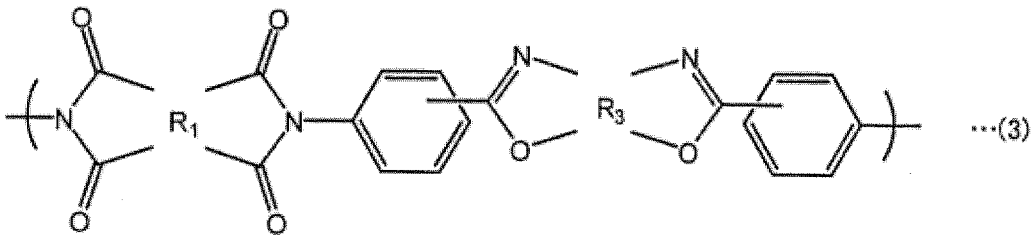
coating is cured with heat or the like to prepare an organic film (for example, Patent Literature 2). In the former method, an adhesive material needs to be provided between a support substrate and a film. Accordingly, subsequent process temperatures may be limited depending on heat resistance of the adhesive material. On the other hand, the latter method is excellent in that an adhesive material is not used; surface smoothness of a prepared film is high; and the like.

[0004] Examples of a resin used in an organic film may include polyester, polyamide, polyimide, polycarbonate, polyethersulfone, acryl, and epoxy. Among these, polyimide resins having a high heat resistance are suitable as a display substrate. Especially, polyimide resins have not only high heat resistance but also excellent mechanical properties such as high mechanical strength, abrasion resistance, dimensional stability and chemical resistance as well as excellent electrical properties such as insulation properties. Therefore, polyimide resins are widely used in an electric and electronic industrial field. When forming a polyimide film by the above-mentioned coating method, there is used a method in which a solution containing a polyamic acid as a precursor is applied by coating on a support substrate, and the polyamic acid is cured to be converted to a polyimide. In general, a polyamic acid can be easily synthesized by reacting an acid dianhydride and a diamine in a solvent.

[0005] Wholly aromatic polyimides derived from aromatic acid dianhydrides and aromatic diamines have high heat resistance. However, there exists an absorption band in a visible light wavelength region originating from an intramolecular and an intermolecular charge-transfer complex, resulting in coloring of an obtained polyimide

atoms with at least two hydroxyl groups.

[0015] Moreover, a polyimide-oxazole resin composition according to the present invention includes: (a'') a polyimide-oxazole including as a main component a structural unit represented by the general formula (3); and (b) a solvent,



...(3)

wherein in the general formula (3), R_1 represents a tetravalent organic group having 4 to 40 carbon atoms with a monocyclic or condensed polycyclic alicyclic structure, or a tetravalent organic group having 4 to 40 carbon atoms with organic groups each having a monocyclic alicyclic structure wherein the organic groups are linked to each other directly or via a cross-linked structure; and R_3 represents a tetravalent organic group having 2 to 40 carbon atoms.

Advantageous Effects of Invention

[0016] According to the present invention, there can be obtained the polyamic acid resin composition, the polyimide resin composition, and the polyimide-oxazole resin composition of which heat-treated films have excellent heat resistance, high optical transmittance in a visible light region, and low birefringence as well as a flexible substrate containing the same.

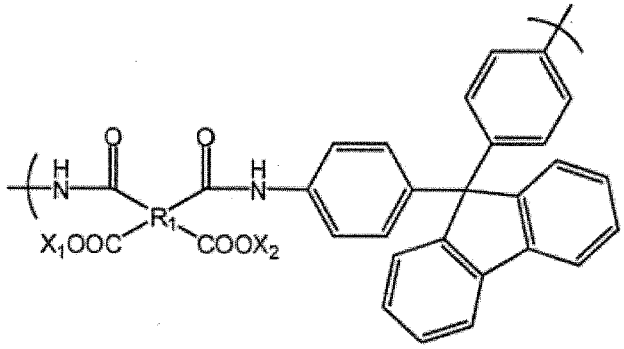
Description of Embodiments

[0017] Embodiments for carrying out the present invention will be described in detail below ~~with reference to the drawings~~. It is noted that the present invention should not be limited by the following embodiments. Also,

wherein a halogen atom may be substituted for a hydrogen atom are linked to each other. Examples of such an alicyclic structure may include 1,1-bicyclohexane and oxydicyclohexane.

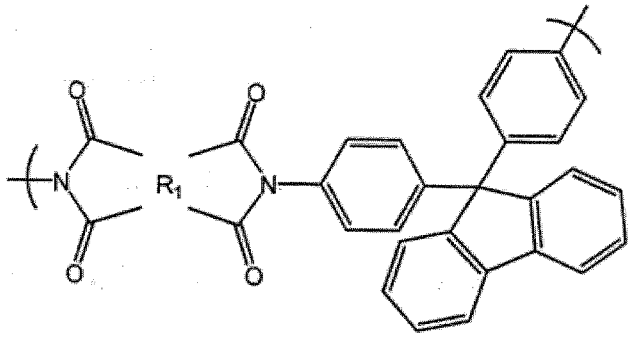
[0040] Examples of the above acid dianhydride may include 1,2,3,4-cyclobutanetetracarboxylic acid dianhydride, 1,2,3,4-cyclopentanetetracarboxylic acid dianhydride, 1,2,3,4-cyclohexanetetracarboxylic acid dianhydride, ~~1,2,4,5-cyclopentanetetracarboxylic acid dianhydride,~~ 1,2,3,4-tetramethyl-1,2,3,4-cyclobutanetetracarboxylic acid dianhydride, 1,2-dimethyl-1,2,3,4-cyclobutanetetracarboxylic acid dianhydride, 1,3-dimethyl-1,2,3,4-cyclobutanetetracarboxylic acid dianhydride, 1,2,3,4-cycloheptanetetracarboxylic acid dianhydride, bicyclo[2.2.2]octo-7-ene-2,3,5,6-tetracarboxylic acid dianhydride, bicyclo[2.2.1]heptanetetracarboxylic acid dianhydride, 7-oxabicyclo[2.2.1]heptane-2,4,6,8-tetracarboxylic acid dianhydride, octahydronaphthalene-1,2,6,7-tetracarboxylic acid dianhydride, tetradecahydroanthracene-1,2,8,9-tetracarboxylic acid dianhydride, 3,3',4,4'-dicyclohexanetetracarboxylic acid dianhydride, and 3,3',4,4'-oxydicyclohexanetetracarboxylic acid dianhydride.

[0041] Among these, from a viewpoint of commercial availability and reactivity with a diamine compound, R_1 in the general formula (1) is preferably 1S,2S,4R,5R-cyclohexanetetracarboxylic acid dianhydride, 1R,2S,4S,5R-cyclohexanetetracarboxylic acid dianhydride, and 3,3',4,4'-dicyclohexanetetracarboxylic acid dianhydride, which are represented by the chemical formulas (11) to (13) below. These acid dianhydrides are commercially available as trade names "PMDA-HH", "PMDA-HS", and "BPDA-H" from Iwatani Industrial Gases Corporation. In this case, these acid



···(36)

[0079]



···(37)

(In the general formula (36), X_1 and X_2 each independently represent a hydrogen atom or a monovalent organic group having 1 to 10 carbon atoms. In the general formulas (36) and (37), R_1 represents a tetravalent organic group having 4 to 40 carbon atoms with monocyclic or condensed polycyclic alicyclic structure, or a tetravalent organic group having 4 to 40 carbon atoms with organic groups each having a monocyclic alicyclic structure wherein the organic groups are linked to each other directly or via a cross-linked structure.

[0080] In general, a polyimide film including the diamine represented by the chemical formula (35) often exhibits coloring. As described later (Comparative Example 8), a polyimide film, in which 4,4'-(hexafluoroisopropylidene)diphthalic acid anhydride used as a raw material monomer of a transparent ~~PI~~polyimide, the diamine

film thickness after prebaking at 140°C for 4 minutes was 5±0.5 μm. Then, using a hot plate D-SPIN manufactured by Dainippon Screen Mfg. Co., Ltd., prebaking at 140°C for 4 minutes was performed. The prebaked film was cured under a nitrogen gas stream (oxygen concentration being 20 ppm or less) using an Inert Oven (INH-21CD manufactured by Koyo Thermo Systems Co., Ltd.) at a temperature elevated to 300°C or 350°C at 3.5°C/min and maintained for 30 minutes. Then, the temperature was lowered to 50°C at 5°C/min. Thus, a heat-resistant resin film (on a silicon substrate) was prepared.

[0149]

(4) Measurement of optical transmittance (T)

The optical transmittance at 400 nm was measured, using a UV-visible spectrophotometer (MultiSpec 1500 manufactured by Shimadzu Corporation). In this case, the heat-resistant resin film prepared in (2) was used for the measurement.

[0150]

(5) Measurement of total light transmittance (Tt)

The total light transmittance of the heat-resistant resin film prepared in (1) was measured, using a direct reading haze computer (HGM2DP manufactured by Suga Test Instruments Co., Ltd., C light source). Here, a value obtained from one measurement was used as Tt. ~~In this case, the heat-resistant resin film prepared in (1) was used for the measurement.~~

[0151]

(6) Measurement of refractive index and in-plane/out-of-plane birefringence

The TE refractive index (n(TE)) and the TM refractive index (n(TM)) at a wavelength of 632.8 nm were measured,

A photosensitive resin composition (varnish) prepared in the example was applied to an 8-inch silicon wafer by spin-coating. Next, using a hot plate (coating-developing apparatus Mark-7 manufactured by Tokyo Electron Limited), the coated wafer was heat-treated (prebaked) at 120°C for 3 minutes. The film thickness of the prebaked film was 2 to 4 μm. The obtained prebaked film was subjected to exposure in an exposure amount of 20 to 320 mJ/cm^2 by steps of 10 mJ/cm^2 using an i-line stepper (DSW-8000 manufactured by GCA Co.). The line & space patterns used for the exposure were 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 30, 50, and 100 μm. After exposure, the film was developed for 60 seconds with an aqueous solution of 2.38% by weight of tetramethylammonium hydroxide (TMAH) (ELM-D manufactured by Mitsubishi Gas Chemical Company Inc.), and then rinsed with pure water to obtain a relief pattern. In this case, the film thicknesses after prebaking and after exposure were measured with a refractive index of 1.63 using an optical interference-type film thickness measuring device Lambda Ace STM-602 manufactured by Dainippon Screen Mfg. Co. Ltd.

[0157]

(12) Calculation of development film reduction amount

The development film reduction amount was calculated according to the following formula:

Development film reduction amount (μm) = film thickness after prebaking - film thickness after development.

[0158]

(13) Calculation of sensitivity

The minimum exposure amount in which line & space patterns(1L/1S) of 10 μm and 20 μm were formed in the proportion of one to one after exposure and development was