CLAIMS:

1. A method for using a functionalized chemical planarization pad in planarization processes, the method comprising:

planarizing a substrate material with the functionalized chemical planarization pad, the functionalized chemical planarization pad including a plurality of functional groups bonded to a material of the pad, the functional groups being configured to chemically react with the substrate material such that a portion of substrate material bonds to the functional groups;

regenerating the pad by applying a regeneration solution configured to break bonds between the functional groups and substrate material bonded to the functional groups to form removed material, wherein regenerating the pad includes reacting the substrate material bonded to the functional groups with a stripping agent configured to break the bonds between the functional groups and the substrate material bonded to the functional groups via oxidation and/or hydrolysis; and

complexing the removed material in a dissolved complexing agent to form dissolved material in an effluent phase, wherein the dissolved complexing agent is provided in the regeneration solution contemporaneously with the stripping agent.

2. The method of claim 1, wherein the substrate material includes one or more of copper, cobalt, gold, hafnium, zirconium, rhenium, niobium, molybdenum, ruthenium, tantalum, vanadium, tungsten, TaN, TiN, polysilicon, or silicon.

3. The method of claim 1, wherein reacting the substrate material bonded to the functional groups with the stripping agent includes reacting the substrate material with the dissolved complexing agent.

4. The method of claim 1, wherein complexing the removed material in the dissolved complexing agent includes complexing the removed material with one or more of a hydroxide, an alcohol, an acid, an amine, an azole, a macrocyclic compound, a sulfonate, a sulfite ester, poly-diallyldimethylammonium chloride (DADMAC), mono-DADMAC, a persulfate, ammonia, ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA), nitrilotriacetic acid (NTA), ethylene diamine, an amino acid, iminodisuccinic acid (IDS), ethylenediaminedisuccinic acid (EDDS), glutamic acid diacetate (GLDA), or methylglycinediacetic acid (MGDA).

5. The method of claim 1, wherein the substrate material includes a metal, and wherein applying the regeneration solution to break the bonds between the functional groups and the substrate material includes forming a metal oxide from the metal.

6. The method of claim 1, further comprising recovering the dissolved material from the effluent phase.

7. The method of claim 6, wherein recovering the dissolved material includes extracting the dissolved material via one or more of liquid-liquid extraction, solvent extraction, or membrane separation.

8. The method of claim 7, wherein an active solvent component of the solvent extraction includes one or more of an amine, an alkyl phosphoric acid, or a sulfonate.

9. The method of claim 7, further comprising performing the solvent extraction with a solution that includes a modifier.

10. The method of claim 9, wherein the modifier includes one or more of di-butyl-butyl phosphonate, phosphine oxide, tributyl phosphate, or isopropyl alcohol.

11. The method of claim 7, wherein extracting the dissolved material via the solvent extraction includes extracting the dissolved material via an ion pair extraction.

12. The method of claim 7, wherein extracting the dissolved material via the membrane separation includes extracting the dissolved material via a liquid membrane system or a surfactant liquid membrane system.

13. The method of claim 12, further comprising:

recovering a metal species in a single step using the surfactant liquid membrane system; or

recovering the metal species in a two-step process comprising, extracting the metal species from the effluent into an organic solution via the liquid membrane system, and stripping the metal species from the organic solution into an aqueous phase.

14. The method of claim 6, wherein the effluent includes at least a first metal species and a second metal species, the method further comprising:

extracting the first metal species in a first extraction stage, wherein the second metal species remains in the effluent following the first extraction stage; and

extracting the second metal species in a second extraction stage.

15. A method for using a functionalized chemical planarization pad and recovery of metal species in planarization processes, the method comprising:

planarizing a substrate material with the functionalized chemical planarization pad including a plurality of functional groups bonded to a material of the pad, the functional groups being configured to chemically react with the substrate material such that a portion of substrate material bonds to the functional groups;

regenerating the pad by applying a regeneration solution configured to break bonds between the functional groups and substrate material bonded to the functional groups to form removed material, wherein regenerating the pad includes reacting the substrate material bonded to the functional groups with a stripping agent configured to break the bonds between the functional groups and the substrate material bonded to the functional groups via oxidation and/or hydrolysis;

complexing the removed material in a dissolved complexing agent to form dissolved material in an effluent phase, wherein the dissolved complexing agent is provided in the regeneration solution contemporaneously with the stripping agent; and

recovering the dissolved material from the effluent phase.