The project

A self healing thermal barrier coating is made of a ceramic material and is deposited onto a metallic substrate. This coating is applied to the surfaces of combustion chambers, blades and vanes in gas turbine engines used for propulsion and power generation in order to allow for higher combustion temperatures. Hence, the thermal barrier function enhances the engine’s fuel efficiency and consequently reduces emission of greenhouse gases.

This project proposal builds on an explorative project entitled self healing thermal barrier coatings (IOP SHM0634). In that project the principle of the crack healing in thermal barrier coatings with Mo-Si containing particles was demonstrated. However, for a successful application this healing mechanism must be characterized in more detail as well as technologically developed further (part A), and quantitative relationships between the damage, the healing reactions and the expected lifetime extension (part B) need to be established. To this end, various as yet unknown physical and chemical and manufacturing aspects of the crack healing concept need to be explored and our existing micromechanical model needs to be extended.

In an explorative study it was demonstrated that the addition of Mo-Si based particles leads to the filling of cracks in the TBC layer. Nonetheless, this self healing mechanism is not fully understood and therefore needs to be thoroughly analyzed in order to significantly improve its efficiency. Hence, the project is aimed at optimizing the self healing capacity of TBC with Mo-Si based dispersed particles for application in gas turbine engines. This will
be achieved through a combined experimental-modelling analysis of a modified self healing approach that relies on the encapsulation of the healing particles. The purpose of the encapsulation is to prevent premature oxidation of the healing agent. A shell of alumina will be created around the healing particles. With this new approach, the healing mechanism will become active only when required.

The project is divided into two concurrent parts that will be executed at Delft University of Technology. The first part (A) will be carried out at the Department of Materials Science and Engineering (Faculty 3mE). It comprises the experimental understanding of the mechanisms of damage development and crack healing in a self healing TBC upon thermal cycling and the practical realization of such a system. The second part (B) will be performed by the Engineering Mechanics Group of the Faculty of Aerospace Engineering. This part concerns the modelling of damage and healing processes and the development of design strategies for self healing TBCs. The manufacturing of the self healing TBC system will be done by KLM and Sulzer. The testing of the system under thermal cycling conditions will be carried out by the National Aerospace Laboratories (NLR).

If successful, this project will lead to a new generation of affordable TBCs with improved lifetime in gas turbine engines. Consequently, a significant economical benefit can be obtained by reducing the number of TBC replacements in critical turbine engine components.

Role of participants
At the Materials Science and Engineering (MSE) Department of Delft University of Technology various projects on high-temperature coating systems have been executed over the last 10 years, which resulted into two patents and more than 20 scientific publications. The research carried out by this participant will focus on the manufacturing, experimental analysis and characterization of an effective self healing TBC system. In addition, this participant will be responsible for the project management.

The Engineering Mechanics (EM) group of Delft University of Technology (participant 2) has a strong track record on the modelling of micro-scale deformation and failure of complex material systems. Recently, participant 2 developed a lifetime model for TBCs, and used it to predict the evolution of complex fracture patterns arising under thermal cycles. The knowledge obtained will be of great benefit for the proposed project. The research will focus on the modelling and subsequent optimization of the self healing mechanism in TBCs.

The Gas Turbine and Structural Integrity Group of the National Aerospace Laboratory (participant 3) has unique facilities and expertise to assess the performance and lifetime of TBC systems. Participant 3 will test the prospective self healing TBC systems and analyze their damage and healing behaviour.

The industrial partners KLM and Sulzer Turbo Systems (participants 4 and 5) will contribute with their abundant knowledge and expertise on advanced plasma spray technology and applications of TBCs in gas turbine engines for propulsion and power generation. They will take care of manufacturing the self healing coatings by co-depositing the self healing particles with the TBC matrix.