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Self Healing Technology

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Abstract— **Today increasingly complex systems, composed of a variety of components, operating in large-scale distributed heterogeneous environments, require more and more human skills to install, configure, tune, and maintain. such complex systems would be able to recognize and solve a large portion of these errors on their own. To this purpose, these systems would need to be self aware, to know when and where an error state occurs, to have adequate knowledge to stabilize themselves, to be able to analyze the problem situation, to make healing plans, to suggest various solutions to the system administrator, to heal themselves without human intervention.**

I. INTRODUCTION

Self - healing can be defined as the ability of a material to heal (recover/repair) damages automatically and autonomously, that is, without any external intervention. Many common terms such as self-repairing, autonomic-healing, and autonomic-repairing are used to define such a property in materials. Incorporation of self-healing properties in manmade materials very often cannot perform the self-healing action without an external trigger. Thus, self-healing can be of the following two types.

- Autonomic

Autonomic healing: Fully self-contained and requiring no external interventionof any kind

- Non Autonomic

Non-autonomic healing: Partially self-contained; healing capability is designed into the material, but additional external stimuli such as heat or uv-radiation is required for the healing to occur. This definition is intended to differentiate this level of autonomy in the healing mechanism from historical approaches such as solvent-welding, which required localization of the damage and manual application of solvent and/or heat.

II. SELF HEALING MATERIAL

Self-healing materials type of smart materials that have the structurally incorporated ability to repair damage caused by mechanical usage over time. The inspiration comes from biological systems, which have the ability to heal after being wounded. Initiation of cracks and other types of damage on a microscopic level has been shown to change thermal, electrical, and acoustical properties, and eventually lead to whole scale failure of the material. Usually, cracks are mended by hand, which is difficult because cracks are often hard to detect. A material (polymers, ceramics, etc.) that can intrinsically correct damage caused by normal usage could lower production costs of a number of different industrial processes through longer part lifetime, reduction of inefficiency over time caused by degradation, as well as prevent costs incurred by material failure. For a material to be defined as self-healing, it is necessary that the healing process occurs without human intervention. Some examples shown below include healing polymers that are not "self-healing" polymers.

III. DESIGN STRATEGIES

The different types of materials such as plastics/polymers, paints/coatings, metals/
alloys, and ceramics/concrete have their own self-healing mechanisms. The different types of self-healing processes are discussed with respect to design strategies and not with respect to types of materials and their related self- healing mechanisms. The different strategies of designing self-healing materials are as
follows:

- Release of healing agent
- Reversible cross-links
- Miscellaneous technologies
- Electrohydrodynamics
- Conductivity
- Shape memory effect
- Nanoparticle migration
- Co-deposition

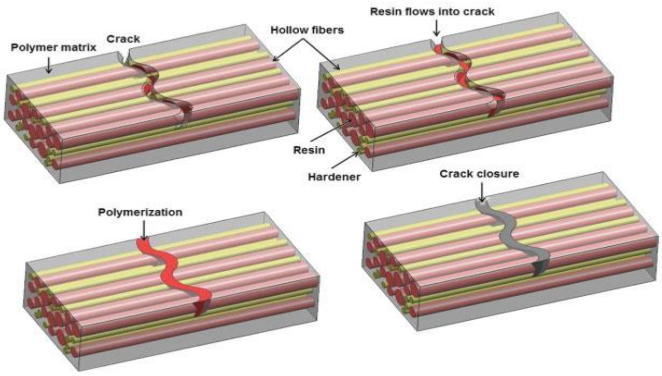

Fig.1 Schematic representation of self-healing concept using hollow fibers.

IV. CHARACTERISTICS OF SELF HEALING MATERIAL

Component	Required characteristics
Liquid healing agent Stability and shelf-life	Must be stable enough to be encapsulated without reaction and must be stable within the microcapsule for long periods until it is released during a healing event.
Deliverablity	Must flow into the site of damage by capillary action, so it cannot be a highly viscous liquid. It must also remain in the site of damage long enough to react, so a highly volatile liquid is not desirable.
Reactivity:	Once the healing agent comes in contact with the catalyst or second reactant, it must react quickly enough to provide healing in a reasonable time frame and to compete with nonproductive processes like evaporation, absorption into the matrix and side reactions
Shrinkage	The resulting polymer should exhibit good adhesive characteristics to rebond the crack planes. Any volume shrinkage could result in the polymerized healing agent pulling away from the crack faces as it is being cured.
Physical and mechanical properties	The incorporation of the healing agent in its encapsulated form should not introduce any deleterious effects to the matrix. Additionally the healing agent must demonstrate mechanical properties equal to or surpassing that of the matrix in its polymerized form
Thermal stability	Must have a low freezing point and a high boiling point to minimize the likelihood of phase changes at various application or use-temperatures
Microcapsule shell wall Chemical compatibility	Material must be chemically inert both to the core material within as well as the surrounding matrix chemistry
Mechanical properties	To facilitate rupture during a healing event, the fracture toughness of the capsule shell wall material should be less than that of the matrix, but high enough to survive standard processing conditions
Dispersion	Must facilitate or at the very least not create a hindrance to dispersion in the desired matrix
Thermal stability	Must be thermally stable over a wide range of temperatures for a wider scope of applications

V. APPLICATION

Applications of self-healing materials are expected almost entirely in all industries in future. The very few applications being developed to date are mainly in the automotive, aerospace, and building industries. self-healing materials development is either in the preliminary or product level, and so these materials are yet to be available for many applications.

Fig.2 LG G flex phone

The very few applications being developed to date are mainly in the automotive, aerospace, and building industries Nissan Motor Co. Ltd has name of this product is ‘‘Scratch Guard

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Coat'' commercialized world's first self-healing clear coat for car surfaces. The trade name of this product is ''Scratch Guard Coat." And other application of self healing technology is that the in smart phones. The latest smart phone of LG company , release its latest G flex smart phone. It will be the first phone to feature a vertically curved screen designed to the contours of the face and more remarkably a self – healing coating on a back cover. Also the future aircraft, paint technology in automotive application could be based on self – healing technology.

VI. CONCLUSION

Small size-scale self-healing systems for composites and optical materials are successfully developed and analyzed. In particular, liquid-filled capsules and active particles on the order of 1 μm in diameter are synthesized and modified such that that minimal aggregation and loss of healing agent occurs during processing. Silica condensation onto 1.4 μm capsules is particularly effective at improving capsule dispersion in both epoxy and polymethylmethacrylate (PMMA). The coatings do not significantly improve capsule stability, however during this work it was found that capsule stability can be significantly enhanced through appropriate work-up
conditions. Catalyst is successfully protected by polymer and silica in sub-micron particles. The silica coating is important for making reducing catalyst deactivation when the particles are cured in epoxy. These capsules and particles are implemented in an epoxy system where the size of damage must be less than 1 μm wide for effective healing to occur. Similarly, partial healing can occur in thermoplastic materials containing micron size dibutyl-phthalate (DBP) capsules.

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