas. This effect is created if e.g. a rainbow embossed film, that is pattern metallized, is laminated against a paperboard. Since the adhesives being used have about the same optical index as the micro embossed film the holographic effect disappears in those areas that are not metallized.
e. Heat Transfer / Hot Stamping Films: It is thought that pattern metallized films can provide higher resolution and crisper, sharper edges compared to standard metallized hot stamping foil. Current technology relies on the ability of the heat release layer as well as the metallized layer to separate at the edges of the transferred areas. Since there is a certain "fuzziness" at the edges the resolution of transferred patterns are limited. It is thought that pattern metallized films can provide much higher resolution and sharpness compared to current technology.

Functional Applications:

a. Microwave Susceptors. The by far largest application for pattern metallization is the use for microwave susceptors. Thin film metallized susceptors, where an aluminum layer with an optical density of about 0.27 is deposited on PET film, have found widespread use to heat food in the microwave. It has been found, however, that the microwave energy can be distributed in much better ways if the susceptor has certain patterns to it. Here again some applications already use demetallization techniques, but pattern metallizing can offer the above mentioned advantages.
b. RFID Antenna: The technology lends itself to the creation of electromagnetic active structures such as antennas for RFID applications. There is still a dispute, however, whether the thickness of the deposited aluminum is sufficient for the absorption of the RF waves. This area certainly requires some development.
c. Electronic Applications: Pattern metallizing can be used to create electronic circuits on flexible films. Applications, where currently conductive inks are being used may be convertible to pattern metallizing. Here again some development may be necessary, as different metals such as copper may be required.

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