

[0080] Examples of monomers in the ionizing-radiation-curing resin compositions include: (1) styrene monomers such as styrene and *a*-methyl-styrene; (2) acrylic esters such as methyl acrylate, 2-ethylhexyl acrylate, methoxyethyl acrylate, butoxyethyl acrylate, butyl acrylate, methoxybutyl acrylate and phenyl acrylate; (3) methacrylic esters such as methyl methacrylate, ethyl methacrylate, propyl methacrylate, methoxyethyl methacrylate, ethoxyethyl methacrylate, phenyl methacrylate and lauryl methacrylate; (4) amino-substituted alcohol esters such as 2-(*N,N*-diethylamino)ethyl acrylate, 2-(*N,N*-dimethylamino)ethyl acrylate, 2-(*N,N*-dibenzylamino)methyl acrylate and 2-(*N,N*-diethylamino)propyl acrylate; (5) unsaturated carboxylic acid amides such as acrylamide and methacrylamide; (6) compounds such as ethylene glycol diacrylate, propylene glycol diacrylate, neopentyl glycol diacrylate, 1,6-hexanediol diacrylate and triethylene glycol diacrylate; (7) polyfunctional compounds such as dipropylene glycol diacrylate, ethylene glycol diacrylate, propylene glycol dimethacrylate and diethylene glycol dimethacrylate; and (8) polythiol compounds having two or more thiol groups in one molecule, such as trimethylolpropane trithioglycolate, trimethylolpropane trithiopropylate and pentaerythritol tetrathioglycolate.

[0081] In general, any one of or two or more of the above-enumerated monomers are used in the ionizing-radiation-curing resin composition. To impart proper coating properties to the ionizing-radiation-curing resin composition, it is preferable to make the ionizing-radiation-curing resin composition contain 5% by weight or more of prepolymers or oligomers selected from the above-described ones and 95% by weight or less of monomers and/or polythiol compounds selected from the above-described ones.

[0082] If the ionizing-radiation-curing resin composition is required to show flexibility after it has been cured, it is proper to decrease the amount of monomers to be incorporated into the ionizing-radiation-curing resin composition or use an acrylate monomer having one or two functional groups. If the cured ionizing-radiation-curing resin composition is required to have resistance to wear, heat or solvents, it is proper to use an acrylate monomer having three or more functional groups. Thus, it is possible to suitably design the ionizing-radiation-curing resin composition. Examples of acrylate monomers having one functional group include 2-hydroxy acrylate, 2-hexyl acrylate and phenoxyethyl acrylate. Examples of acrylate monomers having two functional groups include ethylene glycol diacrylate and 1,6-hexanediol diacrylate. Examples of acrylate monomers having three or more functional groups include trimethylolpropane triacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, and dipentaerythritol hexaacrylate.

[0083] To control the physical properties, such as flexibility and surface hardness, of the cured ionizing-radiation-curing resin composition, a resin that is not cured by the application of ionizing radiation may be added to the ionizing-radiation-curing resin composition. Specific examples of such resins include thermoplastic resins such as polyurethane resins, cellulose resins, polyvinyl butyral resins, polyester resins, acrylic resins, polyvinyl chloride resins and polyvinyl acetate resins of these, polyurethane resins, cellulose resins and polyvinyl butyral resins are preferred from the viewpoint of improvement in flexibility.

[0084] To cure the ionizing-radiation-curing resin composition by the application of light, especially ultraviolet light, it is proper to incorporate a photopolymerization initiator or accelerator into the ionizing-radiation-curing resin composition. To an ionizing-radiation-curing resin composition composed of resins having radically polymerizable unsaturated groups, acetophenones, benzophenones, Michler's benzoylbenzoate, α -amyloxime ester, thioxanethones, benzoin, benzoin methyl ether, etc. may be added either singly or in combination as the photopolymerization initiator. To an ionizing-radiation-curing resin composition composed of resins having cationically polymerizable unsaturated groups, aromatic diazonium salts, aromatic sulfonium salts, aromatic iodonium salts, metallocene compounds, benzoin-sulfonic esters, etc. may be added either singly or in combination as the photopolymerization initiator. The amount of the photopolymerization initiator to be added is from 0.1 to 10 parts by weight for 100 parts by weight of the ionizing-radiation-curing resin composition. In addition to the photopolymerization initiator, *n*-butylamine, triethylamine, tri-*n*-butyl-phosphine or the like may be added as a sensitizer.

[0085] Any of the organic reactive silicon compounds as described below may also be incorporated into the ionizing-radiation-curing resin composition.

[0086] Included in a first group of organic silicon compounds that can be incorporated into the ionizing-radiation-curing resin composition are those compounds represented by the general formula $R_mSi(OR')_n$, wherein R and R' represent an alkyl group having 1 to 10 carbon atoms; and the subscripts m and n for R and R', respectively, are integers that fulfil the relationship $m+n=4$. Specific examples of such organic silicon compounds include tetramethoxysilane, tetraethoxysilane, tetra-*iso*-propoxysilane, tetra-*n*-propoxysilane, tetra-*n*-butoxysilane, tetra-*sec*-butoxysilane, tetra-*tert*-butoxysilane, tetrapentaethoxysilane, tetrapenta-*iso*-propoxysilane, tetrapenta-*n*-propoxysilane, tetrapenta-*n*-butoxysilane, tetrapenta-*sec*-butoxysilane, tetrapenta-*tert*-butoxysilane, methyltriethoxysilane, methyltripropoxysilane, methyltributoxysilane, dimethyldimethoxysilane, dimethyl-diethoxysilane, dimethylethoxysilane, dimethylmethoxysilane, dimethyl-propoxysilane, dimethylbutoxysilane, methyl dimethoxysilane, methyl-diethoxysilane and hexyltrimethoxysilane.

[0087] A second group of organic silicon compounds that can be incorporated into the ionizing-radiation-curing resin composition includes silane coupling agents. Specific examples of such organic silicon compounds include γ -(2-aminoethyl)aminopropyltrimethoxysilane, γ -(2-aminoethyl)aminopropyl-methyldimethoxysilane, β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -aminopropyltriethoxysilane, γ -methacryloxypropylmethoxysilane, *N*- β -(*N*-vinylbenzylaminoethyl)- γ -aminopropylmethoxysilane hydrochloric acid, γ -glycidoxypropyltrimethoxysilane, aminosilane, methylmethoxysilane, vinyl-triacetoxysilane, γ -mercapto-propyltrimethoxysilane, γ -chloropropyl-trimethoxysilane, hexamethyldisilazane, vinyltris(β -methoxyethoxy)silane, octadecyldimethyl [3-(trimethoxysilyl)propyl]ammonium chloride, methyl-trichlorosilane and dimethyldichlorosilane.

[0088] A third group of organic silicon compounds that can be incorporated into the ionizing-radiation-curing resin composition includes ionizing-radiation-curing silicon compounds. Specific examples of such compounds include