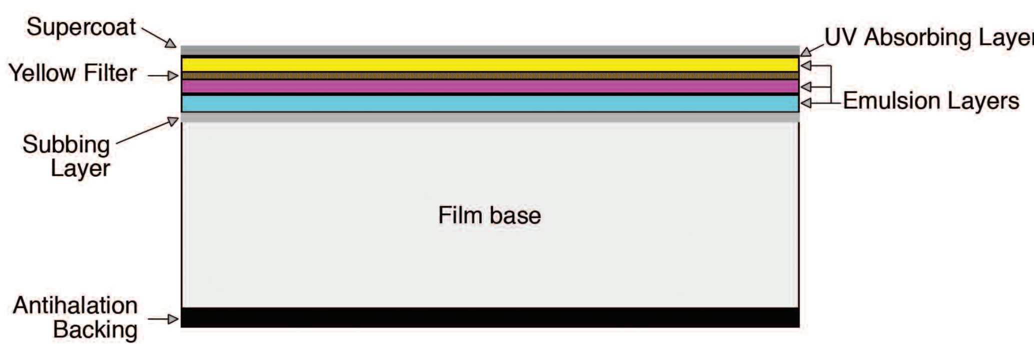
FILM STRUCTURE

What is motion picture film? The American National Standards Institute (ANSI) describes it as “a thick flexible strip of plastic, complying with a dimensional standard as defined within, whose use is specific to the process of manufacturing a motion picture.” That definition leads to about a dozen pages of further definitions about various aspects of motion picture film. For our purposes, let’s take a look at how film is made, and how an image is formed on that film.

THE STRUCTURE OF FILM

Film is made up of layers, and it’s the combination of these layers that give each film its character. Motion picture film consists of a transparent support film base, a light-sensitive emulsion, and a number of layers coated on both sides. Some layers are different from those coated on still film and are designed to help motion picture film travel smoothly through the camera.



Film Base

The supporting layer in film is called the base. This base has to be transparent (with some optical density), free from imperfections, chemically stable, insensitive photographically, and resistant to moisture and processing chemicals, while remaining mechanically strong, resistant to tearing, flexible, and dimensionally stable.

Three plastics have been widely used as a motion picture film base:

- Cellulose nitrate was the first material used. Discontinued in the 1950s because it was highly flammable, cellulose nitrate is chemically unstable if stored in conditions that are too damp (it can decompose) or too hot (it can self-ignite).

- Cellulose acetates were developed to replace nitrate. Cellulose triacetate, called safety base, is much safer to use and store than nitrate. Most current KODAK and EASTMAN Motion Picture Films are coated on a cellulose triacetate base.

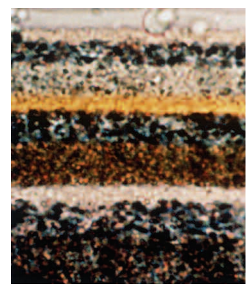
- Polyester base is used for all print films, most duplicating films, and some specialty films. Polyester is stronger and wears better than triacetate. Polyester’s storage life is up to ten times that of acetate. ESTAR Base, a polyethylene terephthalate polyester, is used for some KODAK and EASTMAN Motion Picture Films (usually intermediate and print films) because of its high strength, chemical stability, toughness, tear resistance, flexibility, and dimensional stability. The greater strength of ESTAR Base permits the manufacture of thinner films that require less storage room. ESTAR Base films and other polyester base films cannot be successfully spliced with readily available commercial film cements.

These films are spliced with a tape splicer or with a splicer that uses an ultrasonic or an inductive heating current to melt and fuse the film ends.

Emulsion

The most fundamental layer in a film is the emulsion layer(s), adhered to the base by means of a binder. The emulsion is the photographic part of the film, and as noted from ANSI, "consists of dispersions of light-sensitive materials in a colloidal medium, usually gelatin, carried as a thin layer(s) on a film base." Emulsion is made by dissolving silver bullion in nitric acid to form silver-nitrate crystals. These crystals are dissolved and mixed with other chemicals to form silver-halide grains, and then suspended in the gelatin emulsion coating. The size and degree of light sensitivity of these grains determines the speed or amount of light required to register an image. The faster the film, the greater the apparent "graininess" of the image.

> In 1991, The Motion Picture and Television Imaging division of Eastman Kodak Company received an OSCAR from the Academy of Motion Picture Arts and Sciences for incorporating KODAK T-GRAIN® Emulsion Technology into motion picture films. This term, now familiar among all types of film, describes flat silver crystals that capture more light without an increase in size.



In color films, three dye layers register various parts of the color, one on top of another, for the full color effect—in cyan, magenta, and yellow dyes. In fact, each color may have up to three layers (fast, medium, and slow) to capture the full range of scene brightness—from the deepest shadows to the brightest highlights—and to provide good exposure latitude. The three components also optimize the color, contrast, and tonal reproduction of film.

In each emulsion layer, color couplers are dispersed in tiny oil droplets around silver halide crystals. When the developing agent reaches the sensitized silver grain, oxidized developer is formed after donating electrons to the silver halide. The oxidized developer combines with the coupler molecule to form a colored dye. During subsequent processing steps, the silver is removed, leaving only colored dyeclouds where film grains used to be.

There are three types of color couplers, one for each of the color emulsion layers. Each color coupler forms a dye of one of the three subtractive primary colors and is located in a layer that is sensitive to light of its complementary color:

- A yellow-dye-forming coupler is located in the blue-sensitive emulsion layer
- A magenta-dye-forming coupler is located in the green-sensitive layer
- A cyan-dye-forming coupler is located in the red-sensitive layer

Subbing Layer

The subbing layer is applied to the film base so that the emulsion adheres to the base.

Ultraviolet Absorbing Layer

Although we can't see ultraviolet (UV) radiation, photosensitive silver halide crystals can be exposed by it. An ultraviolet absorbing layer is included to protect the imaging layers from exposure by UV radiation.

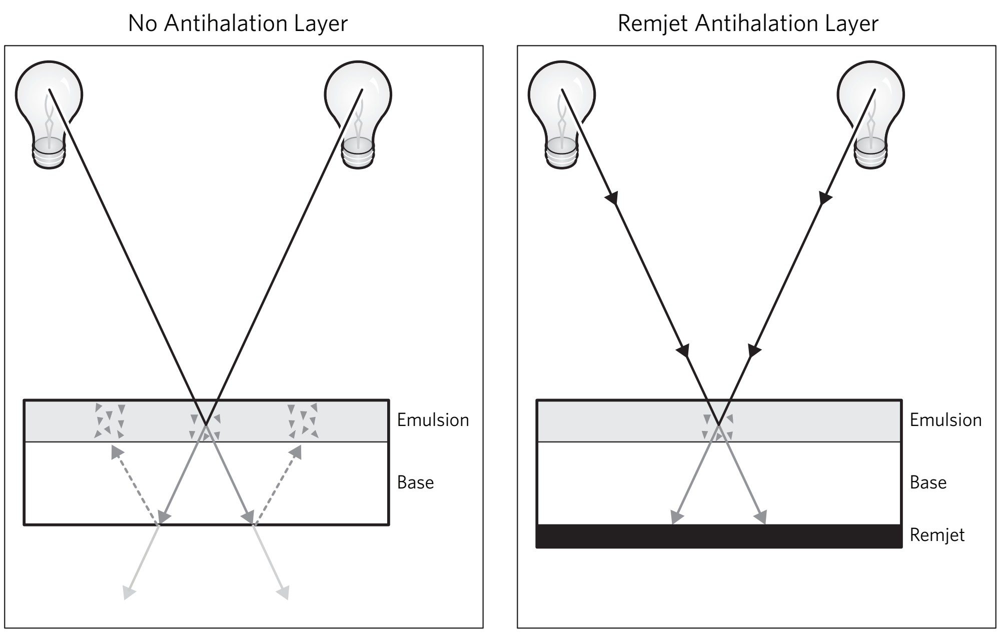
Supercoat

The top layer of the film is the supercoat. The purpose of this clear layer of hardened gelatin is to protect the emulsion from damage during transport through the camera.

Antihalation Backing

Finally, film may have what's called an anti-halation layer.

Light penetrating the emulsion of a film can reflect from the base-emulsion interface back into the emulsion, causing a secondary exposure around images of bright objects. This secondary image (halation) causes an undesirable reduction in the sharpness of the image and some light scattering. An antihalation layer, a dark coating on or in the film base, will absorb and minimize this reflection.



Three antihalation methods are commonly used:

- Remjet, a removable jet black layer, is the coating of carbon black particles in a water-soluble binder on the bottom of the film. It has four purposes: antihalation, antistatic, lubrication, and scratch protection. The remjet carbon layer is also conductive and prevents the build-up and discharge of static charges that can fog film. This is especially important in low relative humidity environments. Remjet also has lubricating properties. Like the supercoat on top of the emulsion, remjet resists scratching on the base side and helps transport the film through cameras, scanners, and printers.

Because remjet is black, it must be removed before the image can be seen. Remjet is removed during the first stage of processing, before the developer.

- Antihalation undercoating, a silver or dyed gelatin layer directly beneath the emulsion, is used on some thin emulsion films. Any color in this layer is removed during processing. This type of layer is particularly effective in preventing halation for high resolution emulsions. An antistatic and/or anticurl layer may be coated on the back of the film base when this type of antihalation layer is used.

- Dyed film base serves to reduce halation and prevent light piping. Film base, especially polyester, can transmit or pipe light that strikes the edge of the film and result in fog. A neutral-density dye is incorporated in some film bases to mitigate this effect. Dye density may vary from a barely detectable level to approximately 0.2. Higher levels are primarily used for halation protection in black-and-white negative films on cellulose bases. Unlike fog, the gray dye doesn't reduce the density range of an image; it adds the same density to all areas just as a neutral-density filter would. It has, therefore, a negligible effect on picture quality.

HOW IMAGES ARE FORMED ON FILM

The most vital components of film are the silver halide crystals. During camera or printer exposure to light, photons are absorbed by the silver halide crystals and form a "latent" or hidden image. The latent images are not visible to the human eye. They become visible during processing.

The latent image consists of a cluster of a minimum of four metallic silver atoms in the silver halide crystal structure. The presence of these silver atoms makes the whole crystal capable of being developed. Without them, the crystal will not develop.

Chemical development of the exposed crystals converts them to 100% silver, providing a huge amplification of the latent image.

In order to differentiate between tones of deep shadows all the way to bright highlights in the film image, various sizes of silver halide crystals are used. The smallest are the least sensitive and can only record the brightest highlights. The largest crystals are the most sensitive and can record the deepest shadows.

“The way I see it, we’re dealing with art. There’s a certain kind of sensation you want an audience to feel when they watch your movie. … I see the choice of media more as an aesthetic and creative choice that eventually lends itself to certain economic aspects. I choose to invest in the look.”

—Lemore Syvan, Independent Producer