Embodiments herein relate generally to the field of footwear, and more particularly to components of performance footwear, such as midsoles, and in particular related to high-stability, multi-density midsoles. In some embodiments, the midsoles disclosed herein may protect a user from over-pronation and/or over-supination of the foot. Embodiments of the high stability midsoles disclosed herein may include a cushioning element and a mid-foot element. In various embodiments, the mid-foot element may be configured to mate with the cushioning element in the mid-foot portion, and may include at least one posterior tail configured to align with a medial or lateral edge of the heel portion of the cushioning element. Alternatively, the midsole may have integrated cushioning regions with different response property regions.
HIGH-STABILITY MULTI-DENSITY MIDSOLE

CROSS REFERENCE TO RELATED APPLICATIONS


TECHNICAL FIELD

[0002] Embodiments herein relate generally to the field of footwear, and more particularly to components of performance footwear, such as midsoles.

BACKGROUND

[0003] Since the introduction of cushioned midsoles in running shoes, injuries associated with the impact of foot strikes have been reduced. Concomitantly, runners have adapted to cushioned running shoes by increasing stride length and landing more toward the lateral posterior edge of the heel. This adaptation may be associated with excessive foot/ankle motion. Moreover, pronation injuries such as inversion and eversion sprains are thought to occur if the initial pronation velocity is too high or the maximum pronation angle is too great.

[0004] To mitigate the negative effects of a cushioned heel, the modern running shoe evolved to feature different midsole stiffness regions. The heel “crash pad” is a soft, beveled midsole feature that facilitates compression of the lateral posterior portion of the midsole as the heel impacts the ground, thereby reducing the initial rate of pronation. “Medial posting” is a common midsole feature designed to reduce maximum pronation. As the stride transitions from heel to mid-stance, the foot pronates in greater measure until it is opposed by a stiffer, less compressive midsole in the arch and just posterior to the arch.

[0005] Both of these concepts effectively use local midsole stiffness to control motion when running on a smooth surface such as a road, in which heel strike kinematics are predictable and repeatable. However, for the trail runner, the surface is much more variable and much less predictable. The smooth, firm road is replaced by a wide range of grades potentially covered with loose gravel, scree, talus, and many other impediments. Consequently, the initial point of heel contact can greatly vary from step-to-step. For example, if the foot lands on a rock under the medial posterior portion of a medially posted running shoe heel, the stiff and less yielding medial midsole will work to force the ankle to quickly rotate to an inverted position and the soft, beveled crash pad may not provide enough resistance to contain excessive and potentially catastrophic inversion of the foot.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings. Embodiments are illustrated by way of example and not by way of limitation in the figures of the accompanying drawings.

[0007] FIGS. 1A-1D illustrate a bottom view (FIG. 1A), and top (FIGS. 1C and 1D) views of a high-stability, impact-absorbing, multi-density midsole that includes a generally soft cushioning element and a firmer mid-foot element, in accordance with various embodiments.

[0008] FIGS. 2A-2D illustrate a medial side view (FIG. 2A), a bottom view (FIG. 2B), a lateral side view (FIG. 2C), and a posterior view (FIG. 2D) of the mid-foot element shown in FIG. 1, in accordance with various embodiments; and

[0009] FIGS. 3A-3D illustrate four examples of a high stability, impact-absorbing, multi-density midsole and its corresponding mid-foot element, including an example with a medium length lateral posterior tail and a long medial posterior tail (FIG. 3A), an example with a short lateral posterior tail and a long medial posterior tail (FIG. 3B), an example with a medium lateral posterior tail and a medium medial posterior tail (FIG. 3C), and an example with a short lateral posterior tail and a medium medial posterior tail (FIG. 3D), in accordance with various embodiments.

DETAILED DESCRIPTION OF DISCLOSED EMBODIMENTS

[0010] In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which are shown by way of illustration embodiments that may be practiced. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope. Therefore, the following detailed description is not to be taken in a limiting sense, and the scope of embodiments is defined by the appended claims and their equivalents.

[0011] Various operations may be described as multiple discrete operations in turn, in a manner that may be helpful in understanding embodiments; however, the order of description should not be construed to imply that these operations are order dependent.

[0012] The description may use perspective-based descriptions such as up/down, back/front, and top/bottom. Such descriptions are merely used to facilitate the discussion and are not intended to restrict the application of disclosed embodiments.

[0013] The terms “coupled” and “connected,” along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Rather, in particular embodiments, “connected” may be used to indicate that two or more elements are in direct physical or electrical contact with each other. “Coupled” may mean that two or more elements are in direct physical or electrical contact. However, “coupled” may also mean that two or more elements are not in direct contact with each other, but yet still cooperate or interact with each other.

[0014] For the purposes of the description, a phrase in the form “A and/or B” means (A), (B), or (A and B). For the purposes of the description, a phrase in the form “at least one of A, B, and/or C” means (A), (B), (C), (A and B), (A and C), (B and C), or (A, B, and C). For the purposes of the description, a phrase in the form “(A)B” means (B) or (AB) that is, A is an optional element.

[0015] The description may use the terms “embodiment” or “embodiments,” which may each refer to one or more of the same or different embodiments. Furthermore, the terms “comprising,” “including,” “having,” and the like, as used with respect to embodiments, are synonymous.

[0016] Embodiments herein are directed to performance footwear components, such as midsoles, that may reduce the initial pronation and supination rates that may occur when the heel strikes on a surface, including uneven, rough surfaces such as gravel roads, scree, talus, or rutted trails. In some embodiments, this may be accomplished by providing a midsole having a full heel area that may provide a long, soft spring rate to absorb shock and/or impact from rocks and debris at heel strike. In various embodiments, the disclosed
midsoles may also reduce the maximum pronation and supination angles that result from heel-to-mid-stance transition on uneven, irregular surfaces. For instance, various examples of the disclosed high-stability midsoles may provide a midfoot structure/element that may guide either a pronated or supinated foot to a neutral position by the midstance-to-toe-off phase of running gait.

While certain embodiments are discussed with reference to trail running, embodiments herein may be applicable to a wide variety of activities, such as running and hiking; various sports, such as volleyball, basketball, and tennis; various professions, such as medical, industrial, safety, rescue, and military, and other suitable applications.

Various embodiments of the midsole may include both a generally soft cushioning element and a firmer midfoot element. In various embodiments, the generally soft cushioning element may include a heel portion that may provide a cushioning and impact-absorbing layer and that is configured to absorb the impact and/or shock of the heel hitting a rock or other uneven surface, without causing the instability (e.g., pronation or supination) that may be caused by a traditional (e.g. firm) post midsole. In various embodiments, the midfoot element may be any suitable shape including angled curved, parabolic, hyperbolic, etc.

In various embodiments, the midsole also may include a mid-foot element that may be firmer than the soft cushioning element, and that may have one or more medial and/or lateral posterior “tails” that may extend along at least a portion of a corresponding medial or lateral edge of the heel portion of the cushioning element. In various embodiments, after the initial heelstrike, as the foot begins to roll forward, the firmer consistency of the medial and or posterior tails of the midfoot element may then begin to correct any pronation or supination and may return the foot to a neutral position, for instance by the time the foot has transitioned to the midstride or toe-off phases. In various embodiments, the firmness of the cushioning element and/or mid-foot element and the length and/or height of the mid-foot element and/or posterior tails may be varied to suit a particular condition or set of conditions, such as the surface conditions, a user’s running/walking style, a particular sport, activity, or profession, weight of the user, weight and distribution of carried objects such as backpacks, length or height of the user, or to accommodate or correct a particular gait problem, such as over-pronation or oversupination.

In various embodiments, a midfoot portion 112 and/or a forefoot portion 126 may include a foam and/or rubber type material having different response properties (e.g., densities or durometers) providing a variety of biomechanical improvements, including, but not limited to improved impact cushioning, support, and stability, for instance when used on uneven terrain. In the illustrated embodiment, materials having different response properties (e.g., different durometers, which may generate different sensations of softness or firmness) are strategically positioned in a configuration that may be useful in, for example, athletic shoes or boots, to help reduce the initial pronation and/or supination rate and the maximum pronation and supination angle. For instance, midsole 100 may include different response property areas arranged about one or more edges 120, 122 of heel portion 114, with, for example, a higher density or durometer material disposed therein in mid-foot element 112. In use, as heel portion 114 absorbs the impact force of the initial heelstrike, one or more posterior tails 116, 118 may serve to arrest and reverse any excessive pronation or supination and return the foot to a more neutral position.

Although Figs. 1A-1D depict midsole 100 as having two separate (discrete, couplable) components (e.g., cushioning element 110 and midfoot element 112), one of skill in the art will appreciate that midsole 100 may be constructed as a single component having different response property regions, i.e., the cushioning element and the frame may be integral components of the midsole. For instance, instead of discrete components, midsole 100 may be constructed as a unitary structure, which, in some embodiments, may have blended transitions between materials having different densities or durometers, such as described in U.S. Patent Application No. 61/345,978, which is incorporated by reference herein. As used herein, the term “blended transition zones” and any variation thereof may generally refer to the interlocking or intermixing of materials (e.g. foams) having different response properties (e.g. densities or durometers), such that there is not a definite, clearly defined linear or planar path between the materials with different response properties.

Cushioning element 110 may also include a midfoot portion 124 and a forefoot portion 126. In some embodiments, cushioning element 110 may form an entire upper surface of midsole 100, providing the entire footbed with cushioning, for instance for comfort and impact absorption. In various embodiments, midfoot element 112 also may include an anterior medial tail 128 and/or an anterior lateral tail 130, and may maintain a neutral foot position during toe-off. Furthermore, anterior medial tail 128 and anterior lateral tail 130 may provide lateral stabilization, and they may help the shoe to flex across the forefoot in an anatomically correct location.

Additionally, one of skill in the art will appreciate that although midfoot element 112 is depicted as mating with a bottom surface of cushioning element 110, midsole 100 may be constructed only as a midfoot element 112, or as a midfoot element 112 configured to mate with a top surface of cushioning element 110. Furthermore, although midsole 100 is illustrated as having forefoot 126, mid-foot 124, and heel 114 portions, one of skill in the art will appreciate that some embodiments of midsole 100 may only include a heel portion 114 and a mid-foot portion 124.

In various embodiments, cushioning element 110 and midfoot element 112 may have different response properties, which may be characterized in terms of density, durometer, flex, specific gravity, and other footwear design characteristics. These different properties may allow for a variety of biomechanical improvements, including, but not limited to improved impact cushioning, support, and stability, for instance when used on uneven terrain. In the illustrated embodiment, materials having different response properties (e.g., different durometers, which may generate different sensations of softness or firmness) are strategically positioned in a configuration that may be useful in, for example, athletic shoes or boots, to help reduce the initial pronation and/or supination rate and the maximum pronation and supination angle.
ness or support is needed (e.g., in a heel portion or fore-foot portion). The thickness of mid-foot element 212 also may be greater at the medial and/or lateral edges, for instance, when greater stabilization or protection from supination or pronation is desired.

[0026] FIGS. 3A-3D illustrate four examples of a high stability, impact-absorbing, multi-density midsole 300(a-d), including cushioning element 310(a-d) and its corresponding mid-foot element 312(a-d). These include an example of a cushioning element 310a and corresponding mid-foot element 312a, wherein mid-foot element 312a may have a medium length lateral posterior tail 316a and a long medial posterior tail 316a (FIG. 3A), an example of a cushioning element 310b and corresponding mid-foot element 312b, wherein mid-foot element 312b may have a short lateral posterior tail 318b and a long medial posterior tail 316b (FIG. 3B), an example of a cushioning element 310c and corresponding mid-foot element 312c, wherein mid-foot element 312c may have a medium lateral posterior tail 318c and a medium medial posterior tail 316c (FIG. 3C), and an example of a cushioning element 310d and corresponding mid-foot element 312d, wherein mid-foot element 312d may have a short lateral posterior tail 316d and a medium medial posterior tail 316d (FIG. 3D), in accordance with various embodiments.

[0027] As illustrated, the length of the posterior tails 316(a-d), 318(a-d) may be varied to suit a particular condition or set of conditions. For instance, the medium length lateral posterior tail 318a and long medial posterior tail 316a illustrated in FIG. 3A may serve to stabilize the foot in both medial and lateral directions and may provide strong protection from over-pronation and moderate protection from over-supination. In another example, the short lateral posterior tail 318b and a long medial posterior tail 316b illustrated in FIG. 3B may provide strong protection from over-pronation, for instance for a user or set of conditions prone to over-pronation but not at serious risk of over-supination. The example illustrated in FIG. 3C has a medium lateral posterior tail 318c and a medium medial posterior tail 316c, and may provide moderate protection from both over-pronation and over-supination. Finally, the example illustrated in FIG. 3D includes a short lateral posterior tail 318d and a medium medial posterior tail 316d, which may provide moderate protection from over-pronation, for instance for a user or set of conditions in which over-pronation is more of a risk than over-supination.

[0028] FIGS. 3A-3D illustrate the lengths of the lateral posterior tail(s) and the medial posterior tail(s) measured as a percentage of entire sole length measured from the heel. For example, the long tails reach back to about 10% of full length from the heel, for example, about 3-14%, about 5-13%, or about 7-12%. Likewise, a medium tail reaches back to about 20% of full length from the heel, for example, about 15-24%, about 17-23%, or about 18-21%, and a short tail reaches back to about 30% of full length from the heel, for example about 25-37%, about 27-35%, or about 28-33%. These lengths are merely examples, and may be modified in line with the teachings herein as desired for different functionality. For instance, a tail may be as long as about 3%, 5% or 7% of full length from the heel, as short as about 37%, 35%, or 33% of full length from the heel, or any length therebetween. In addition to varying the length of the tails, the thickness and/or height of each tail may be individually configured for a desired amount of lateral or medial support. For example, a slightly thicker tail may provide more support, and a slightly thinner tail may provide less support, as compared to the illustrated examples.

[0029] One of skill in the art will appreciate that, although not illustrated, anterior tails 128, 228, 328(a-d), and 130, 230, 330(a-d) may be similarly varied in length to create a desired degree of stability and mid-foot alignment during toe-off. Additionally, in various embodiments, the thickness and/or height of each anterior or posterior tail may be optimized to provide the degree of support desired for a particular user or set of conditions. Furthermore, in various embodiments, the thickness of mid-foot element 112, 212, 312(a-d) may be increased in any region where more stabilization or firmer support is desired, or for a heavier or taller user. Many conventional midsoles include a support Shank for this purpose or to stabilize the midsole from torsional motion. Although a support Shank such as a steel Shank may be included in some embodiments, in other embodiments, mid-foot element 112, 212, 312(a-d) may make a support Shank unnecessary. In some embodiments, mid-foot element 112 may occupy the full thickness of the midsole in some regions, such as in the mid-foot portion 126 for instance to provide firm arch support. Additionally or alternatively, in some embodiments, cushioning element 110, 310(a-d) may be made thicker in a particular region or throughout midsole 100, 200, 300(a-d) if greater comfort or cushioning is required, for instance for a heavier user, for certain terrain conditions, or for a user with foot pain or an injury.

[0030] In the foregoing embodiments, one of skill in the art will appreciate that, although only two different material response property areas are illustrated (e.g., cushioning element 110 and mid-foot element 112), any number of response property areas may be used, for instance 3, 4, 5, 6, or even more. Such different response property areas may be arranged in a number of strategic configurations. For example, an additional low density or low durometer material may be used wherever extra softness or cushioning is needed, such as in the heel or fore-foot portions, or for use when the user has an injury or otherwise requires more cushioning. In another example, an additional higher density or higher durometer material may be included in any area requiring firm support, extra stability, or extra durability. As described above, in some embodiments, the specific configuration of the midsole may be customized to suit the needs, footstrike pattern, terrain, or running style of an individual user.

[0031] Although the response property areas are referred to herein as low and high (e.g., as it relates to firmness, density, or durometer), one of skill in the art will appreciate that these terms are relative. For example, where the material response property is durometer, the term “low” may correspond to about 40-60 durometer, or about 50-60 durometer in some embodiments. Correspondingly, where the material response property is durometer, the term “high” may correspond to about 60-75 durometer C, or about 65-75 durometer C in some embodiments. In other embodiments, greater or lower response property materials also may be used to suit the desired application.

[0032] In some embodiments, the midsole material may extend around and/or over the instep, for instance to provide greater protection and stability through the midfoot portion. In still other embodiments, the midsole material may extend around and/or over the forefoot portion, for instance to provide protection to the toes. In particular embodiments, the midsole material that extends past the midsole may include a less dense material, such as an extra soft response property material.

[0033] The different response properties may be achieved by a variety of materials suitable for midsole construction.
For example, in some embodiments, EVA foam materials may be formed or cut to a desired size and shape to form the cushioning element 110, 210, 310(a-d) and/or mid-foot element 112, 212, 312(a-d), and the two components may be glued or otherwise affixed together. A variety of midsole-forming techniques are known, such as pre-form and compression molding, injection molding, pellet pour and the like. In other embodiments, polymer foam pellets (such as EVA pellets) may be arranged such that compression molding of the pellets results in blending of the different response properties in the transition zones. In other embodiments, the midsole may include one or more other types of material in foamed or solid form, such as rubberized EVA, polyurethane, thermo-plastic elastomers, polyolefins, rubber, or any other suitable midsole/footwear construction material.

Although certain embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent embodiments or implementations calculated to achieve the same purposes may be substituted for the embodiments shown and described without departing from the scope. Those with skill in the art will readily appreciate that embodiments may be implemented in a very wide variety of ways. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that embodiments be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A high stability midsole comprising:
   a cushioning element comprising mid-foot and heel portions; and
   a mid-foot element configured to mate with the cushioning element in the mid-foot portion, wherein the mid-foot element comprises at least one posterior tail configured to align with a medial or lateral edge of the heel portion of the cushioning element.

2. The high stability midsole of claim 1, wherein the heel portion comprises low density foam, and wherein the low density foam comprises 40-60 Asker C foam.

3. The high stability midsole of claim 1, wherein the heel portion comprises low density foam, and wherein the low density foam comprises 50-60 Asker C foam.

4. The high stability midsole of claim 1, wherein the mid-foot element comprises high density foam, and wherein the high density foam comprises 60-75 Asker C foam.

5. The high stability midsole of claim 1, wherein the mid-foot element comprises high density foam, and wherein the high density foam comprises 65-75 Asker C foam.

6. The high stability midsole of claim 1, wherein the heel portion comprises 50-60 Asker C foam, and wherein the heel portion comprises 60-75 Asker C foam.

7. The high stability midsole of claim 1, wherein the mid-foot element comprises a medial posterior tail configured to align with a medial edge of the heel portion of the cushioning element, and a lateral posterior tail configured to align with a lateral edge of the heel portion of the cushioning element.

8. The high stability midsole of claim 7, wherein the medial posterior tail is long and the lateral posterior tail is of medium length.

9. The high stability midsole of claim 7, wherein the medial posterior tail is long and the lateral posterior tail is short.

10. The high stability midsole of claim 7, wherein the medial posterior tail is of medium length and the lateral posterior tail is of medium length.

11. The high stability midsole of claim 7, wherein the medial posterior tail is of medium length and the lateral posterior tail is short.

12. The high stability midsole of claim 7, wherein the medial posterior tail is of medium length and the lateral posterior tail is long.

13. The high stability midsole of claim 7, wherein the medial posterior tail is longer than the lateral posterior tail.

14. The high stability midsole of claim 7, wherein the medial posterior tail is shorter than the lateral posterior tail.

15. The high stability midsole of claim 7, wherein the medial posterior tail and the lateral posterior tail are substantially the same length.

16. The high stability midsole of claim 1 wherein the cushioning element further comprises a fore-foot portion, and wherein the mid-foot element comprises a fore-foot portion of the cushioning element and a lateral anterior tail configured to align with a lateral edge of the fore-foot portion of the cushioning element.

17. The high stability midsole of claim 16, wherein the medial anterior tail is longer than the lateral anterior tail.

18. The high stability midsole of claim 1, wherein the midsole is configured to be customizable to suit a particular user, gait problem, or terrain.

19. The high stability midsole of claim 1, wherein the cushioning element and the mid-foot element are two separate components of the midsole.

20. The high stability midsole of claim 1, wherein the cushioning element and the mid-foot element are integral components of the midsole.

21. A high stability midsole comprising:
   a cushioning element comprising fore-foot, mid-foot, and heel portions, wherein the heel portion comprises 40-60 Asker C foam; and
   a mid-foot element comprising 60-75 Asker C foam and configured to mate with the cushioning element in the mid-foot portion, wherein the mid-foot element comprises:
   a medial posterior tail configured to align with a medial edge of the heel portion of the cushioning element; a lateral posterior tail configured to align with a lateral edge of the heel portion of the cushioning element; a medial anterior tail configured to align with a lateral edge of the fore-foot portion of the cushioning element; and a lateral anterior tail configured to align with a lateral edge of the fore-foot portion of the cushioning element.

22. The high stability midsole of claim 21, wherein the medial posterior tail is longer than the lateral posterior tail.

23. The high stability midsole of claim 21, wherein the medial posterior tail is shorter than the lateral posterior tail.

24. The high stability midsole of claim 21, wherein the medial posterior tail is substantially the same length as the lateral posterior tail.

25. The high stability midsole of claim 21, wherein the medial anterior tail is longer than the lateral anterior tail.

26. The high stability midsole of claim 21, wherein the cushioning element and the mid-foot element are two separate components of the midsole.

27. The high stability midsole of claim 21, wherein the cushioning element and the mid-foot element are integral components of the midsole.