tion step) either where exposed or unexposed. The silicon containing gases render the material less volatile in a subsequent plasma etching process. While the capillary forces encountered in the wet process are thus avoided, gas diffusion has been a problem with this dry process. Resolution has been found to be limited due to lowering of the glass transition temperature, swelling, and high line edge roughness.

[0014] Notwithstanding these attempts to deal with the problem of pattern collapse, there remains a need for a simple, repeatable process which avoids structure collapse, while at the same time providing high resolution results.

SUMMARY OF THE INVENTION

[0015] By way of this invention a novel dry blanket exposure approach is used to develop the resist, which, in one embodiment, where exposed forms a volatile compound which volatilizes or ablates from the resist surface. The invention is also directed to a novel class of compounds which form a volatilization product when a change in chemical structure is induced by exposure to an energy source such as a laser light source.

[0016] More particularly, according to an embodiment of the invention, a broad beam light source is used to dry develop or blanket expose a resist with high resolution. In one embodiment, the light source may be a visible light source, in another embodiment a laser light source. The material that is being dry developed needs to be responsive to the optical frequency of the light source such that it absorbs energy to undergo chemical change, where the changed material becomes volatile. In another embodiment, for a laser light source, using appropriate power settings, the laser light source, can be used to selectively ablate resist materials in areas that have been pre-exposed by electron beam lithography, or other high resolution lithography, such as EUV lithography. By pre exposure to high resolution radiation, chemical changes to the material are initiated to the point that when the resist is next exposed to the broad beam light source, volatilization rapidly initiates. In still another embodiment, the use of laser development may be combined with wet development techniques, with the benefit of a reduction in the development time that is required in the high resolution tool. As an additional benefit to laser development, a negative resist when developed in solvent can become positive when developed by laser

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The foregoing aspects and others will be readily appreciated by the skilled artisan from the following description of illustrative embodiments when read in conjunction with the accompanying drawings.

[0018] FIG. **1** is an illustration of a development process according to an embodiment of the invention.

[0019] FIGS. **2** and **3** are pictorial representations of exemplary calixarenes which may be used as a resist material according to an embodiment of the processes of this invention.

[0020] FIG. **4** are photographs of the results of both a wet development and a dry development of a structure according to the processes of this invention, illustrating one of the advantages of the instant dry process.

DETAILED DESCRIPTION

[0021] With reference to FIG. **1**, according to one process of this invention, a resist layer **112** is first deposited onto a substrate **110** which can be a wafer. Thereafter the resist layer is exposed to a high resolution radiation **114** which may be provided according to an electron beam lithography process, an EUV lithography or other lithography process. In the illustration shown, the exposed areas have been designated as areas **116**. In the next dry development step, the resist/wafer combination is exposed to a visible light source **118**, which in one embodiment may be a laser light source. The resist material **112**, already having been chemically changed in the exposed areas **116**, ablates (item **120**) under the influence of the light source, the ablation process continued until the resist material is removed down to underlying substrate **110** to form the desired patterned features **122**.

[0022] According to an embodiment of the invention, it has been found that at least one group of resist materials can be dry developed using a laser light, and more particularly, in one embodiment, a continuous wave 532 nm wavelength (visible light) laser. The laser can also be pulsed. In addition, the laser can be used to give a low resolution exposure dose which can be followed with high resolution radiation exposure dose and still be selectively developed using the resist in the high resolution areas.

[0023] Most generally, it has been found that any class of conjugated polymers may potentially be used as a resist in this ablation/volatilization process, so long as the polymer is either in liquid form at application temperatures, or is dissolvable in a solvent such that it may be applied as a thin film to a wafer. Further, it must be responsive to the optical frequency of the light source such that where the polymer is exposed it undergoes a chemical change.

[0024] In one embodiment, a suitable class of resist materials include those which under the influence of a high resolution energy source (such as e-beam, EUV exposure, or alternatively a field confined laser beam using plasmonics), undergo a chemical change (such as through further conjugation or creation of a light absorbing moiety), whereby its absorptive response to visible light is materially changed in those areas where exposed, to produce a volatility contrast between those areas where the resist has been exposed, and those areas where not. Suitable materials exhibiting these characteristics include conjugated molecules such as aromatic polymers.

[0025] Within this class, we have further found a group of compounds known as calixarenes to be useful, especially calixarenes such as methyl acetoxy calixarene, t-butyl acetoxy calixarene, and methyl acetoxy calixarenes substituted with a moiety selected from the group comprising halo, cyano, and nitro. These calixarenes (cyclic oligomers) comprise a class of compounds based on the hydroxyalkylation product of a phenol and an aldehyde. Exemplary representations of such acetoxy calixarenes are illustrated in FIG. **2** and FIG. **3**. This class of calixarene compounds, in addition to their optical properties, has been found to be particularly suitable for the processes of this invention, in that they are easily dissolved in a casting solvent for deposition on planar surfaces, but can be used as well without the need for a casting solvent.

[0026] Generally any class of compounds can be used if they can be applied to a substrate, e.g. a wafer, using already existing tools. In addition these compounds must be capable of undergoing chemical change in response to light energy and become volatile under continued exposure. While not intending to be bound by the following, it is believed that exposure of the compound to a light source causes the com-