New REALA Technology of Fujicolor Nexia and Superia

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Abstract

In August 1998, Fuji Photo Film Co., Ltd. announced the introduction of two new lines of Fujicolor negative film: New Nexia series for the Advanced Photo System, and Superia series for 35mm photography. In the most sweeping update in the history of Fujicolor products, the new films incorporate Fuji Photo Film's proprietary New REALA Technology for color reproduction that is more vivid and truer to life. New REALA Technology consists of the fourth light-sensitive layer, two-stage timing DIR coupler and optimized spectral sensitization. The most important of these is the fourth light-sensitive layer technology.

Introduction

Fujicolor New Nexia and Superia put on the market in August 1998 are new color negative films developed with emphasis on the improved color reproduction, which is an element that represents the attractiveness of silver halide photography most effectively. The newly-developed "new REALA technology" reproduces red, yellow, and other primary colors more vividly, while faithfully reproducing purple, yellowish green, and other neutral colors.

In addition, the technology permits photos taken under fluorescent light, which easily causes color change, to turn out naturally. This report discusses the technology that permits materialization of such features.

Technology for Improving Color Reproduction by the Fourth Light-Sensitive Layer

Fuji Photo Film first introduced the fourth light-sensitive layer into Fujicolor REALA in 1989, substantially enhancing the color fidelity.[1] The fourth layer technology is briefly explained below.

To enhance the color fidelity of a color photo, the spectral sensitivity distribution of color film must be approximated to that of human eyes. Figure 1 shows the color matching functions recommended by the Commission Internationale de l'Eclairage (CIE), which are characterized by the negative lobe. Basically, color film reproduces colors by mixture of the three positive primary colors; therefore, the negative spectral sensitivity cannot be reproduced by color film, which has been adopted as an excuse that color reproduction by color film is not faithful.

Two methods were conceivable to overcome such difficulty. The first method is the linear transformation of the RGB color matching functions to obtain positive sensitivity functions alone, and the second is some approximation to materialize negative sensitivity.

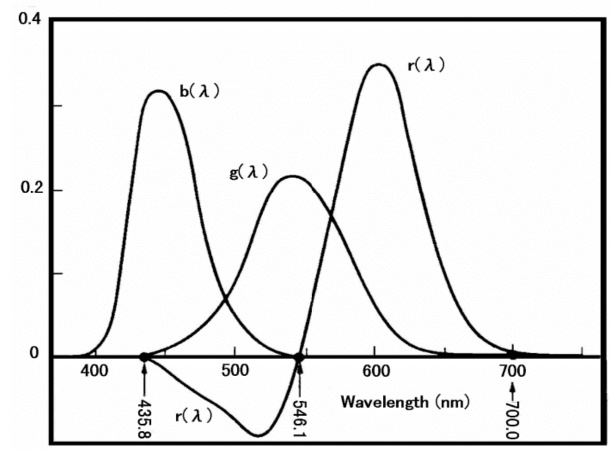

Figure 1. Color matching functions

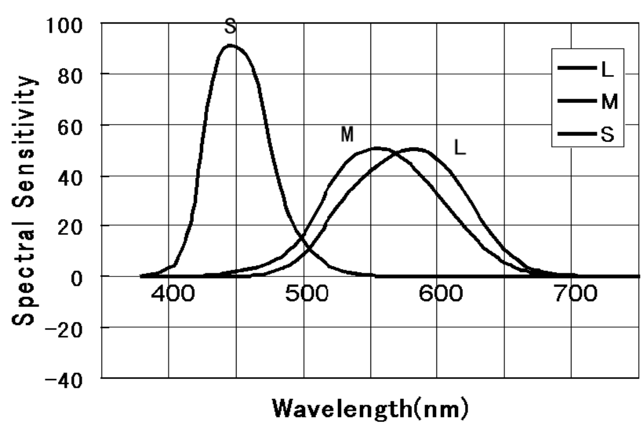

Figure 2. No negative lobe color matching functions(LMS)

Figure 2 shows the LMS color matching functions obtained by the linear transformation of the RGB color matching functions. The LMS color matching functions are represented by the linear combination of the RGB color matching functions.

$$L(\lambda) = 0.354\, r(\lambda) + 0.643\, g(\lambda) + 0.002\, b(\lambda)$$

$$M(\lambda) = 0.182\, r(\lambda) + 0.807\, g(\lambda) + 0.011\, b(\lambda)$$

$$S(\lambda) = 0.000\, r(\lambda) + 0.010\, g(\lambda) + 0.990\, b(\lambda)$$

The LMS sensitivity approximately corresponds to the RGB sensitivity, but the former is featured by the fact that all are represented by positive values and that the overlapping portion of L and M is extremely large. As described above, reproduction of colors merely by mixture of the three positive primary colors is possible. However, when the negative spectral sensitivity is avoided, the overlapping of the RG sensitivity increases to deteriorate color separation, and since the primary colors that correspond to LMS are not true colors, huge color correction is necessary.

The following conditions must be satisfied for actualization of the color matching functions by color negative film.

(1) The spectral sensitivity must coincide with the LMS color matching functions.
(2) Huge color correction must be made by digital processing or an interlayer effect.
(3) The target color are within the color mixture of three primaries used by the output media.

First, the condition (1) is discussed. It is well known that color negative film consists of blue, green, and red sensitive layers. The red sensitive layer is exposed only to the light that has passed through the green sensitive layer.

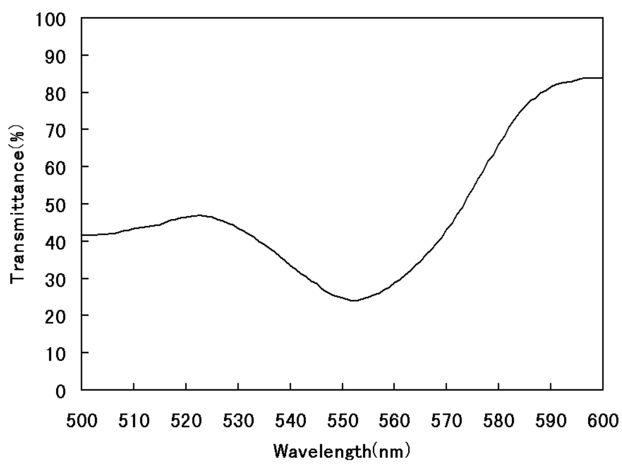

Figure 3. Transmittance of green sensitive layers

Figure 3 shows the transmittance of the green sensitive layer of the present ISO 400 color negative film. As shown in the figure, the transmittance of the 550nm light reduces to approx. 25% after passing through the green sensitive layer. It means that when the overlapping area of the green and red layers is increased, the quantity of the light with the wavelength of the overlapping portion is reduced. Therefore, it is difficult to increase the overlapping portion of the green and red layers in color negative film that has a layer structure.

Then the actual degree of huge color correction in the condition (2) is considered below. The degree of color correction can be estimated by finding the coefficient of conversion from the LMS to RGB color matching functions. The conversion formulae are as follows:

$$r(\lambda) = 4.22\, L(\lambda) - 3.20\, M(\lambda) - 0.02\, S(\lambda)$$

$$g(\lambda) = -1.25\, L(\lambda) + 2.28\, M(\lambda) - 0.03\, S(\lambda)$$

$$b(\lambda) = 0.03\, L(\lambda) - 0.05\, M(\lambda) + 1.02\, S(\lambda)$$

The first formula suggests that the red density ($r(\lambda)$) can be obtained by subtracting $M(\lambda)$ x 3.2 from $L(\lambda)$ x 4.22. In the ordinary color negative film, subtraction of the green sensitive layer density x 3.2 from the red sensitive layer is unrealistic.

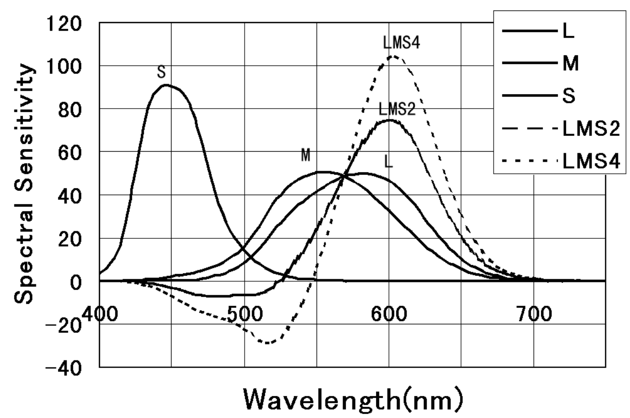

Figure 4. New red sensitive distribution given by linear combination of LMS functions

Upon examination of possible solutions to the above problem with color negative film, it was found that the creation of new spectral sensitivity distribution of the red sensitive layer by means of the linear combination of the LMS color matching functions would be a solution to the difficult problem. Figure 4 shows the spectral sensitivity distribution of the red sensitive layer created by the linear combination of the LMS color matching functions. The creation of a negative lobe in the red sensitive layer can permit to reduce the speed of the shorter-wavelength of the red sensitive layer, changing the peak wavelength to be longer. As a result, the overlapping portion of the green and red sensitive layers can be reduced.

The creation of a negative lobe of color matching functions can be materialized by approximation through enhancement of the interlayer effect on the red sensitive layer. However, attention must be paid to the fact that the wavelength of the negative lobe of the red sensitive layer does not coincide with that of the green sensitive layer and that the wavelength of the negative lobe of the red sensitive layer is shorter. If the interlayer effect is given from the green sensitive layer to the red sensitive layer, the wavelength of the negative lobe of the red sensitive layer will be the same as that of the green sensitive layer, which is longer than the color matching function. Simultaneously, the short wavelength edge of the positive portion of the red sensitive layer shifts longer, and the overlapping portion of the green and red sensitive layers reduces, which is undesirable. To eliminate such problem, a new light-sensitive layer with a spectral sensitivity equivalent to the wavelength of the negative lobe of the red sensitive layer is introduced to materialize the spectral sensitivity similar to the color matching function. This new layer is the fourth light-sensitive layer.

New Technology that Materialized New Nexia and Superia

1 . New REALA Technology

New REALA Technology consists of the fourth light-sensitive layer, two-stage timing DIR coupler and optimized spectral sensitization. The most important of these is the fourth light-sensitive layer technology.

As stated at the beginning of this report, the fourth light-sensitive layer (CL) is introduced in order to materialize the spectral sensitivity that is approximated to the RGB color matching functions with a negative spectral sensitivity. In Fujicolor REALA, the fourth layer was placed between the yellow filter layer and the green sensitive layer, while in the new products it is placed between the green and red sensitive layers.

The merits of this layer structure are:

(1) The CL is adopted to inhibit the development of the red sensitive layer, and the location near the red sensitive layer is advantageous.

(2) There is no sensitivity loss due to the filter effect of the CL on the green sensitive layer, and this technology can be applied to highspeed films.

(3) Since the neighboring layer is not the maximum sensitive layer of the green sensitive layers but the minimum sensitive layer, a color mixture preventive layer is unnecessary. Therefore, the film can be thinner.

2. Super Uniform Fine Grain technology

CL is provided under the green sensitive layer, and the GL functions as a filter for the CL, reducing the quantity of light reaching the CL, which is disadvantageous from the viewpoint of CL sensitivity. However, Super Uniform Fine Grain technology prevents the deterioration of the sensitivity-granularity ratio.

Fuji Photo Film introduced hexagonal tabular grains into Fujicolor Super G400, which was put on the market in 1992, in order to improve the photosensitive efficiency, and has repeated improvement of photosensitive grains thereafter.[2]

In this new development, the nucleus formation condition for preparation of tabular grains was searched to make high-tabularity and mono-dispersity compatible with each other, and the structure built in each grain is made uniform.

It is effective to incorporate an edge dislocation structure on the fringe of a hexagonal tabular grain to prevent intrinsic desensitization due to a large quantity of dye. The measurement of microwave photoconductivity verified that the dislocation works as a temporary trap for photoelectrons. Restraint of recombination of photo-electrons and holes in spectral sensitizer by that temporary trap is the mechanism of intrinsic desensitization prevention. Electrons reemitted from the trap in the fringe portion are considered to be captured at the sensitivity center in the vertex of a hexagonal grain, efficiently producing a concentrated latent image.[3,4] Based on this hypothesis, still more new emulsion with uniform structures between grains was introduced, and the performance was improved as a result.

Conclusion

10 years have passed since Fujicolor REALA was put on the market. This technology has been applied to general-purpose color negative film, and the color negative film has been able to take a new step forward toward the 21st century. The new REALA technology, as well as other new technologies, has been introduced into the New Nexia and Superia series. The lineup of color negative films for amateurs, ISO 400 and below, has the fourth layer almost since REALA ACE and Nexia F were included, meeting the needs of users in all photographic scenes. Fuji Photo Film will continue to develop innovative technologies to meet many users' needs and to promote photographic culture. The original mission of color film is to reproduce the faithful color as seen by human eyes, and the effort to carry out the mission has just begun.

Reference

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