HIGH-TEMPERATURE SELF-REPAIRING COATING MATERIAL FOR SAMPLE RETURN SPACE CAPSULES (SRSC) FOR EARTH ENTRY

E. R. Kutelia[1], S. I. Bakhtiyarov[2], O. O. Tsurtsumia[1], A. I. Bakhtiyarov[2] and B. Eristavi[1], [1] Georgian Technical University, RCSR, 77 Kostava Street, 0175 Tbilisi, Georgia, [2] New Mexico Institute of Mining and Technology, 801 Leroy Place, Socorro, NM 87801, USA, sayavur@nmt.edu

Introduction: A designing of a Sample Return Space Capsule (SRSC) must consider its survivability at high temperatures. The surface of the Space Capsule can reach temperatures of 1480 ^{0}C (~2700 F) as it descends through Earth's atmosphere. This heat can create cracks at the capsule surface which will propagate deeper and eventually destroy the capsule and the content. Early space capsules (e. g., the Apollo capsules) were coated with material that melted and vaporized. Usually, the Space Capsules are coated by high porous and low heat conductive light weight silica. However, if the silica coating is damaged (which happens quite often), then the space capsule will not be protected against high temperature and the content of the capsule will be obliterated.

This work presents the possibility to realize the self healing mechanisms for heterogeneous architectural metal/ceramic high temperature sandwich thermal barrier coating systems on the surfaces refractory metals by analogy of wound healing in the skin.

An idea of engineering of synthetic substances that are capable of self-repairing and adaptation to changing environments came to the scientific world many years ago. Application of these materials would range from space exploration to civil manufacturing. The objective of this part of the purposed research is to understand a biological mechanism of self-healing phenomena, and based on this knowledge to develop a wide range of self-healing materials for aerospace structures. The biological findings will be translated into composite materials. A final goal of the project will be a fabrication of a new class of self-healing composites and testing their thermophysical properties and structural behavior.
This work presents the possibility to realize the self healing mechanisms for heterogeneous architectural metal/ceramic high temperature sandwich thermal barrier coating (TBC) systems on the surfaces refractory metals by analogy of wound healing in the skin. A self-healing of skin is a typical example occurring in nature. Its principles and strategies must be understood and adapted for the engineered heterogeneous architectural metal/metal/ceramic coating systems. A skin protection function was used in our studies in modeling and developing heterogeneous architectural composites with desirable combination of creep resistance and corrosive proof properties at extreme high temperatures (~1200 ^{0}C). A structure of architectural metal/metal/ceramic high-temperature (HT) coating system is given in Figure 1. Each of these three regions of this composition has the following functions:

- the basis provides the HT creep resistance
- the interlayer of the corrosion resistance alloy serves as a reservoir of the scale forming elements necessary for the existence of the thermally activated self-healing cracks
- a thermal grown oxide (TGO) layer provides a resistance against HT gas corrosion of the metal matrix.

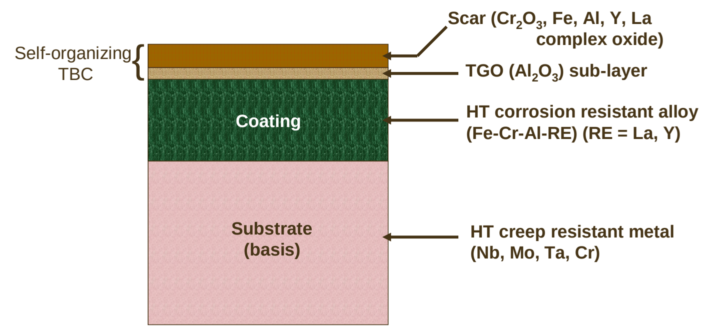

Figure 1. Structure of architectural metal/metal/ceramic HT coating system.

Heterogeneous architectural high temperature (HT) thermal barrier coating (TBC) systems, and more generally, hybrid materials such as sandwiched metal/metal/ceramic TBCs with thermal activated self-healing functional surfaces have received special attention in applications such as aerospace jet and gas turbine engines. The existing TBCs do not exhibit any self-healing capabilities compared to the metallic bond coatings. TBC is made out of a ceramic material and it is a most critical part of the coating system for the lifetime of the coating component. During heating↔cooling cycles the high stresses will be developed due to the mismatch between the thermal expansion coefficients of the substrate and the different layers of the coating system. A life span of the coating system is set by the development of the crack patterns that coalesce and ultimately lead to the failure. An application of the self-healing TBCs are very attractive as a lifetime of such coatings critically determines a time between overhaul and revision of aerospace jet and gas turbine engines for the specific HT applications.