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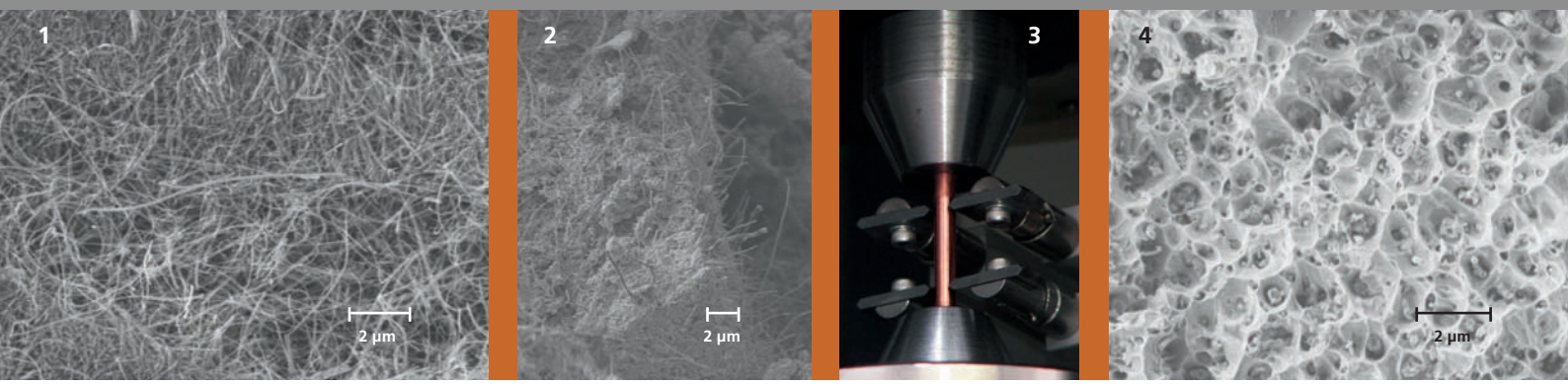

1 *Dispersible CNT*
2 *Powder made out of Cu and CNT before sintering*
3 *Cu/CNT tensile bar during mechanical testing*
4 *Fracture surface of a composite made out of Cu and 5 Vol. % CNT*

METAL / CARBON NANOTUBE COMPOSITES

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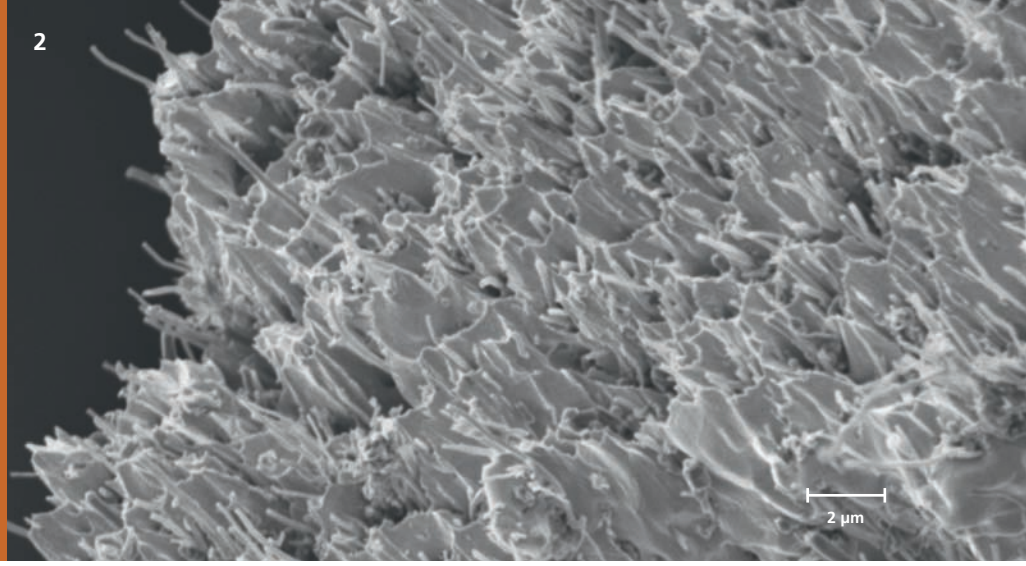
Motivation

Carbon Nanotubes (CNT) provide, based on their high strength, electrical and thermal conductivity, the potential to manufacture composites made out of a metal matrix and CNT as reinforcement component. The composites are characterized by an increase of strength while the electrical and thermal conductivity is the same or nearly that of the pure matrix metal. The manufacturing of metal/CNT composites using powder metallurgical processes is one topic in the research field of the Dresden branch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials. The metals copper, aluminium, iron and their respective alloys are used.

Approach

Carbon Nanotubes of various suppliers are conditioned to dispersible CNT (picture 1). The following ultra sonic mixing of copper powder and dispersible CNT in an aqueous medium provides the opportunity to generate homogenous powder mixtures (picture 2). These mixtures can be consolidated by hot pressing, spark plasma sintering and hot isostatic pressing. The semi-finished parts have a density greater than 90 % of the theoretical density and can be transformed by hot extrusion and/or drawing out a wire. Depending on the production process, the alignment of the CNT can be influenced from one-dimensional up to three-dimensional alignment.



Characterization

The composites made out of a metal and CNT are chracterized regarding microstructure, mechanical and thermophysical properties.

Mechanical strength

Hot extruded composites made out of copper and CNT provide the opportunity to increase the strength parallel to the extrusion direction with increasing volume content of CNT. Figure 1 displays the stress-strain curves of composites made out of a copper matrix and up to 10 vol. % CNT of one supplier.

Different types of CNT show a different increase of strength at the same volume content of CNT (figure 2). For a composite made out of copper and 3.5 vol. % CNT, an increase of the yield strength $R_{p0.2}$ at 200 % and the tensile strength R_m at 125 % compared to pure copper ($R_{p0.2}$ = 70 MPa, R_m = 210 MPa) was detected.

Electrical conductivity

The Cu/CNT composites show an anisotropic behaviour of the electrical conductivity caused by the alignment of the CNT (figure 3). When being parallel to the hot extrusion direction, the electrical conductivity is higher than perpendicular. This endorses the a priori statement that the hot extrusion process leads to a nearly one dimensional alignment of the CNT. The influences of different CNT types are also visible. For a composite made out of copper and 3.5 vol. % CNT, the specific electrical conductivity is comparable to pure copper.

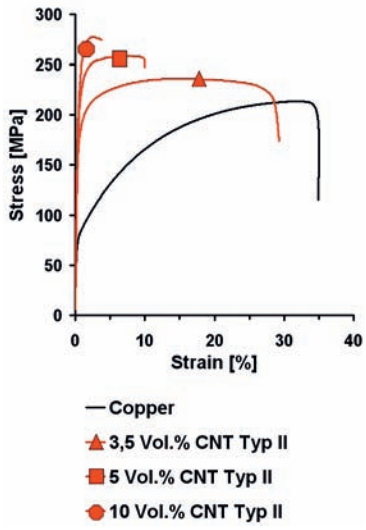


Fig. 1 Stress-strain curves of composites made out of copper and CNT with different volume content of CNT

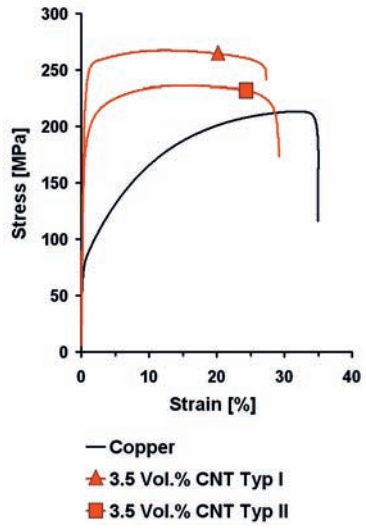


Fig. 2 Strength-strain-curves of composites made out of copper and 3.5 vol. % CNT of the same CNT type

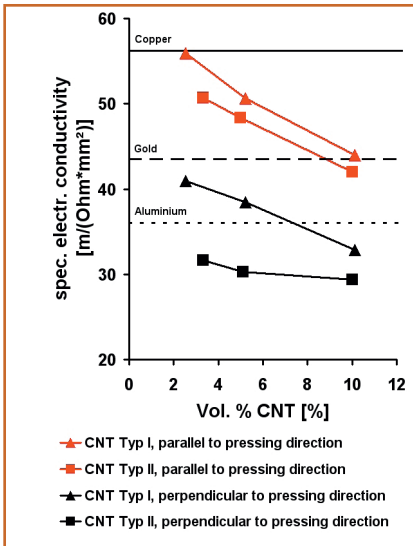


Fig. 3 Specific electrical conductivity of Cu/CNT composites parallel and perpendicular to the hot extrusion direction in comparison to reference materials

1 *Wire made out of copper and 10 Vol. % CNT*

2 *Alignment of CNT in the Cu/CNT composite*