Selective Laser Melting of AlSi12 Enhanced with Carbon Additives

Powder Modification by Electroplated Carbon Deposition, Polymeric Based CNT Bonding, Polysacceride Based

Graduate

Silvan Oehy

Robin Schrag

Matias Büchel

Objective: Powders modified with nano-scale carbon additives can be processed in the SLM process to produce a material with improved process and/or material properties.

Approach / Technology: Powder blends with extreme particle size differences tend to segregate, resulting in an uneven distribution of nanoparticles in the modified powder. To overcome this problem and also to enable an industrially suitable and process-safe powder modification with nano-scale particles from the nanosafety point of view, suitable methods for powder modification must be developed and tested. Three different process technologies offer suitable possibilities for the attachment of nano-scale additives to the alloy powder surface:
a) galvanic deposition of carbon, b) polymeric bonding of Carbon Nanotubes (CNT), and bonding of organic carbon in the form of the polysaccheride agar agar by solvent evaporation. The modified powders were then tested for SLM process suitability by an analytical nanosaftey test which was developed in the thesis. SLM samples were subsequently manufactured from the obtained powder modifications for material characterisation.

While no successful modification of the alloy powder particles could be achieved with the galvanic process route, modified powders could be produced with the other two process routes.
With the solvent evaporation method, the polysaccheride agar agar could be bonded to the alloy powder utilizing the formation of an thin coating on the surfacees of the alloy powder particles. CNT could be successfully attached to the AlSi12 powder particles by a polymeric bonding process utilizing hydrogen bonds (Fig.1).
Both powders showed sufficiently high flowability and an appropriate grain size distribution for SLM processing. Because CNT are nanoparticles that can be harmful to humans and the environment, the AlSi12 CNT powder was also checked for nanosafety. The exposure from the powder was found to be far below the recommended limits of the national security ordinance of Switzerland. Thus, both powders met the requirements for SLM process suitability and could therefore be processed into SLM samples.

Result: Samples prepared from CNT-additivated alloy powders show lower density and better mechanical properties (yield strength) compared to those prepared from the AlSi12 starting powder, while those prepared from agar agar additivated alloy powders have the worst material properties (Fig.3). The lower material properties from agar agar modified alloy can either be due to suboptimal process parameters for SLM or to an unsuitable carbon concentration. The CNT-modified material has a slightly higher yield strength than AlSi12. The improvement may come from the CNT in the aluminium structure or from carbon precipitations. The minor improvement is explained by the small ratio of CNT. To offer an advantage over AlSi12 in technical applications, the improvement is too low. This study shows that a safe SLM powder can be produced with the used CNT bonding method, which already results in material improvement at low CNT concentration.

Fig.1: SEM image of the surface of an AlSi12 powder particle with attached CNT
Own presentment

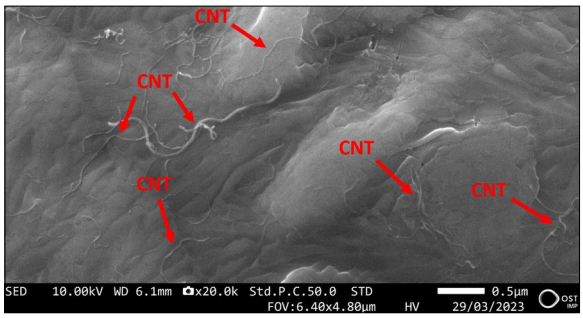


Fig.2: micrograph of an AlSi12 alloy showing scale-like scan traces from the SLM process
Own presentment

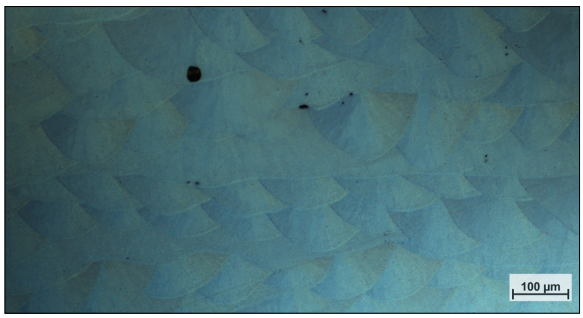
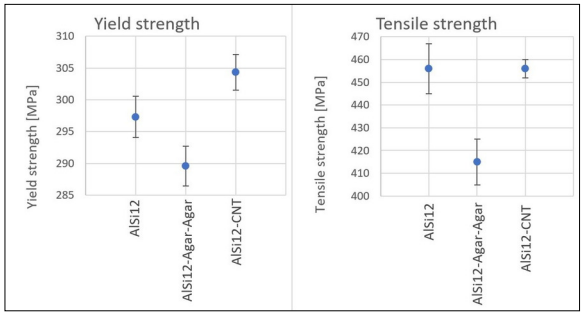


Fig.3: strength of AlSi12 and modified alloy powders mean values (68% confidence interval)
Own presentment



Advisor
Prof. Dr. Cord Henrik Surberg

Co-Examiner
Dr. Noémie Ott

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