

alumina particle defects, and higher levels of substrate scratching that can be associated with the use of alumina abrasive particles.

These and other slurry embodiments can also include secondary abrasive particles that are not alumina, that are silica, but that are different from the charged silica particles described herein (that contain cationic compound incorporated into the silica particles).
5 These particles can be referred to as “secondary silica abrasive particles” or “secondary silica particles”. And, because these particles do not include a cationic compound incorporated into the particles, these particles may also be referred to as “non-cationic compound-containing silica particles.” The secondary silica particles may still become
10 charged (e.g., cationically) and exhibit a measurable zeta potential (positive or negative) at a low slurry pH, or may be relatively uncharged (exhibit a neutral charge) at slurry pH.

Secondary silica particles can be of any desired size. Example DLS particle sizes of secondary silica abrasive particles can be at least about 50 nanometers (nm) or more (e.g., about 70 nm or more, or about 100 nm or more. Accordingly, secondary silica
15 particles may have an average particle size (aggregate size) in a range from about 50 nm to about 200 nm, e.g., from about 70 nm to about 190 nm, or from about 100 nm to about 180 nm).

According to example “silica-only” slurries, abrasive particles of a slurry can consist of or consist essentially of cationic silica particles as described, which include a
20 cationic compound incorporated into the particles, and optional secondary silica particles (“non-cationic compound-containing silica particles”), and can contain not more than 3, 2, or 1 percent, e.g., not more than 0.5, 0.1, 0.05, or 0.01 non-silica particles, based on total weight abrasive particles in the slurry. The amount of the secondary silica particles (“non-cationic compound-containing silica particles”) relative to the cationic silica
25 particles (cationic compound-containing silica particles) can be as desired, with example amounts being in a range of from 1 to 50 weight percent, e.g., from 5 to 40 or from 10 to 30 weight percent secondary silica abrasive particles based on total silica particles (and total abrasive particles) in the slurry.

Still other slurry embodiments do not include any secondary particles and include
30 only cationic silica particles as described; the cationic silica particles may all be the same, or the slurry may include different types of cationic silica particle, meaning cationic silica

hardness, thickness, compressibility, ability to rebound upon compression, and compression modulus. Suitable polymers include, for example, polyvinylchloride, polyvinylfluoride, nylon, fluorocarbon, polycarbonate, polyester, polyacrylate, polyether, polyethylene, polyamide, polyurethane, polystyrene, polypropylene, coformed products thereof, and mixtures thereof.

According to preferred embodiments of slurries and CMP processes that involve a slurry with cationic silica abrasive particles as described (containing incorporated cationic compound), a nickel layer can be processed by CMP processing in a manner that produces a relatively high removal rate of the nickel material (e.g., NiP, electroless nickel) as compared to a CMP process that treats an identical substrate using identical CMP conditions, but with a comparable slurry, wherein the comparable slurry is identical to an inventive slurry except that the abrasive particles of the comparable slurry are uncharged (i.e., neutral) silica particles or anionically-charged silica particles. For example, according certain embodiments of the inventive methods a removal rate of NiP (using an inventive slurry) can be greater than a removal rate of a similar method wherein the substrate, CMP equipment and process parameters, slurry, and abrasive particles are the same except that the abrasive particles in the similar method exhibit a zeta potential of not greater than zero, as compared to an inventive method wherein the silica particles are the same but exhibit a positive zeta potential, such as a zeta potential of at least 5 millivolts.

Without wishing to be bound by theory, it is postulated that a nickel-phosphorus surface (e.g., containing a relatively high level of phosphorus, such as at least 8, or at least 10 atomic percent phosphorus versus total nickel and phosphorus), during chemical-mechanical processing in the presence of an oxidizing agent, can become negatively charged at the surface. Cationic silica particles in a CMP slurry used to process this surface are believed to be attracted to the negatively charged surface, and this attraction is believed to improve removal rate of the nickel-phosphorus material at the surface in a manner that does not occur if the silica abrasive particles are either un-charged or anionically charged in the CMP slurry (all other features of the CMP process and materials being otherwise identical).