atom-substituted alkyl group, R^3 is a hydrogen atom, an unsubstituted alkyl group, or a fluorine atom-substituted alkyl group, p and q are each an integer of not less than 0 and not more than 5, and p+q=5.

[0035] Note that although the copolymer may also include any monomer units other than the monomer unit (A) and the monomer unit (B), the proportion constituted by the monomer unit (A) and the monomer unit (B) among all monomer units of the copolymer is, in total, preferably 90 mol % or more, and is preferably 100 mol % (i.e., the copolymer preferably only includes the monomer unit (A) and the monomer unit (B)). The total number of fluorine atoms included in the monomer unit (A) and the monomer unit (B) is preferably 5 or 6. This is because the sensitivity in a method of forming a resist pattern can be further increased due to further increased sensitivity of a resist film in a case in which the total number of fluorine atoms included in the monomer unit (A) and the monomer unit (B) is 5 or 6.

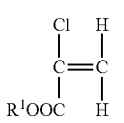
[0036] Although the copolymer may be a random copolymer, a block copolymer, an alternating copolymer (ABAB . . .), or the like, for example, without any specific limitations so long as it includes the monomer unit (A) and the monomer unit (B), a copolymer including 90 mass % or more (upper limit of 100 mass %) of an alternating copolymer is preferable.

[0037] The copolymer undergoes main chain scission to lower molecular weight upon irradiation with extreme ultraviolet light as a result of including the specific monomer unit (A) and monomer unit (B). Moreover, the copolymer displays excellent sensitivity to extreme ultraviolet light when used as a resist as a result of at least the monomer unit (A) including 5 or more fluorine atoms. In particular, as a result of at least the monomer unit (A) including 5 or more fluorine atoms, the copolymer enables especially significant improvement of sensitivity in a case in which extreme ultraviolet light is used compared to sensitivity in a case in which the number of fluorine atoms in the monomer unit (A) is 4 or fewer and sensitivity in a case in which an electron beam or the like is used.

[0038] Note that although it is not clear why the copolymer can display excellent sensitivity to extreme ultraviolet light as a result of at least the monomer unit (A) including 5 or more fluorine atoms, it is presumed that absorption efficiency of extreme ultraviolet light is improved through the presence of fluorine atoms, thereby enabling rapid main chain scission.

[0039] Monomer Unit (A)

[0040] The monomer unit (A) is a structural unit that is derived from a monomer (a) represented by general formula (III), shown below.



(III)

(In general formula (III), 10 is the same as in general formula (I).)

[0041] The proportion constituted by the monomer unit (A) among all monomer units of the copolymer is not specifically limited but can, for example, be set as not less than 30 mol % and not more than 70 mol %.

[0042] R^1 in general formula (I) and general formula (III) is required to be an organic group including 5 or more fluorine atoms from a viewpoint of improving main chain scission properties of the copolymer upon irradiation with extreme ultraviolet light.

[0043] The number of fluorine atoms included in 10 in general formula (I) and general formula (III) is preferably 6 or more from a viewpoint of improving main chain scission properties of the copolymer upon irradiation with extreme ultraviolet light and further improving sensitivity in a case in which extreme ultraviolet light is used. Moreover, the number of fluorine atoms included in R^1 in general formula (I) and general formula (III) is preferably 7 or fewer from a viewpoint of improving the clarity of a resist pattern obtained when the copolymer is used as a positive resist.

[0044] The carbon number of R^1 is preferably not less than 2 and not more than 10, more preferably not less than 3 and not more than 4, and even more preferably 3. Solubility in a developer can be sufficiently improved when the carbon number is not less than any of the lower limits set forth above. Moreover, lowering of the glass-transition point can be inhibited and sufficient clarity of an obtained resist pattern can be ensured when the carbon number is not more than any of the upper limits set forth above.

[0045] More specifically, R^1 in general formula (I) and general formula (III) is preferably a fluoroalkyl group, a fluoroalkoxyalkyl group, or a fluoroalkoxyalkenyl group, and is more preferably a fluoroalkyl group. When R^1 is any of the groups set forth above, main chain scission properties of the copolymer upon irradiation with extreme ultraviolet light can be sufficiently improved.

[0046] The fluoroalkyl group is, for example, a 2,2,3,3,3-pentafluoropropyl group (number of fluorine atoms: 5; carbon number: 3), a 3,3,4,4,4-pentafluorobutyl group (number of fluorine atoms: 5; carbon number: 4), a 1H-1-(trifluoromethyl)trifluoroethyl group (number of fluorine atoms: 6; carbon number: 3), a 1H,1H,3H-hexafluorobutyl group (number of fluorine atoms: 6; carbon number: 4), a 2,2,3,3,4,4,4-heptafluorobutyl group (number of fluorine atoms: 7; carbon number: 4), or a 1,2,2,2-tetrafluoro-1-(trifluoromethyl)ethyl group (number of fluorine atoms: 7; carbon number: 3), of which, a 2,2,3,3,3-pentafluoropropyl group (number of fluorine atoms: 5; carbon number: 3) is preferable.

[0047] The fluoroalkoxyalkyl group is, for example, a pentafluoroethoxymethyl group or a pentafluoroethoxyethyl group.

[0048] The fluoroalkoxyalkenyl group is, for example, a pentafluoroethoxyvinyl group.

[0049] Examples of the monomer (a) represented by the previously described general formula (III) that can form the monomer unit (A) represented by the previously described general formula (I) include, but are not specifically limited to, fluoroalkyl esters of α-chloroacrylic acid such as 2,2,3,3,3-pentafluoropropyl α-chloroacrylate, 3,3,4,4,4-pentafluorobutyl α-chloroacrylate, 1H-1-(trifluoromethyl)trifluoroethyl α-chloroacrylate, 1H,1H,3H-hexafluorobutyl α-chloroacrylate, 1,2,2,2-tetrafluoro-1-(trifluoromethyl) ethyl α-chloroacrylate, and 2,2,3,3,4,4,4-heptafluorobutyl α-chloroacrylate; fluoroalkoxyalkyl esters of α-chloroacrylic acid such as pentafluoroethoxymethyl α-chloroacrylate and pentafluoroethoxyethyl α-chloroacrylate; and fluoroalkoxyalkenyl esters of α-chloroacrylic acid such as pentafluoroethoxyvinyl α-chloroacrylate.