ground gray levels to which the gray level of candidate security particles will be compared. Average gray levels may be established for portions of an image or an entire image. In one embodiment, average gray level is determined by for each of the 80 sections by calculating (R level+G level+B level)/3 for each pixel in the section. These average gray levels will be used as background gray levels to which the gray level of candidate particles will be compared.

[0102] Once an average gray level determination has been completed, the software scans each pixel block in the image. In one embodiment, the CMS **15A** starts at the upper left corner of the image and proceeds top-to-bottom and left-to-right. Pixel scanning examines each pixel block to determine if the gray level for a pixel is above a certain value. In preferred embodiments, the value is a threshold ratio of the gray level of the pixel to the average gray level of a portion of the image, or the entire image. Where the gray level of the composite color pixel **1110** exceeds the average gray level, the composite color pixel **1110** is tested for color.

[0103] **FIG. 10** is an illustration of the processing of an image **404** of a document **200** submitted for authentication, wherein the image **404** has been divided into 80 individual sections **610**. One section **610**, in the upper left hand corner is further presented as **FIG. 10A**. **FIG. 10A** shows the section **610** contains a grid **1100** formed of composite color pixels **1110**. The grid **1100** is 34 pixels wide by 32 pixels high. In **FIG. 10A**, three security particles **1150** are shown.

[0104] In one exemplary embodiment of a set up of the device **5**, each axis of the selected color space correlates to a color in the bayer mosaic pattern **510**. For example, the X axis represents red, the Y axis represents blue, and the Z axis represents green. Accordingly, the bayer mosaic pattern **510** is constructed of color filters **22** that are one of red, blue and green. In this embodiment, the brightness of a given color correlates to distance from the origin in the color space, and increases with distance therefrom.

[0105] Color testing of a pixel **1110** begins with assigning a set of color space coefficients to the pixel **1110**. Once color coordinates for the pixel **1110** are known, the location in the color space of the pixel **1110** is checked for membership in several "color cones." The color cones are actually sets of color coordinates that are representative of the pigments associated with the security particles **1150** appearing in an authentic document **200**, and are described as cones due to their representation within the color space. A color cone **700** is illustrated in **FIG. 11**.

[0106] In other embodiments, the color cone **700** is described by other shapes. For example, in embodiments using color space models having different coordinate systems, the color cone **700** may appear more as a box, or as a cell within a cylinder.

[0107] In a preferred embodiment, testing of the membership of the color of the pixel block **1110** within the color cone **700** is completed by comparing pairs of coordinates representing the projection of the color point onto each of the three color planes (RG **701**, GB **702**, RB **703**) with data describing authentic colors.

[0108] Consider one example where a measured value for a pixel block **1110** is plotted in colorspace having R, G and B axes, as shown in **FIG. 11**. Within the colorspace, a color cone **700** defines a set of points that represent valid colors. When the color cone **700** is projected on to the principle planes of the colorspace (RG **701**, GB **702**, RB **703**), the color cone **700** is defined by two lines which define the boundaries **711**, **712** of the color cone **700** as a valid color area **705**. A valid color area **705** is thus defined in each of the principal planes **701**, **702**, **703**. The lines in each principal plane **701**, **702**, **703** are described by the equation:

$$y=mx+\beta$$

[0109] or,

$$b=mg+\beta$$

[0110] The lines have known values for slope m and intercept β in each plane **701**, **702**, **703**. Various methods may be used to determine the slope m and intercept β. In one embodiment, these values are derived empirically, using a predetermined set of data. In another embodiment, a line fit is completed using computational techniques for analysis of the predetermined set of data.

[0111] Using this relation, the position of a pixel **1110** in the GB plane **702** is given by (g, b). This position is evaluated against the two line equations that correspond to the boundaries of the valid color area **705**. For the upper line, the "g" value for the pixel **1110** is multiplied by the slope (m), and this result is added to the intercept (β). The process is carried out again for the lower line. If the "b" value for the pixel **1110** is both below the upper line's value and above the lower line's value, the color value of the pixel **1110** is determined to reside within the GB **702** projection of the color cone **700**. Thus, testing the color of a pixel **1110** in a principal plane **701**, **702**, **703** involves two multiplications, two additions and one comparison and results in a determination of whether the color of a pixel **1110** is resides within (is a member of) a valid color area **705**. In this case, the valid color area **705** is defined by an upper boundary **711** and a lower boundary **712**.

[0112] Testing the membership of a pixel **1110** is repeated for remaining principal planes **701**, **703**. Thus, for a three test involving three colors, the foregoing operations are carried out a total of nine times per particle (i.e., 3 color cones×3 principal planes).

[0113] **FIG. 12** provides an illustration of two valid color areas **8705**, **8706** projected onto the GB plane **702**. Each valid color area **8705**, **8706** has associated with it, a series of composite color pixels **8110**, **8111**. As can be seen referring to **FIG. 12**, some of the pixels **8110**, **8111** lie within the respective valid color area **8705**, **8706**, some of the pixels **8110**, **8111** outside of the respective valid color area **8705**, **8706**. The foregoing calculation therefore determines whether each of the pixels **8110**, **8111** is valid or invalid when compared to the respective valid color area **8705**, **8706**. Accordingly, statistical qualifications can be useful in determination of overall authenticity of a substrate **200**. For example, a statistical qualification may include evaluation of error at a specific confidence interval.

[0114] In the foregoing embodiment, the color of the pixel **1110** is tested against the valid color areas **8705**, **8706** having an upper boundary **711** and a lower boundary **712**. However, it is recognized that these boundaries **711**, **712** may be uniquely associate with certain color space models. Therefore, it is recognized that other color models may present valid color areas that are defined by other sets of boundaries.