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Non-Confidential Description - PSU No. 1731
"Crack Arrest in Brittle Materials Using Residual Stresses"

Keywords:

Material science, engineering, ceramics, glasses, strengthening, crack arrest, ceramic durability, ion exchange, chemical strengthening, damage tolerance, strength uniformity, electronic display glasses

Links:

Inventor Website
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Background

Brittle materials, such as ceramics and silicate glasses, are sensitive to contact damage, which gives rise to flaws that reduce overall strength. Moreover, these materials usually fail in an unstable and catastrophic way. For example, when most ceramics and glasses are tested in bending or uniaxial tension, a single flaw forms into a propagating crack that grows rapidly and unstably. In many cases, the crack branches, forming splinters. This behavior causes dangerous failure, with no forewarning and produces potentially harmful splinters. Clearly a technique for arresting cracks in brittle materials would have advantages over the present situation. While some researchers have looked to increase material strength, this approach often leads to increased strength variability. A more viable process, then, would increase material strength while reducing strength variability. Another importance consequence of the crack arrest is greatly improved damage tolerance, in which the strength becomes independent of the degree of contact damage. For example, the strength is reduced by increasing scratch depth or contact flaw size over some damage range.

Invention Description

This invention uses residual compressive stresses to induce crack stabilization in brittle materials – a novel alternative means of enhancing mechanical reliability. These compressive residual stresses increase the difficulty of crack propagation. Brittle materials, such as glass, demonstrate some degree of fail-safe behavior after treatment. Treated materials undergo multiple cracking: A crack forms in the surface, but then arrests. This is followed by the formation of other cracks, but design of the stresses avoids the unstable and catastrophic failure typically associated with brittle materials. This novel behavior offers advantages in many ceramics and glass applications. The crack arrest behavior is produced by a novel manipulation of the stresses produced when a glass is strengthened by surface compression. In particular,

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a compressive stress maximum is produced and the stress gradient is controlled. This effect has been demonstrated by a two-step ion exchange process or by changing the process parameters during ion exchange.

Advantages / Applications

- Improved mechanical reliability of glasses, especially those used as screens for mobile electronic devices, electronic tablets, computers, television and video player screens.
- Strengthened materials, with a significant reduction in strength variability; strength insensitive to initial flaw size.
- Crack arrest and multiple cracking precede catastrophic failure.
- Damage tolerance in which strength is not reduced by increasing degree of surface damage.
- Concept can be applied to ceramics and laminates.

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