Extending Additive Manufacturing to the Atomic Scale Focus Topic
Room Hall B - Session AM-TuP

Extending Additive Manufacturing to the Atomic Scale Poster Session

AM-TuP-1 Direct-Write Fabrication of 3D Nano-Probes for Thermal Microscopy, *J Sattelkow, J Froech, R Winkler,* Graz University of Technology, Austria*; C Schwalb, E Fantner,* GETec Microscopy Inc., Austria*; **Harald Plank**,* Graz University of Technology, Austria

With the recent introduction of controlled 3D nano-printing via focused electron beam induced deposition (FEBID), entirely new ranges of applications such as nano-optics, –sensors, -magnetics or -mechanics comes within reach whose fabrication is extremely challenging or even impossible with alternative techniques. In this study, we use 3D FEBID for the direct-write fabrication of thermal 3D nano-probes for further application in Scanning Thermal Microscopy (SThM). In more detail, freestanding Pt–C multi-branch architectures are used as thermistors, where the electric bridge resistivity changes in dependency on local temperatures during SThM. The main advantage of this nano-bridge concept is the small volume in the tip merging zone together with end radii down to 5 nm, which enable fast thermal response and high lateral resolution, respectively.

First, the relations between multi-branch design and nano-mechanical properties are studied by a combined approach of finite element simulations, Atomic Force Microscopy (AFM) based force spectroscopy and real-time imaging via scanning electron microscopy. This not only leads to identification of ideal overall geometries but also reveals the high demands on fabrication accuracy to minimize unwanted morphological twisting and non-linear mechanical behavior under force load. In the second step, we introduce a material tuning approach via post-growth e-beam curing, which effectively transforms the carbon matrix around the Pt nano-grains into sp^3 hybridized 3D carbon networks. This not only increases the overall mechanical stability but in particular improves the wear resistance of the tip apex for stable AFM imaging. In the final step, we use FEBIDs direct-write capabilities to modify pre-structured AFM cantilevers by fully optimized 3D nano-probes for active thermistor operation via monitoring the electric current through the 3D nano-bridges. Thermal response studies in ambient and vacuum conditions are presented and demonstrate temperature sensitivities with sub-degree resolution as well as response times better than 32 ms/K for dynamic thermo-studies

AM-TuP-2 Laser Induced Formation of Eutectic Nanostructures in Al-Cu Powder for Additive Manufacturing, ***Jonathan Skelton**, C Headley, J Floro, J Fitz-Gerald,* University of Virginia

With the emergence of additive manufacturing (AM) via laser powder bed sintering, design of the starting powders represents a critical area of interest, dictating the final properties of the AM components a large degree. The ability to design the nanoscale physical structure within powder particles in order to improve the final properties (optical, mechanical, thermal) remains a challenge. This research investigates the change in the eutectic microstructure of Al-Cu powders following laser irradiation. The initial powder alloy (gas atomized, Al-33wt%Cu) exhibited a variety of eutectic microstructures due to the varying solidification rates of particles within the gas atomized process. As-received powder was annealed at 450°C for 2 hours so as to create a uniform, Al+Al_2Cu two-phase structure with an interphase periodicity of about 2 µm. The original lamellar eutectic is broken down into a more irregular structure as part of the coarsening process. The powder, mounted on a glass slide and within an air ambient, is then subject to pulsed laser irradiation (wavelength = 248 nm, pulse duration 25 ns, fluence of 1.5 J/cm^2). Irradiation melted the particles, creating a new eutectic solidification structure with lamellar morphology. The interphase spacing was reduced to 30 nm, indicative of rapid solidification. Due to the lack of wetting or sintering between particles, it was concluded that each particle was melting and solidifying within its respective oxide shell. Though particles retain a largely spherical shape, many particles displayed a collapsed or partially “deflated” morphology after laser irradiation. The origin of the deformed morphology is not understood, but does not appear to be a phenomenon strictly associated with an instability imposed by the pulsed irradiation. It is suspected that the rapid growth and deflation of the oxide shell due to the thermal expansion of the Al-Cu particles may play a role. Samples were characterized by scanning electron microscopy (SEM), dual beam focused ion beam (DB FIB), and x-ray photoelectron spectroscopy (XPS). Support of the National Science Foundation through grants CMMI-1663085 is gratefully acknowledged.

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