

3D Formats

3D programming is typically transmitted by your video provider--i.e. via cable, satellite, telco--in one of two formats: Side-by-Side or Top-and-Bottom. The electronics in your 3D HDTV should detect the *format* and converts it into full-screen left and right images for viewing with 3D eyewear. However, some do not, and in that case, it may be helpful to understand formats so you can make the appropriate selection on your television.

3D formats are compatible with existing video standards. If you come across a channel on your 2D television that has a split picture, you are viewing a 3D channel. If you have a 3D HDTV, select the appropriate 3D *format* (ie. Top-and-Bottom or Side-by-Side) grab your glasses and enjoy the show!

Side-by-Side 3D Format

Side-by-side is another 3D transmission format. Side-by-side preserves vertical image resolution, but cuts horizontal image resolution in half, as the left eye and right eye images are squeezed to fit into one video frame. The TV converts these squeezed frames back into sequential full frames of left and right eye video.

Side by Side



Top-and-Bottom 3D Format

Top-and-Bottom is a transmission *format* for 3D video streams. In a top/bottom 3D image, both the left eye and right eye information occupy the same video frame, with left eye information on top and right eye information below. The vertical resolution of each frame is decreased, but the horizontal resolution remains constant.

Top/Bottom



Both Top-and-Bottom and Side-by-Side are both referred to as *Frame Compatible* .

SENSIO Hi-Fi 3D Format

SENSIO® Hi-Fi 3D is another 3D frame-compatible transmission format. Based on quincunx subsampling, SENSIO® Hi-Fi 3D preserves both vertical and horizontal image resolution by reconstructing the source images using a decoder in the 3DTV. The resulting 3D image is very close to the originally-captured one.

Blu-ray 3D Format

You may be asking yourself, 'what is the difference between the signal coming from my provider, and that coming from my Blu-ray player?' The Blu-ray 3D *format* is two full resolution 1920x1080p images, plus a small buffer of dark pixels to separate them.

So one full frame of video delivered from a 3D *Blu-ray disc* is twice as large as the two formats described above, providing double the resolution. 3D broadcasts (over cable, satellite or via antenna) will, over time, migrate to this higher resolution picture. However, today this

high resolution *format* requires clearer standards and more bandwidth than broadcasters are able to devote to it.

A **3D** or **3-D** (**three-dimensional**) **film** or **S3D** (**stereoscopic 3D**) **film** is a [motion picture](#) that enhances the [illusion](#) of [depth perception](#). Derived from [stereoscopic](#) photography, a regular motion picture camera system is used to record the images as seen from two perspectives (or [computer-generated imagery](#) generates the two perspectives in [post-production](#)), and special projection hardware and/or eyewear are used to provide the illusion of depth when viewing the film. 3D films are not limited to [feature film](#) theatrical releases; [television broadcasts](#) and [direct-to-video](#) films have also incorporated similar methods, especially since [3D television](#) and [Blu-ray 3D](#).

3D films have existed in some form since 1915, but had been largely relegated to a niche in the motion picture industry because of the costly hardware and processes required to produce and display a 3D film, and the lack of a standardized format for all segments of the entertainment business. Nonetheless, 3D films were prominently featured in the 1950s in American cinema, and later experienced a worldwide resurgence in the 1980s and 1990s driven by [IMAX](#) high-end theaters and [Disney](#) themed-venues. 3D films became more and more successful throughout the 2000s, culminating in the unprecedented success of 3D presentations of [Avatar](#) in December 2009 and January 2010.

Timeline

Early patents and tests

The stereoscopic era of motion pictures began in the late 1890s when British film pioneer [William Friese-Greene](#) filed a [patent](#) for a 3D movie process. In his patent, two films were projected side by side on screen. The viewer looked through a [stereoscope](#) to converge the two images. Because of the obtrusive mechanics behind this method, theatrical use was not practical. [Frederic Eugene Ives](#) patented his stereo camera rig in 1900. The camera had two lenses coupled together 1 3/4 inches (4.45 centimeters) apart.

On June 10, 1915, [Edwin S. Porter](#) and William E. Waddell presented tests to an audience at the Astor Theater in New York City. In red-green [anaglyph](#), the audience was presented three reels of tests, which included rural scenes, test shots of [Marie Doro](#), a segment of [John Mason](#) playing a number of passages from [Jim the Penman](#) (a film released by [Famous Players-Lasky](#) that year, but not in 3D), Oriental dancers, and a reel of footage of [Niagara Falls](#). However, according to [Adolph Zukor](#) in his 1953 [autobiography](#) *The Public Is Never Wrong: My 50 Years in the Motion Picture Industry*, nothing was produced in this process after these tests.

Early systems of stereoscopic filmmaking (pre-1952)

The earliest confirmed 3D film shown to a paying audience was [The Power of Love](#), which premiered at the [Ambassador Hotel](#) Theater in Los Angeles on 27 September 1922. The camera rig was a product of the film's producer, Harry K. Fairall, and [cinematographer](#) Robert F. Elder. It was projected dual-strip in the red/green anaglyph format, making it both the earliest known film that utilized dual strip projection and the earliest known film in which anaglyph glasses were used. Whether Fairall used colored filters on the projection ports or

whether he used [tinted](#) prints is unknown. After a preview for exhibitors and press in New York City, the film dropped out of sight, apparently not booked by exhibitors, and is now considered [lost](#).

Early in December 1922, William Van Doren Kelley, inventor of the [Prizma](#) color system, cashed in on the growing interest in 3D films started by Fairall's demonstration and shot footage with a camera system of his own design. Kelley then struck a deal with [Samuel "Roxy" Rothafel](#) to premiere the first in his series of "Plasticon" shorts entitled *Movies of the Future* at the Rivoli Theater in New York City .

Also in December 1922, [Laurens Hammond](#) (later inventor of the [Hammond organ](#)) and William F. Cassidy unveiled their [Teleview](#) system. Teleview was the earliest alternate-frame sequencing form of [film projection](#). Through the use of two interlocked projectors, alternating left/right frames were projected one after another in rapid succession. Synchronized viewers attached to the arm-rests of the seats in the theater open and closed at the same time, and took advantage of the viewer's [persistence of vision](#), thereby creating a true stereoscopic image. The only theater known to have installed this system was the Selwyn Theater in New York. Only one show was ever produced for the system, a groups of shorts and the only Teleview feature [The Man From M.A.R.S.](#) (later re-released as *Radio-Mania*) on December 27, 1922 in New York City.

In 1922, [Frederic Eugene Ives](#) and Jacob Leventhal began releasing their first stereoscopic shorts made over a three-year period. The first film entitled, *Plastigrams*, which was distributed nationally by [Educational Pictures](#) in the red/blue anaglyph format. Ives and Leventhal then went on to produce the following stereoscopic shorts in the "Stereoscopiks Series" for [Pathé Films](#) in 1925: *Zowie* (April 10), *Luna-cy!* (May 18), *The Run-Away Taxi* (December 17) and *Ouch* (December 17). On 22 September 1924, *Luna-cy!* was re-released in the [DeForest Phonofilm](#) sound-on-film system.

The late 1920s to early 1930s saw little to no interest in stereoscopic pictures, largely due to the [Great Depression](#). In Paris, [Louis Lumiere](#) shot footage with his stereoscopic camera in September 1933. The following March he premiered a remake of his 1895 film *L'Arrivée du Train*, this time in anaglyphic 3D, at a meeting of the French Academy of Science.

In 1936, Leventhal and John Norling were hired based on their test footage to film MGM's *Audioscopiks* series. The prints were by [Technicolor](#) in the red/green anaglyph format, and were narrated by [Pete Smith](#). The first film, *Audioscopiks*, premiered January 11, 1936 and *The New Audioscopiks* premiered January 15, 1938. *Audioscopiks* was nominated for the Academy Award in the category [Best Short Subject, Novelty](#) in 1936.

With the success of the two Audioscopiks films, MGM produced one more short in anaglyph 3D, another Pete Smith Specialty called [Third Dimensional Murder](#) (1941). Unlike its predecessors, this short was shot with a studio-built camera rig. Prints were by Technicolor in red/blue anaglyph. The short is notable for being one of the few live-action appearances of the Frankenstein Monster as conceived by [Jack Pierce](#) for [Universal Studios](#) outside of their company.

While many of these films were printed by color systems, none of them was actually in color, and the use of the color printing was only to achieve an anaglyph effect.

Introduction of Polaroid

While attending [Harvard University](#), [Edwin H. Land](#) conceived the idea of reducing [glare](#) by [polarizing light](#). He took a [leave of absence](#) from Harvard to set up a lab and by 1929 had invented and patented a polarizing sheet. In 1932, he introduced **Polaroid J Sheet** as a commercial product. While his original intention was to create a filter for reducing glare from car headlights, Land did not underestimate the utility of his newly-dubbed [Polaroid filters](#) in stereoscopic presentations.

In January 1936, Land gave the first demonstration of Polaroid filters in conjunction with 3D photography at the [Waldorf-Astoria Hotel](#). The reaction was enthusiastic, and he followed it up with an installation at the New York Museum of Science. It is unknown what film was run for audiences at this exhibition.

Using Polaroid filters meant an entirely new form of projection, however. Two prints, each carrying either the right or left eye view, had to be synced up in projection using an external [selsyn](#) motor. Furthermore, polarized light would be largely depolarized by a matte white screen, and only a [silver screen](#) or screen made of other reflective material would correctly reflect the separate images.

Later that year, the feature, *Nozze Vagabonde* appeared in Italy, followed in Germany by *Zum Greifen Nah (You Can Nearly Touch It)*, and again in 1939 with Germany's *Sechs Mädel Rollen Ins Wochenende (Six Girls Drive Into the Weekend)*. The Italian film was made with the Gualtierotti camera; the two German productions with the Zeiss camera and the Vierling shooting system. All of these films were the first exhibited using Polaroid filters. The [Zeiss Company](#) in Germany manufactured glasses on a commercial basis commencing in 1936; they were also independently made around the same time in Germany by E. Käsemann and by J. Mahler.

In 1939, John Norling shot *In Tune With Tomorrow*, the first commercial 3D film using Polaroid in the US. This short premiered at the [1939 New York World's Fair](#) and was created specifically for the Chrysler Motors Pavilion. In it, a full 1939 Chrysler Plymouth is magically put together, set to music. Originally in black and white, the film was so popular that it was re-shot in color for the following year at the fair, under the title *New Dimensions*. In 1953, it was reissued by RKO as *Motor Rhythm*.

Another early short that utilized the Polaroid 3D process was 1940's [Magic Movies: Thrills For You](#) produced by the [Pennsylvania Railroad](#) Co. for the [Golden Gate International Exposition](#). Produced by John Norling, it was filmed by Jacob Leventhal using his own rig. It consisted of shots of various views that could be seen from the Pennsylvania Railroad's trains.

In the 1940s, World War II prioritized military applications of stereoscopic photography and it once again went on the back burner in most producers' minds.

The "golden era" (1952–1955)

What aficionados consider the "golden era" of 3D began in 1952 with the release of the first color stereoscopic feature, *Bwana Devil*, produced, written and directed by [Arch Oboler](#). The film was shot in *Natural Vision*, a process that was co-created and controlled by M. L.

Gunzberg. Gunzberg, who built the rig with his brother, Julian, and two other associates, shopped it without success to various studios before Oboler used it for this feature, which went into production with the title, *The Lions of Gulu*. The film starred [Robert Stack](#), [Barbara Britton](#) and [Nigel Bruce](#).

As with practically all of the features made during this boom, *Bwana Devil* was projected dual-strip, with [Polaroid filters](#). During the 1950s, the familiar disposable anaglyph [glasses](#) made of cardboard were mainly used for comic books, two shorts by exploitation specialist [Dan Sonney](#), and three shorts produced by [Lippert Productions](#). However, even the Lippert shorts were available in the dual-strip format alternatively.

Because the features utilized two projectors, a capacity limit of film being loaded onto each projector (about 6,000 feet (1,800 m), or an hour's worth of film) meant that an intermission was necessary for every feature-length film. Quite often, intermission points were written into the script at a major plot point.

During Christmas of 1952, producer [Sol Lesser](#) quickly premiered the dual-strip showcase called *Stereo Techniques* in Chicago. Lesser acquired the rights to five dual-strip shorts. Two of them, *Now is the Time (to Put On Your Glasses)* and *Around is Around*, were directed by [Norman McLaren](#) in 1951 for the [National Film Board of Canada](#). The other three films were produced in Britain for [Festival of Britain](#) in 1951 by Raymond Spottiswoode. These were *A Solid Explanation*, *Royal River*, and *The Black Swan*.

James Mage was also an early pioneer in the 3D craze. Using his 16 mm 3D Bolex system, he premiered his *Triorama* program on February 10, 1953 with his four shorts: *Sunday In Stereo*, *Indian Summer*, *American Life*, and *This is Bolex Stereo*. This show is considered lost.

Another early 3D film during the boom was the Lippert Productions short, *A Day in the Country*, narrated by [Joe Besser](#) and composed mostly of test footage. Unlike all of the other Lippert shorts, which were available in both dual-strip and anaglyph, this production was released in anaglyph only.

April 1953 saw two groundbreaking features in 3D: [Columbia's *Man in the Dark*](#) and [Warner Bros. *House of Wax*](#), the first 3D feature with [stereophonic sound](#). *House of Wax*, outside of [Cinerama](#), was the first time many American audiences heard recorded stereophonic sound. It was also the film that typecast [Vincent Price](#) as a horror star as well as the "King of 3-D" after he became the actor to star in the most 3D features (the others were [The Mad Magician](#), [Dangerous Mission](#), and [Son of Sinbad](#)). The success of these two films proved that major studios now had a method of getting moviegoers back into theaters and away from television sets, which were causing a steady decline in attendance.

[The Walt Disney Studios](#) waded into 3D with its May 28, 1953 release of [Melody](#), which accompanied the first 3D western, Columbia's *Fort Ti* at its Los Angeles opening. It was later shown at [Disneyland's](#) Fantasyland Theater in 1957 as part of a program with Disney's other short [Working for Peanuts](#), entitled, *3-D Jamboree*. The show was hosted by the [Mousketeers](#) and was in color.

[Universal-International](#) released their first 3D feature on May 27, 1953, *It Came from Outer Space*, with stereophonic sound. Following that was Paramount's first feature, *Sangaree* with [Fernando Lamas](#) and [Arlene Dahl](#).

Columbia released several 3D westerns produced by [Sam Katzman](#) and directed by [William Castle](#). Castle would later specialize in various technical in-theater gimmicks for such Columbia and Allied Artists features as *13 Ghosts*, *House on Haunted Hill*, and *The Tingler*. Columbia also produced the only slapstick comedies conceived for 3D. [The Three Stooges](#) starred in *Spooks* and *Pardon My Backfire*; dialect comic Harry Mimmo starred in *Down the Hatch*. Producer [Jules White](#) was optimistic about the possibilities of 3D as applied to slapstick (with pies and other projectiles aimed at the audience), but only two of his stereoscopic shorts were shown in 3D. *Down the Hatch* was released as a conventional, "flat" motion picture. (Columbia has since printed *Down the Hatch* in 3D for film festivals.)

[John Ireland](#), [Joanne Dru](#) and [Macdonald Carey](#) starred in the [Jack Broder](#) color production *Hannah Lee*, which premiered June 19, 1953. The film was directed by Ireland, who sued Broder for his salary. Broder counter-sued, claiming that Ireland went over production costs with the film.

Another famous entry in the golden era of 3D was the 3 Dimensional Pictures production of *Robot Monster*. The film was allegedly scribed in an hour by screenwriter Wyatt Ordung and filmed in a period of two weeks on a shoestring budget. Despite these shortcomings and the fact that the crew had no previous experience with the newly-built camera rig, luck was on the [cinematographer](#)'s side, as many find the 3D photography in the film is well shot and aligned. *Robot Monster* also has a notable score by then up-and-coming composer [Elmer Bernstein](#). The film was released June 24, 1953 and went out with the short *Stardust in Your Eyes*, which starred nightclub comedian, Slick Slavin. ^{[[citation needed](#)]}

[20th Century Fox](#) produced their only 3D feature, *Inferno* in 1953, starring [Rhonda Fleming](#). Fleming, who also starred in *Those Redheads From Seattle*, and *Jivaro*, shares the spot for being the actress to appear in the most 3D features with Patricia Medina, who starred in *Sangaree*, *Phantom of the Rue Morgue* and *Drums of Tahiti*. [Darryl F. Zanuck](#) expressed little interest in stereoscopic systems, and at that point was preparing to premiere the new widescreen film system, [CinemaScope](#).

The first decline in the theatrical 3D craze started in August and September 1953. The factors causing this decline were:

- Two prints had to be projected simultaneously.
- The prints had to remain exactly alike after repair, or synchronization would be lost.
- It sometimes required two projectionists to keep sync working properly.
- When either prints or shutters became out of sync, the picture became virtually unwatchable and accounted for headaches and eyestrain.
- The necessary silver projection screen was very directional and caused sideline seating to be unusable with both 3D and regular films, due to the angular darkening of these screens. Later films that opened in wider-seated venues often premiered flat for that reason (such as *Kiss Me Kate* at the [Radio City Music Hall](#)).
- The few cartoons made in 3D had a "cardboard cutout" effect, where flat objects appeared on different planes.

Because projection booth operators were at many times careless, even at preview screenings of 3D films, trade and newspaper critics claimed that certain films were "hard on the eyes."

Sol Lesser attempted to follow up *Stereo Techniques* with a new showcase, this time five shorts that he himself produced. The project was to be called *The 3-D Follies* and was to be distributed by RKO. Unfortunately, because of financial difficulties and the growing disinterest in 3D, Lesser canceled the project during the summer of 1953, making it the first 3D film to be aborted in production. Two of the three shorts were shot: *Carmenesque*, a burlesque number starring exotic dancer [Lili St. Cyr](#), and *Fun in the Sun*, a sports short directed by famed set designer/director [William Cameron Menzies](#), who also directed the 3D feature *The Maze* for Allied Artists.

Although it was more expensive to install, the major competing realism process was [anamorphic](#), first utilized by Fox with [Cinemascope](#) and its September premiere in *The Robe*. [Anamorphic](#) features needed only a single print, so synchronization was not an issue. Cinerama was also a competitor from the start and had better quality control than 3D because it was owned by one company that focused on quality control. However, most of the 3D features past the summer of 1953 were released in the flat [widescreen](#) formats ranging from 1.66:1 to 1.85:1. In early studio advertisements and articles about widescreen and 3D formats, widescreen systems were referred to as "3D", causing some confusion among scholars.

There was no single instance of combining Cinemascope with 3D until 1960, with a film called *September Storm*, and even then, that was a blow-up from a non-anamorphic negative. *September Storm* also went out with the last dual-strip short, *Space Attack*, which was actually shot in 1954 under the title *The Adventures of Sam Space*.

In December 1953, 3D made a comeback with the release of several important 3D films, including MGM's musical *Kiss Me, Kate*. *Kate* was the hill over which 3D had to pass to survive. MGM tested it in six theaters: three in 3D and three flat. According to trade ads of the time, the 3D version was so well-received that the film quickly went into a wide stereoscopic release. However, most publications, including [Kenneth Macgowan](#)'s classic film reference book *Behind the Screen*, state that the film did much better as a "regular" release. The film, adapted from the popular [Cole Porter Broadway](#) musical, starred the MGM songbird team of [Howard Keel](#) and [Kathryn Grayson](#) as the leads, supported by [Ann Miller](#), [Keenan Wynn](#), [Bobby Van](#), [James Whitmore](#), Kurt Kaszner and [Tommy Rall](#). The film also prominently promoted its use of stereophonic sound.

Several other features that helped put 3D back on the map that month were the John Wayne feature *Hondo* (distributed by Warner Bros.), Columbia's *Miss Sadie Thompson* with [Rita Hayworth](#), and Paramount's *Money From Home* with [Dean Martin](#) and [Jerry Lewis](#). Paramount also released the cartoon shorts *Boo Moon* with [Casper, the Friendly Ghost](#) and *Popeye, Ace of Space* with [Popeye the Sailor](#). [Paramount Pictures](#) released a 3D [Korean War](#) film *Cease Fire* filmed on actual Korean locations in 1953.

Top Banana, based on the popular [stage musical](#) with [Phil Silvers](#), was brought to the screen with the original cast. Although it was merely a filmed stage production, the idea was that every audience member would feel they would have the best seat in the house through color photography and 3D. Although the film was shot and edited in 3D, [United Artists](#), the distributor, felt the production was uneconomical in stereoscopic form and released the film

flat on January 27, 1954. It remains one of two "Golden era" 3-D features, along with another United Artists feature, *Southwest Passage* (with John Ireland and Joanne Dru), that are currently considered lost (although flat versions survive).

A string of successful 3D movies followed the second wave. Some highlights are:

- [The French Line](#), starring [Jane Russell](#) and [Gilbert Roland](#), a [Howard Hughes](#)/RKO production. The film became notorious for being released without an MPAA seal of approval, after several suggestive lyrics were included, as well as one of Ms. Russell's particularly revealing costumes. Playing up her sex appeal, one tagline for the film was, "It'll knock *both* of your eyes out!" The film was later cut and approved by the MPAA for a general flat release, despite having a wide and profitable 3D release.
- [Taza, Son of Cochise](#), a sequel to 1950s [Broken Arrow](#), which starred [Rock Hudson](#) in the title role, Barbara Rush as the love interest, and [Rex Reason](#) (billed as Bart Roberts) as his renegade brother, released through Universal-International. It was directed by the great stylist [Douglas Sirk](#), and his striking visual sense made the film a huge success when it was "re-premiered" in 2006 at the Second 3D Expo in Hollywood.
- Two ape films: *Phantom of the Rue Morgue*, featuring [Karl Malden](#) and Patricia Medina, and produced by Warner Bros. and based on [Edgar Allan Poe](#)'s "[The Murders in the Rue Morgue](#)", and [Gorilla At Large](#), a Panoramic Production starring [Cameron Mitchell](#), distributed through Fox.
- [Creature from the Black Lagoon](#), starring [Richard Carlson](#) and [Julie Adams](#), directed by [Jack Arnold](#). Arguably the most famous 3D movie, and the only 3D feature that spawned a sequel, [Revenge of the Creature](#) in 3D (followed by another sequel, *The Creature Walks Among Us*, shot flat).
- [Cat-Women of the Moon](#), an [Astor Picture](#) starring [Victor Jory](#) and [Marie Windsor](#). Elmer Bernstein composed the score.
- [Dial M for Murder](#), directed by [Alfred Hitchcock](#) and starring [Ray Milland](#), [Robert Cummings](#), and [Grace Kelly](#), is considered by aficionados of 3D to be one of the best examples of the process. Although available in 3D in 1954, there are no known playdates in 3D, since Warner Bros. had just instated a simultaneous 3D/2D release policy. The film's screening in 3D in February 1980 at the York Theater in San Francisco did so well that Warner Bros. re-released the film in 3D in February 1982.
- [Gog](#), an [Ivan Tors](#) production, dealing with realistic science fiction. The second film in Tors' "Office of Scientific Investigation" trilogy of film, which included, *The Magnetic Monster* and *Riders to the Stars*.
- *The Diamond Wizard*, the only stereoscopic feature shot in Britain, released flat in both the UK and US. It starred and was directed by [Dennis O'Keefe](#).
- [Irwin Allen's Dangerous Mission](#) released by RKO in 1954 featuring Allen's trademarks of an all star cast facing a disaster (a forest fire).
- *Son of Sinbad*, another RKO/Howard Hughes production, starring [Dale Robertson](#), Lili St. Cyr, and Vincent Price. The film was shelved after Hughes ran into difficulty with *The French Line*, and wasn't released until 1955, at which time it went out flat, converted to the SuperScope process.

3D's final decline was in the late spring of 1954, for the same reasons as the previous lull, as well as the further success of widescreen formats with theater operators. Even though [Polaroid](#) had created a well-designed "Tell-Tale Filter Kit" for the purpose of recognizing and adjusting out of sync and phase 3D, exhibitors still felt uncomfortable with the system and turned their focus instead to processes such as [CinemaScope](#). The last 3D feature to be

released in that format during the "Golden era" was [Revenge of the Creature](#), on February 23, 1955. Ironically, the film had a wide release in 3D and was well received at the box office.

Revival (1960–1984) in single strip format

Stereoscopic films largely remained dormant for the first part of the 1960s, with those that were released usually being anaglyph exploitation films. One film of notoriety was the Beaver-Champion/Warner Bros. production, [The Mask](#) (1961). The film was shot in 2-D, but to enhance the bizarre qualities of the dream-world that is induced when the main character puts on a cursed tribal mask, these scenes went to anaglyph 3D. These scenes were printed by Technicolor on their first run in red/green anaglyph.

Although 3D films appeared sparsely during the early 1960s, the true second wave of 3D cinema was set into motion by Arch Oboler, the same producer who started the craze of the 1950s. Using a new technology called *Space-Vision 3D*, stereoscopic films were printed with two images, one above the other, in a single academy ratio frame, on a single strip, and needed only one projector fitted with a special lens. This so-called "over and under" technique eliminated the need for dual projector set-ups, and produced widescreen, but darker, less vivid, polarized 3D images. Unlike earlier dual system, it could stay in perfect synchronization, unless improperly spliced in repair.

Arch Oboler once again had the vision for the system that no one else would touch, and put it to use on his film entitled *The Bubble*, which starred [Michael Cole](#), [Deborah Walley](#), and [Johnny Desmond](#). As with *Bwana Devil*, the critics panned *The Bubble*, but audiences flocked to see it, and it became financially sound enough to promote the use of the system to other studios, particularly independents, who did not have the money for expensive dual-strip prints of their productions.

In 1970, [Stereovision](#), a new entity founded by director/inventor Allan Silliphant and optical designer [Chris Condon](#), developed a different 35 mm single-strip format, which printed two images squeezed side-by-side and used an anamorphic lens to widen the pictures through Polaroid filters. Louis K. Sher (Sherpix) and Stereovision released the softcore sex comedy [The Stewardesses](#) (self-rated X, but later re-rated R by the MPAA). The film cost \$100,000 USD to produce, and ran for months in several markets. eventually earning \$27 million in North America, alone (\$140 million in constant-2010 dollars) in fewer than 800 theaters, becoming the most profitable 3-Dimensional film to date, and in purely relative terms, one of the most profitable films ever. It was later released in 70 mm 3D. Some 36 films worldwide were made with Stereovision over 25 years, using either a widescreen (above-below), anamorphic (side by side) or 70 mm 3D formats. In 2009 *The Stewardesses* was remastered by Chris Condon and director Ed Meyer, releasing it in [XpanD 3D](#), [RealD Cinema](#) and [Dolby 3D](#).

The quality of the 1970s 3D films was not much more inventive, as many were either softcore and even hardcore adult films, horror films, or a combination of both. Paul Morrissey's [Flesh For Frankenstein](#) (aka *Andy Warhol's Frankenstein*) was a superlative example of such a combination.

Between 1981 and 1983 there was a new Hollywood 3D craze started by the spaghetti western [Comin' at Ya!](#). When [Parasite](#) was released it was billed as the first horror film to come out in 3D in over 20 years. Horror movies and reissues of 1950s 3D classics (such as

Hitchcock's *Dial 'M' for Murder*) dominated the 3D releases that followed. The second sequel in the [Friday the 13th](#) series, *Friday the 13th Part III*, was released very successfully. Apparently saying "part 3 in 3D" was considered too cumbersome so it was shortened in the titles of [Jaws 3-D](#) and [Amityville 3-D](#), which emphasized off the screen effects to the point of being annoying at times, especially when flashlights were shone into the eyes of the audience.

The science fiction film [Spacehunter: Adventures in the Forbidden Zone](#) was the most expensive 3D movie made up to that point with production costs about the same as [Star Wars](#) but not nearly the same box office success, causing the craze to fade quickly through spring 1983. Other sci-fi/fantasy films were released as well including [Metalstorm: The Destruction of Jared-Syn](#) and [Treasure of the Four Crowns](#), which was widely criticized for poor editing and plot holes, but did feature some truly spectacular closeups.

3D releases after the second craze included [The Man Who Wasn't There](#) (1983), *Silent Madness* and the 1985 animated film [Starchaser: The Legend of Orin](#), whose plot seemed to borrow heavily from *Star Wars* .

Only *Comin' At Ya!*, *Parasite*, and *Friday the 13th Part III* have been officially released on VHS and/or DVD in 3D in the United States (although *Amityville 3D* has seen a 3D DVD release in the United Kingdom). Most of the 1980s 3D movies and some of the classic 1950s movies such as [House of Wax](#) were released on the now defunct Video Disc (VHD) format in Japan as part of a system that used shutter glasses. Most of these have been unofficially transferred to DVD and are available on the [grey market](#) through sites such as eBay.

Rebirth of 3D (1985–2003)

In the mid-1980s, [IMAX](#) began producing non-fiction films for its nascent 3D business, starting with *We Are Born of Stars* ([Roman Kroitor](#), 1985). A key point was that this production, as with all subsequent IMAX productions, emphasized mathematical correctness of the 3D rendition and thus largely eliminated the eye fatigue and pain that resulted from the approximate geometries of previous 3D incarnations. In addition, and in contrast to previous 35mm based 3D presentations, the very large field of view provided by IMAX allowed a much broader 3D "stage", arguably as important in 3D film as it is theatre.

In 1986, [The Walt Disney Company](#) began more prominent use of 3D films in special venues to impress audiences, [Captain Eo](#) ([Francis Ford Coppola](#), 1986) starring [Michael Jackson](#), being a very notable example. In the same year, the [National Film Board of Canada](#) production [Transitions](#) ([Colin Low](#)), created for [Expo 86](#) in Vancouver, was the first IMAX presentation using polarized glasses. *Echoes of the Sun* ([Roman Kroitor](#), 1990) was the first IMAX film to be presented using alternate-eye shutterglass technology, a development required because the dome screen precluded the use of polarized technology.

From 1990 onward, numerous films were produced by all three parties to satisfy the demands of their various high-profile special attractions and [IMAX](#)'s expanding 3D network. Films of special note during this period include the extremely successful *Into the Deep* ([Graeme Ferguson](#), 1995) and the first IMAX 3D fiction film [Wings of Courage](#) (1996), by director [Jean-Jacques Annaud](#), about the pilot [Henri Guillaumet](#).

Other stereoscopic films produced in this period include:

- *The Last Buffalo* ([Stephen Low](#), 1990)
- *Jim Henson's Muppet*Vision 3D* ([Jim Henson](#), 1991)
- *Imagine* (John Weiley, 1993)
- *Honey, I Shrunk the Audience* (Daniel Rustuccio, 1994)
- *Into the Deep* ([Graeme Ferguson](#), 1995)
- *Across the Sea of Time* ([Stephen Low](#), 1995)
- *Wings of Courage* ([Jean-Jacques Annaud](#), 1996)
- *L5, First City in Space* ([Graeme Ferguson](#), 1996)
- *T2 3-D: Battle Across Time* ([James Cameron](#), 1996)
- *Paint Misbehavin* ([Roman Kroitor](#) and Peter Stephenson, 1997)
- *IMAX Nutcracker* (1997)
- *The Hidden Dimension* (1997)
- *T-Rex: Back to the Cretaceous* ([Brett Leonard](#), 1998)
- *Mark Twain's America* ([Stephen Low](#), 1998)
- *Siegfried & Roy: The Magic Box* ([Brett Leonard](#), 1999)
- *Galapagos* (Al Giddings and David Clark, 1999)
- *Encounter in the Third Dimension* ([Ben Stassen](#), 1999)
- *Alien Adventure* ([Ben Stassen](#), 1999)
- *Ultimate G's* (2000)
- *Cyberworld* (Hugh Murray, 2000)
- *Cirque du Soleil: Journey of Man* (Keith Melton, 2000)
- *Haunted Castle* ([Ben Stassen](#), 2001)
- *Space Station 3D* (Toni Myers, 2002)
- *SOS Planet* ([Ben Stassen](#), 2002)
- *Ocean Wonderland* (2003)
- *Falling in Love Again* (Munro Ferguson, 2003)
- *Misadventures in 3D* ([Ben Stassen](#), 2003)

Shortly thereafter, higher quality [computer animation](#), competition from DVDs and other media, digital projection, digital video capture, and the use of sophisticated IMAX 70mm film projectors, created an opportunity for another wave of 3D films.

Mainstream resurgence (2003–present)

In 2003, *Ghosts of the Abyss* by [James Cameron](#) was released as the first full-length 3D IMAX feature filmed with the [Reality Camera System](#). This camera system used the latest HD video cameras, not film, and was built for Cameron by Vince Pace, to his specifications. The same camera system was used to film *Spy Kids 3-D: Game Over* (2003), *Aliens of the Deep* IMAX (2005), and *The Adventures of Sharkboy and Lavagirl in 3-D* (2005).

In 2004, Las Vegas Hilton released *Star Trek: The Experience* which included two films. One of the films, *Borg Invasion 4-D* (Ty Granoroli), was in 3D. In August of the same year, rap group [Insane Clown Posse](#) released their ninth studio album *Hell's Pit*. One of two versions of the album contained a DVD featuring a 3D short film for the track "[Bowling Balls](#)", shot in high-definition video.

In November 2004, *The Polar Express* was released as IMAX's first full-length, animated 3D feature. It was released in 3,584 theaters in 2D, and only 66 IMAX locations. The return from those few 3D theaters was about 25% of the total. The 3D version earned about 14 times as much per screen as the 2D version. This pattern continued and prompted a greatly intensified interest in 3D and 3D presentation of animated films.

In June 2005, the Mann's Chinese 6 theatre in Hollywood became the first commercial movie theatre to be equipped with the Digital 3D format. Both [Singin' in the Rain](#) and [The Polar Express](#) were tested in the Digital 3D format over the course of several months. In November 2005, Walt Disney Studio Entertainment released [Chicken Little](#) in digital 3D format.

[The Butler's in Love](#), a [short film](#) directed by [Anders Laursen](#) and starring [Elizabeth Berkley](#) and [Thomas Jane](#) was released on June 23, 2008. The film was shot at the former [Industrial Light & Magic](#) studios using [KernerFX](#)'s prototype KernerCam stereoscopic camera rig.

Ben Walters suggests that both filmmakers and [film exhibitors](#) regain interest in 3D film. There is now more 3D exhibition equipment, and more dramatic films being shot in 3D format. One incentive is that the technology is more mature. Shooting in 3D format is less limited, and the result is more stable. Another incentive is the fact that while 2D ticket sales are in an overall state of decline, revenues from 3D tickets continue to grow.

Through the entire history of 3D presentations, techniques to [convert](#) existing 2D images for 3D presentation have existed. Few have been effective or survived. The combination of digital and digitized source material with relatively cost-effective [digital post-processing](#) has spawned a new wave of conversion products. In June 2006, [IMAX](#) and [Warner Bros.](#) released [Superman Returns](#) including 20 minutes of 3D images converted from the 2D original digital footage. [George Lucas](#) has announced that he will re-release his [Star Wars](#) films in 3D based on a conversion process from the company In-Three. Later on in 2011, it was announced that Lucas was working with the company Prime Focus on this conversion.

In late 2005, [Steven Spielberg](#) told the press he was involved in patenting a 3D cinema system that does not need glasses, and which is based on plasma screens. A computer splits each film-frame, and then projects the two split images onto the screen at differing angles, to be picked up by tiny angled ridges on the screen.

Animated films [Open Season](#), and [The Ant Bully](#), were released in analog 3D in 2006. [Monster House](#) and [The Nightmare Before Christmas](#) were released on [XpanD 3D](#), [RealD](#) and [Dolby 3D](#) systems in 2006.

On May 19, 2007 [Scar3D](#) opened at the Cannes Film Market. It was the first US-produced 3D full-length feature film to be completed in [Real D 3D](#). It has been the #1 film at the [box office](#) in several countries around the world, including Russia where it opened in 3D on 295 screens.

In 2008 3D films included [Hannah Montana & Miley Cyrus: Best of Both Worlds Concert](#), [Journey to the Center of the Earth](#), and [Bolt](#).

On January 16, 2009, [Lionsgate](#) released [My Bloody Valentine 3D](#), the first horror film and first R-rated film to be projected in [Real D 3D](#). It was released to 1,033 3D screens, the most ever for this format, and 1,501 regular screens. Another R-Rated film, [The Final Destination](#), was released later that year (August 28) to even more screens. It was the first of its [series](#) to be released in HD 3D.

On May 7, 2009 the [British Film Institute](#) commissioned a 3D film installation. The film [Radio Mania: An Abandoned Work](#) consists of two screens of [stereoscopic](#) 3D film with 3D [Ambisonic](#) sound. It stars [Kevin Eldon](#) and is by British artists [Iain Forsyth and Jane Pollard](#).

The first 3D [webisode](#) series was [Horrorween](#) starting September 1, 2009.

Major 3D films in 2009 included [Coraline](#), [Monsters vs. Aliens](#), [Up](#), [X Games 3D: The Movie](#), [The Final Destination](#), and [Avatar](#). *Avatar* has gone on to be one of the most expensive films of all time, with a budget at \$237 million; it is also the highest-grossing film of all time. The main technologies used to exhibit these films, and many others released around the time and up to the present, are [Real D 3D](#), [Dolby 3D](#), [XpanD 3D](#), [MasterImage 3D](#), and [IMAX 3D](#).

March and April 2010 saw three major 3D releases clustered together, with [Alice in Wonderland](#) hitting US theaters on March 5, 2010, [How to Train Your Dragon](#) on March 26, 2010 and [Clash of the Titans](#) on April 2, 2010.

On May 13, 2010, China's first [IMAX 3D](#) film started shooting. The pre-production of the first 3D film shot in France, [Derrière les murs](#), began in May 2010, and it will be released in mid-2011.

On October 1, 2010 [Scar3D](#) was the first-ever stereoscopic 3D [Video-on-demand](#) film released through major cable broadcasters for [3D televisions](#) in the United States.

Released in the United States on May 21, 2010, [Shrek Forever After](#) by [DreamWorks Animation](#) ([Paramount Pictures](#)) used the Real D 3D system, also released in IMAX 3D.

[World 3-D Expositions](#)

In September 2003, Sabucat Productions organized the first World 3-D Exposition, celebrating the 50th anniversary of the original craze. The Expo was held at [Grauman's Egyptian Theatre](#). During the two-week festival, over 30 of the 50 "golden era" stereoscopic features (as well as shorts) were screened, many coming from the collection of film historian and archivist Robert Furmanek, who had spent the previous 15 years painstakingly tracking down and preserving each film to its original glory. In attendance were many stars from each film, respectively, and some were moved to tears by the sold-out seating with audiences of film buffs from all over the world who came to remember their previous glories.

In May 2006, the second World 3-D Exposition was announced for September of that year, presented by the [3-D Film Preservation Fund](#). Along with the favorites of the previous exposition were newly discovered features and shorts, and like the previous Expo, guests from each film. Expo II was announced as being the locale for the world premiere of several films never before seen in 3D, including *The Diamond Wizard* and the Universal short, *Hawaiian Nights* with [Mamie Van Doren](#) and [Pinky Lee](#). Other "re-premieres" of films not seen since their original release in stereoscopic form included *Cease Fire!*, *Taza*, *Son of Cochise*, *Wings of the Hawk*, and *Those Redheads From Seattle*. Also shown were the long-lost shorts *Carmenesque* and *A Day in the Country* (both 1953) and William Van Doren Kelley's two *Plasticon* shorts (1922 and 1923).

[Reported audience decline](#)

In the wake of its initial popularity and corresponding increase in the number of screens, more films are being released in the 3D format. However, industry observers have noted that 2011 showed a considerable decline in audience interest. For instance, only 45% of the

premiere weekend box office earnings of [Kung Fu Panda 2](#) came from 3D screenings as opposed to 60% for [Shrek Forever After](#) in 2010. In addition, the premiere of [Cars 2](#) opening weekend gross consisted of only 37% from 3D theatres. [Harry Potter and the Deathly Hallows – Part 2](#) and [Captain America: The First Avenger](#) were major releases that achieved similar percentages: 43% and 40% respectively. In view of this trend, there has been box office analysis concluding the implementation of 3D presentation is apparently backfiring by discouraging people from going to movie theatres at all. As Brandon Gray of [Box Office Mojo](#) notes, "In each case, 3D's more-money-from-fewer-people approach has simply led to less money from even fewer people."

According to the Motion Picture Association of America, despite a record total of 47 3D movies being released in 2011, the overall domestic box office receipts were down 18% to \$1.8 billion from \$2.2 billion in 2010. Although revenues as a whole increased during 2012, the bulk has so far come from 2D presentations as exemplified by little over 50% of moviegoers opting to see the likes of [The Avengers](#) and 32% choosing [Brave](#) in their 3D versions. Conflicting reasons are respectively offered by studios and exhibitors: whereas the former blame more expensive 3D ticket prices, the latter argue that the quality of movies in general is at fault. However, despite the perceived decline of 3D in the U.S. market, studio chiefs are optimistic of better receipts internationally, where there still appears to be a strong appetite for the format.

Studios are also using 3D to generate additional income from films that are already commercially successful. Such re-releases usually involve a conversion from 2D. For example, Disney has reissued both [The Lion King](#) and [Beauty and the Beast](#), with plans to add some of its other well-known titles. [Titanic](#) has also been modified for 3D, and there are also plans to similarly present all six [Star Wars](#) films.

[Jeffrey Katzenberg](#), one of the leading proponents of 3D film and the producer of some of the most critically acclaimed films in this format, such as [How to Train Your Dragon](#) (RT 98%) and [Kung Fu Panda 2](#) (RT 82%), blames oversaturation of the market with inferior films, especially ones photographed conventionally and then digitally processed in [post-production](#). Examples include [The Last Airbender](#) (RT 6%) and [Cats & Dogs: The Revenge of Kitty Galore](#) (RT 13%), which have led audiences to conclude that the format is not worth the additional expense to see. Daniel Engber, a columnist for [Slate](#), comes to a similar conclusion: "What happened to 3-D? It may have died from a case of acute [septicemia](#)—too much crap in the system." However, at the global box office there are six films whose combined 2D and 3D versions achieved grosses of over \$1 billion each: three in [2011](#), two in [2010](#) and one in [2009](#).

Film critic [Mark Kermode](#), a noted detractor of 3D, has surmised that there is an emerging policy of distributors to limit the availability of 2D versions, thus "railroading" the 3D format into cinemas whether the paying moviegoer likes it or not. This was especially prevalent during the release of [Prometheus](#) in 2012, where only 30% of prints for theatrical exhibition (at least in the UK) were in 2D.^[47] His suspicions were later reinforced by a substantial number of complaints about [Dredd](#) from those who wished to see it in 2D but were denied the opportunity.^[48]

Techniques

Stereoscopic motion pictures can be produced through a variety of different methods. Over the years the popularity of systems being widely employed in movie theaters has waxed and waned. Though [anaglyph](#) was sometimes used prior to 1948, during the early "Golden Era" of 3D cinematography of the 1950s the polarization system was used for every single feature length movie in the United States, and all but one short film. In the 21st century, [polarization](#) 3D systems have continued to dominate the scene, though during the 1960s and 1970s some classic films which were converted to anaglyph for theaters not equipped for polarization, and were even shown in 3D on television. In the years following the mid-1980s, some movies were made with short segments in anaglyph 3D. The following are some of the technical details and methodologies employed in some of the more notable 3D movie systems that have been developed.

Producing 3D films

Live action

The standard for shooting live-action films in 3D involves using two cameras mounted so that their lenses are about as far apart from each other as the average pair of human eyes, recording two separate images for both the left eye and the right eye. In principle, two normal 2D cameras could be put side-to-side but this is problematic in many ways. The only real option is to invest in new stereoscopic cameras. Moreover, some cinematographic tricks that are simple with a 2D camera become impossible when filming in 3D. This means those otherwise cheap tricks need to be replaced by expensive CGI.

In 2008, *Journey to the Center of the Earth* became the first live-action feature film to be shot with the earliest [Fusion Camera System](#) released in Digital 3D and was later followed by several others. *Avatar* (2009) was shot in a 3D process that is based on how the human eye looks at an image. It was an improvement to the existing 3D camera system. Many 3D camera rigs still in use simply pair two cameras side by side, while newer rigs are paired with a [beam splitter](#) or both camera lenses built into one unit. While Digital Cinema cameras are not a requirement for 3D they are the predominant medium for most of what is photographed. Film options include IMAX 3D and [Cine 160](#).

Animation

[CGI](#) animated films can be rendered as stereoscopic 3D version by using two virtual cameras. [Stop-motion](#) 3D films are photographed with two cameras similar to live action 3D films.

In 2004 *The Polar Express* was the first stereoscopic 3D computer-animated feature film. In November 2005, Walt Disney Studio Entertainment released *Chicken Little* in digital 3D format, being Disney's first CGI-animated film in 3D. The first 3D feature by [DreamWorks Animation](#), *Monsters vs Aliens*, followed in 2009 and used a new digital rendering process called [InTru3D](#), which was developed by [Intel](#) to create more realistic animated 3D images. InTru3D is not used to exhibit 3D films in theaters; they are shown in either RealD 3D or IMAX 3D.

2D to 3D conversion

Main article: [2D to 3D conversion](#)

In the case of 2D CGI animated films that were generated from 3D models, it is possible to return to the models to generate a 3D version.

For all other 2D films, different techniques must be employed. For example, for the 3D re-release of the 1993 film *The Nightmare Before Christmas*, Walt Disney Pictures scanned each original frame and manipulated them to produce left-eye and right-eye versions. Dozens of films have now been converted from 2D to 3D. There are several approaches used for [2D to 3D conversion](#), most notably depth-based methods.

Anaglyph

Main article: [Anaglyph 3D](#)



The archetypal 3D glasses, with modern red and cyan color filters, similar to the red/green and red/blue lenses used to view early anaglyph films.

Anaglyph images were the earliest method of presenting theatrical 3D, and the one most commonly associated with [stereoscopy](#) by the public at large, mostly because of non-theatrical 3D media such as comic books and 3D television broadcasts, where polarization is not practical. They were made popular because of the ease of their production and exhibition. The first anaglyph movie was invented in 1915 by [Edwin S Porter](#). Though the earliest theatrical presentations were done with this system, most 3D movies from the 1950s and 1980s were originally shown polarized.

In an anaglyph, the two images are [superimposed](#) in an [additive light](#) setting through two filters, one red and one cyan. In a [subtractive light](#) setting, the two images are printed in the same [complementary colors](#) on white paper. Glasses with colored filters in each eye separate the appropriate images by canceling the filter color out and rendering the complementary color black.

Anaglyph images are much easier to view than either parallel sighting or crossed eye [stereograms](#), although the latter types offer bright and accurate color rendering, particularly in the red component, which is muted, or desaturated with even the best color anaglyphs. A compensating technique, commonly known as Anachrome, uses a slightly more transparent cyan filter in the patented glasses associated with the technique. Process reconfigures the typical anaglyph image to have less [parallax](#).

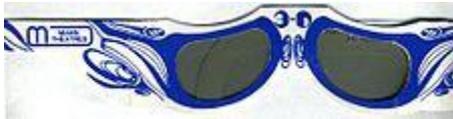
An alternative to the usual red and cyan filter system of anaglyph is [ColorCode 3D](#), a patented anaglyph system which was invented in order to present an anaglyph image in conjunction with the NTSC television standard, in which the red channel is often

compromised. ColorCode uses the complementary colors of yellow and dark blue on-screen, and the colors of the glasses' lenses are amber and dark blue.

The *polarization 3D system* has been the standard for theatrical presentations since it was used for [Bwana Devil](#) in 1952, though early Imax presentations were done using the eclipse system and in the 1960s and 1970s classic 3D movies were sometimes converted to anaglyph for special presentations. The polarization system has better color fidelity and less ghosting than the anaglyph system. In the post-'50s era, anaglyph has been used instead of polarization in feature presentations where only part of the movie is in 3D such as in the 3D segment of [Freddy's Dead: The Final Nightmare](#) and the 3D segments of [Spy Kids 3D](#).

Anaglyph is also used in printed materials and in 3D television broadcasts where polarization is not practical. 3D polarized televisions and other displays only became available from several manufacturers in 2008; these generate polarization on the receiving end.

Polarization systems



cardboard 3D linear polarized glasses from the 1980s similar to those used in the 1950s. Though some were plain white, they often had the name of the theatre and/or graphics from the movie

Main article: [Polarized 3D system](#)

To present a stereoscopic motion picture, two images are projected superimposed onto the same screen through different [polarizing filters](#). The viewer wears low-cost eyeglasses which also contain a pair of polarizing filters oriented differently (clockwise/counterclockwise with circular polarization or at 90 degree angles, usually 45 and 135 degrees, with linear polarization). As each filter passes only that light which is similarly polarized and blocks the light polarized differently, each eye sees a different image. This is used to produce a three-dimensional effect by projecting the same scene into both eyes, but depicted from slightly different perspectives. Since no head tracking is involved, the entire audience can view the stereoscopic images at the same time. Additionally, since both lenses have the same color, people with one dominant eye ([amblyopia](#)), where one eye is used more, are able to see the 3D effect, previously negated by the separation of the two colors.



Resembling sunglasses, RealD circular polarized glasses are now the standard for theatrical releases and theme park attractions.

Circular polarization has an advantage over linear polarization, in that the viewer does not need to have their head upright and aligned with the screen for the polarization to work properly. With linear polarization, turning the glasses sideways causes the filters to go out of alignment with the screen filters causing the image to fade and for each eye to see the opposite frame more easily. For circular polarization, the polarizing effect works regardless of how the viewer's head is aligned with the screen such as tilted sideways, or even upside down. The left eye will still only see the image intended for it, and vice versa, without fading or crosstalk.

In the case of [RealD](#) a [circularly polarizing liquid crystal](#) filter which can switch polarity 144 times per second is placed in front of the projector lens. Only one projector is needed, as the left and right eye images are displayed alternately. [Sony](#) features a new system called [RealD XLS](#), which shows both circular polarized images simultaneously: A single [4K](#) projector (4096×2160 resolution) displays both [2K](#) images (2048×858 resolution) on top of each other at the same time, a special lens attachment polarizes and projects the images.

Optical attachments can be added to traditional 35mm projectors to adapt them for projecting film in the "over-and-under" format, in which each pair of images is stacked within one frame of film. The two images are projected through different polarizers and superimposed on the screen. This is a very cost-effective way to convert a theater for 3-D as all that is needed are the attachments and a non-depolarizing screen surface, rather than a conversion to digital 3-D projection. Thomson Technicolor currently produces an adapter of this type. A metallic screen is necessary for these systems as reflection from non-metallic surfaces destroys the polarization of the light.

Polarized stereoscopic pictures have been around since 1936, when [Edwin H. Land](#) first applied it to motion pictures. The so-called "3-D movie craze" in the years 1952 through 1955 was almost entirely offered in theaters using linear polarizing projection and glasses. Only a minute amount of the total 3D films shown in the period used the [anaglyph color filter](#) method. Linear polarization was likewise used with consumer level stereo projectors. Polarization was also used during the 3D revival of the 1980s.

In the 2000s, [computer animation](#), competition from DVDs and other media, digital projection, and the use of sophisticated IMAX 70mm film projectors, have created an opportunity for a new wave of polarized 3D films.

All types of polarization will result in a darkening of the displayed image and poorer contrast compared to non-3D images. Light from lamps is normally emitted as a random collection of polarizations, while a polarization filter only passes a fraction of the light. As a result the screen image is darker. This darkening can be compensated by increasing the brightness of the projector light source. If the initial polarization filter is inserted between the lamp and the image generation element, the light intensity striking the image element is not any higher than normal without the polarizing filter, and overall image contrast transmitted to the screen is not affected.

Eclipse method



A pair of LCD shutter glasses used to view XpanD 3D films. The thick frames conceal the electronics and batteries.

Main article: [Active shutter 3D system](#)

With the eclipse method, a shutter blocks light from each appropriate eye when the converse eye's image is projected on the screen. The projector alternates between left and right images, and opens and closes the shutters in the glasses or viewer in synchronization with the images on the screen. This was the basis of the [Teleview](#) system which was used briefly in 1922.

A variation on the eclipse method is used in [LCD shutter glasses](#). Glasses containing [liquid crystal](#) that will let light through in synchronization with the images on the cinema, television or computer screen, using the concept of [alternate-frame sequencing](#). This is the method used by nVidia, [XpanD 3D](#), and earlier [IMAX](#) systems. A drawback of this method is the need for each person viewing to wear expensive, electronic glasses that must be synchronized with the display system using a wireless signal or attached wire. The shutter-glasses are heavier than most polarized glasses, though lighter models are no heavier than some sunglasses or deluxe polarized glasses. However these systems do not require a silver screen for projected images.

Liquid crystal light valves work by rotating light between two polarizing filters. Due to these internal polarizers, LCD shutter-glasses darken the display image of any LCD, plasma, or projector image source, which has the result that images appear dimmer and contrast is lower than for normal non-3D viewing. This is not necessarily a usage problem; for some types of displays which are already very bright with poor grayish [black levels](#), LCD shutter glasses may actually improve the image quality.

Interference filter technology

Main article: [Anaglyph 3D#Interference filter systems](#)

[Dolby 3D](#) uses specific wavelengths of red, green, and blue for the right eye, and different wavelengths of red, green, and blue for the left eye. Eyeglasses which filter out the very specific wavelengths allow the wearer to see a 3D image. This technology eliminates the expensive silver screens required for polarized systems such as [RealD](#), which is the most common 3D display system in theaters. It does, however, require much more expensive glasses than the polarized systems. It is also known as **spectral comb filtering** or **wavelength multiplex visualization**

The recently introduced Omega 3D/[Panavision 3D](#) system also uses this technology, though with a wider spectrum and more "teeth" to the "comb" (5 for each eye in the Omega/Panavision system). The use of more spectral bands per eye eliminates the need to

color process the image, required by the Dolby system. Evenly dividing the visible spectrum between the eyes gives the viewer a more relaxed "feel" as the light energy and color balance is nearly 50-50. Like the Dolby system, the Omega system can be used with white or silver screens. But it can be used with either film or digital projectors, unlike the Dolby filters that are only used on a digital system with a color correcting processor provided by Dolby. The Omega/Panavision system also claims that their glasses are cheaper to manufacture than those used by Dolby. In June 2012 the Omega 3D/[Panavision 3D](#) system was discontinued by DVPO Theatrical, who marketed it on behalf of Panavision, citing "challenging global economic and 3D market conditions".

Autostereoscopy

In this method, glasses are not necessary to see the stereoscopic image. [Lenticular lens](#) and [parallax barrier](#) technologies involve imposing two (or more) images on the same sheet, in narrow, alternating strips, and using a screen that either blocks one of the two images' strips (in the case of parallax barriers) or uses equally narrow lenses to bend the strips of image and make it appear to fill the entire image (in the case of lenticular prints). To produce the stereoscopic effect, the person must be positioned so that one eye sees one of the two images and the other sees the other.

Both images are projected onto a high-gain, corrugated screen which reflects light at acute angles. In order to see the stereoscopic image, the viewer must sit within a very narrow angle that is nearly perpendicular to the screen, limiting the size of the audience. Lenticular was used for theatrical presentation of numerous shorts in Russia from 1940–1948 and in 1946 for the feature length film [Robinzon Kruzo](#)

Though its use in theatrical presentations has been rather limited, lenticular has been widely used for a variety of novelty items and has even been used in amateur 3D photography. Recent use includes the [Fujifilm FinePix Real 3D](#) with an [autostereoscopic](#) display that was released in 2009. Other examples for this technology include autostereoscopic [LCD displays](#) on monitors, notebooks, TVs, mobile phones and gaming devices, such as the [Nintendo 3DS](#).

Health effects

Some viewers have complained of headaches and eyestrain after watching 3D films. [Motion sickness](#), in addition to other health concerns, are more easily induced by 3D presentations.

There are primarily two effects of 3D film that are unnatural for the human vision: crosstalk between the eyes, caused by imperfect image separation, and the mismatch between convergence and accommodation, caused by the difference between an object's perceived position in front of or behind the screen and the real origin of that light on the screen.

It is believed that approximately 12% of people are unable to properly see 3D images, due to a variety of medical conditions. According to another experiment up to 30% of people have very weak stereoscopic vision preventing them from depth perception based on stereo disparity. This nullifies or greatly decreases immersion effects of digital stereo to them.

The concerns affected such a large portion of audiences that, in 2010, online entrepreneur [Hank Green](#) created "2D Glasses", a product designed to combat adverse effects by reversing

three-dimensional cinema images into ordinary two-dimensional ones, selling his creation through online retailers.

Post-conversion

Another major criticism is that many of the movies in the 21st century to date were not filmed in 3D, but [converted into 3-D](#) after filming. Filmmakers who have criticized the quality of this process include [James Cameron](#), whose film [Avatar](#) was created in 3D from the ground up and is largely credited with the revival of 3D, and [Michael Bay](#).^[73] Despite this, a significant portion of Bay's [Transformers: Dark of the Moon](#) was post-converted to 3D, and the results were still acclaimed.^[8]