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Passive Sensor Coatings to Detect Critical Temperature-Conditions in High-Performance Fiber Applications

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Ropes and belts made of synthetic fibers are increasingly applied for hoisting, industrial tractions, and supporting elements in constructions, but also for mountain climbing robes and safety belts. Above a critical temperature, high performance fibers may lose their mechanical properties resulting in unexpected failure under load. Therefore, a passive 'structural health monitoring' sensing the temperature history of these ropes would be useful. In this study, we introduce a method to functionalize polymer fibers with thermochromic optical phase-change coatings by Magnetron sputtering that enable signaling of deterioration caused by thermal history. These smart coatings are comprised of an index-tunable anti-reflection coating based on chalcogenide phase change materials (PCM). In a first step, the optical contrast for the amorphous-to-crystalline transition of $Ge_2Sb_2Te_5$ (GST) structures upon heating to the critical temperature, T_c, were simulated on gold reflectors. In a second step, the GST coatings were applied on flat substrates comprising a silver reflector. We found, that the color change can be adjusted by the Ge content to the demanded temperature range. Finally, the results are demonstrated on two different polymer fibers with different deterioration temperature. Polyethylene terephthalate (PET) monofilaments (T_c ~150°C), and liquid-crystal aromatic polyester (LCAP) yarn (T_c~300°C) were coated with the passive sensor system enabling the detection of thermal history by the color change of the PCM visible by eye.

Keywords
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Ge2Sb2Te5
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