tation, an electric current, an electric field (voltage), a temperature change, a magnetic field, a mechanical loading or stressing (such as stress induced superelasticity in SMA), a chemistry or pH change, and the like.

[0017] Also, as used herein, the terms "first", "second", and the like do not denote any order or importance, but rather are used to distinguish one element from another, and the terms "the", "a", and "an" do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. Furthermore, all ranges directed to the same quantity of a given component or measurement is inclusive of the endpoints and independently combinable.

[0018] In one embodiment, a device for selectively controlling and varying surface texture includes a body having at least one surface, and an active material in operative communication with the at least one surface, wherein the active material is configured to undergo a change in a property upon receipt of an activation signal, wherein the change in a property is effective to change a texture of the at least one surface. The change in the texture of the surface can include, without limitation, creation of a surface texture on an otherwise smooth surface and/or a change in scale, magnitude, shape, spacing, number, pattern, compliance characteristics and the like of the existing surface texture.

[0019] The devices for selectively controlling and varying surface texture and frictional force levels on a surface as disclosed herein may be used in any application adversely or beneficially affected by friction, such as traction devices, clutches, brakes, bearings, aerodynamics, clamps, and the like. Moreover, the active material based bodies can be employed for control of fluid boundary layer flow over surfaces. For example, airflow boundary layers, aero drag, and aero noise can be controlled by varying the texture of the surface through the use of active materials. This could be employed, for example, to alter the pressure forces on a vehicle and adjust the downforce applied to wheels to tailor performance to specific operating conditions. The texture can be varied to create turbulent or laminar boundary layer flow patterns over any variable texture surface. The active material based bodies can also be used to control noise generated by the flow of air over a surface. For example, a vehicle antenna comprising an active material surface can be configured to change the surface texture of the antenna upon receipt of an activation signal by the active material. The change in the surface texture, such as a roughening of the surface, is effective to reduce the noise generated by airflow over the surface of the antenna. In the case of a powered antenna, for example, the antenna can have a smooth first surface when stowed and while deploying. Once the antenna is fully deployed, however, the active material can be activated to create a rough textured antenna surface. Likewise, the active material based bodies can be used not only to reduce the noise of airflow over a surface, but also to control the reflection of sound in acoustic applications.

[0020] In yet another application, the active material based bodies for varying surface texture can be used to control the visual appearance and/or feel of a surface to provide haptic signals to a user. In other words, the appearance and/or feel of a surface can be altered/controlled through the use of the active material based bodies. For example, glare on a vehicle dashboard can be reduced by varying the surface texture of the dashboard to create a surface which diffuses or scatters the sunlight. Alternatively, the surface can be made temporarily highly reflective to help manage heat from radiation entering the vehicle when parked in the sun. In a haptic example, the texture of a control knob surface can be controlled, such that the feel of the knob changes in a user's hand when the knob reaches a predetermined desired position. The active material based bodies can be employed to passively indicate a certain temperature or exposure to a specified level of temperature or magnetic field strength of a surface. In other words, the active material based body can be configured to change a surface texture to indicate a hot surface or to show exposure of the surface to a high temperature. A change in the texture of the surface can be used to help separate and remove coatings, deposits, and contaminants (such as ice) from the surface. The change in the texture of the surface can be used to help reduce the intimacy of contact between the surface and a second surface, uses including, but not limited to, permitting gas or liquid flow through a normally sealed interface such as for cooling or ventilation purposes.

[0021] These are just some of the many examples where the ability to adjust the frictional forces and/or vary the texture of a surface would be advantageous. Other applications, which could advantageously make use of the active material based body embodiments and methods disclosed below, will be known to those skilled in the art, and can include without limitation, haptic steering wheel feedback, haptic elevator floor wherein texture indicates floor number, and the like. Any platform configuration where the user is already in contact with a surface and one wants to create communication or feedback through that surface. In addition, it is to be understood that the surface texture and/or frictional force levels of the surface is controlled by active materials in communication with the body having the surface. Moreover, while certain methods were described with reference to specific active materials, it is to be understood that any active material may be capable of use for a certain application and method and may depend on the physical characteristics of the materials. The active materials may also take any physical form, such as, for example, porous, solid, embedded in second material (randomly or oriented), laminate, solid, lattice, particles, fibers, and the like.

[0022] The active material may change at least one property in response to an activation signal, and revert back to the original state of the at least one property upon discontinuation of the activation signal, or, for the classes of active materials that do not automatically revert upon discontinuation of the activation signal, alternative means can be employed to revert the active materials to their original state. In this manner, the active material based bodies function to adjust to changing conditions while increasing device simplicity and reducing the number of failure modes. As an example of an application where reversion back to the active material's original state is not advantageous, an SMP based body could be used. The SMP based body has a dimple textured surface in its memory state. Upon activation of a heat signal, the SMP dramatically softens and the surface texture can be flattened by pressing the textured surface against a flat surface. Cooling while holding the surfaces in contact locks in the flattened surface geometry on the SMP based body due to the accompanying dramatic increase in the modulus of the SMP. Reapplication of the heat signal with the surface loading removed would be required to return the SMP to the original dimpled surface. In another example, the active material based body can be a shaft configured for sliding into a vehicle hub. In its original state, the shaft could have a diameter smaller than the hub so that it can easily be installed within the hub. Once properly positioned