

CLAIMS

1. A silicon conditioning head comprising:

a substrate, wherein the substrate comprises a silicon; and wherein the substrate includes a substrate surface;

a plurality of protrusions extending approximately 2 to approximately 75 microns from the substrate surface;

wherein the plurality of protrusions are arranged in a plurality of sinusoidal wave patterns across at least a portion of the substrate surface.
2. The silicon conditioning head of claim 1 wherein the plurality of sinusoidal wave patterns include at least two sinusoidal wave patterns with a phase offset.
3. The silicon conditioning head of claim 1 wherein the substrate comprises a first side and an opposing second side; and wherein the plurality of protrusions extend from the first side of the substrate ; and wherein the substrate further comprises:

a macro pattern; wherein the macro pattern comprises:

one or more first portions; and

one or more second portions; wherein the one or more second portions of the macro pattern are disposed closer to the second side of the conditioning head than the one or more first portions of the macro pattern;

and wherein the plurality of protrusions are disposed on the one or more first portions of the macro pattern.

4. A layered conditioning head comprising:

a substrate, wherein the substrate comprises a substrate surface; and wherein the substrate comprises:

a first layer, wherein the first layer comprises at least one of:

a carbide ceramic,

or a composite; wherein the composite comprises a carbide and a first carbide forming material;

a second layer, wherein the second layer comprises a composite that includes a second carbide forming material, and wherein the second layer is disposed on top of the first layer; and wherein the second layer comprises:

a plurality of protrusions extending approximately 2 to approximately 100 microns from the substrate surface;

wherein the plurality of protrusions are arranged in a plurality of sinusoidal wave patterns across at least a portion of the substrate surface.

5. The layered conditioning head of claim 4 wherein the substrate surface comprises a portion of the first layer or a portion of the second layer.
6. The layered conditioning head of claim 4 wherein the first layer comprises a ceramic.
7. The layered conditioning head of claim 4 wherein the second carbide forming material comprises at least one of Silicon, Titanium, or Molybdenum.

8. The layered conditioning head of claim 4 wherein the plurality of sinusoidal wave patterns include at least two sinusoidal wave patterns with a phase offset.
9. A conditioning head comprising:
 - a substrate; wherein the substrate comprises at least one of:
 - a carbide forming material,
 - a ceramic,
 - or a composite, wherein the composite comprises a carbide and a carbide forming material;
 - a plurality of protrusions extending approximately 2 to approximately 75 microns from the substrate surface;
 - wherein the plurality of protrusions are arranged in a plurality of sinusoidal wave patterns across at least a portion of the substrate surface.
10. The conditioning head of claim 9 wherein an aspect ratio of height to width of each protrusion of the plurality of protrusions comprises approximately 1: approximately 1.
11. The conditioning head of claim 9 wherein the plurality of protrusions form an array comprising a plurality of repeating unit cells, and wherein a subset of the plurality of protrusions are arranged the plurality of sinusoidal wave patterns in each unit cell of the repeating unit cells.
12. The conditioning head of claim 9 wherein a density of protrusions is approximately 1 protrusions/mm² to approximately 100 protrusions/mm².

13. The conditioning head of claim 9, wherein a wavelength of each wave pattern comprises at least 6 protrusions.
14. The conditioning head of claim of claim 9 wherein the substrate comprises a first side and an opposing second side; and wherein the plurality of protrusions extend from the first side of the substrate; and wherein the substrate further comprises:
- a macro pattern; wherein the macro pattern comprises:
- one or more first portions; and
- one or more second portions; wherein the one or more second portions of the macro pattern are disposed closer to the second side of the conditioning head than the one or more first portions of the macro pattern;
- and wherein the plurality of protrusions are disposed on the one or more first portions of the macro pattern.
15. The conditioning head of claim 9 wherein the macro pattern comprises a radial pattern in which the one or more first portions of the macro pattern extend from a center of the substrate surface and the one or more second portions of the micropattern extend radial from the center of the substrate surface.
16. The conditioning head of claim 9 wherein each protrusion has a width of approximately 10 microns to approximately 100 microns, and wherein each protrusion has a length of approximately 10 microns to approximately 100 microns.
17. The conditioning head of claim 9, wherein the plurality of sinusoidal wave patterns include at least two sinusoidal wave patterns with a phase offset.
18. The conditioning head of claim 9 wherein at least one of the sinusoidal wave patterns in the plurality of sinusoidal wave patterns comprises at least one of different

amplitude or different frequency than one or more other sinusoidal wave patterns in the plurality of sinusoidal wave patterns.

19. The conditioning head of claim 9 wherein a first subset of protrusions in the plurality of protrusions do not have the same cross-sectional shape as a second subset of protrusions in the plurality of protrusions.

20. The conditioning head of claim 15, wherein one or more of the plurality of sinusoidal wave patterns is defined by the formula:

$$Y = A * \sin(B(X - C)) + D;$$

wherein

A = amplitude of the wave;

B = the frequency of the wave;

C = the horizontal shift of the wave; and

D = the vertical shift of the wave.