The measurement of the adhesion force between ceramic particles and metal matrix in ceramic reinforced-metal matrix composites.

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1. Introduction

Metal matrix composites (MMCs) are widely used in many fields of engineering, just to mention aviation and aircraft, automotive and thermal management. These materials provided significantly enhanced properties – like higher strength, stiffness and weight savings – in comparison to conventional monolithic materials. Furthermore, they are attractive due to their cost-effectiveness, isotropic properties, and their ability to be processed using the similar technology as in the case of monolithic materials. A large amount of work has been conducted recently in an effort to characterize the mechanical behaviour of particle reinforced MMCs. Not only new production technologies have been developed but also analytical and numerical modelling has been done. The latest provides an effective and relatively cheap and fast means of predicting effective properties of the composite (e.g. Young modulus) from the known properties of the constituents and revealing deformation and damage characteristics. Unfortunately, due to the lack of a sufficient knowledge about the mechanical properties of the interface between constituents, the simulations are not able to predict the real values of the materials parameters. Therefore, there is a need to develop methods for the experimental evaluation of the adhesion force between the metal matrix and the applied reinforcement, especially in the case of micro- and nanocomposites.

This paper presents the method for measurement of the adhesion force and fracture strength of the interface between ceramic particles and metal matrix in ceramic reinforced-metal matrix composites.

2. Experimental

Small rods were cut from the metal matrix composites using a precise wire saw. The rods were then put on a special holder and carefully electro etched in the phosphoric acid solution (40%) in order to produce microwires. Furthermore, the sample holder with a microwire was mounted on the microtensile tester of our own production (Fig. 1). The microtensile tester consists of two stages, to which two endings of the microwire are fixed. In order to make the stage stable and sensitive to very low loads, the first stage is mounted at the end of four thin, flat springs on which 4 strain gauges are glued. The springs are made of steel. Their height is 70 mm, their width is 5 mm and their thickness is 0.2 mm. The strain gauge bridge is used to precisely measure the force which is applied on a microwire. The force measurement module was calibrated using precise weights. The precision of the force measurement is equal to 0.1 mN.

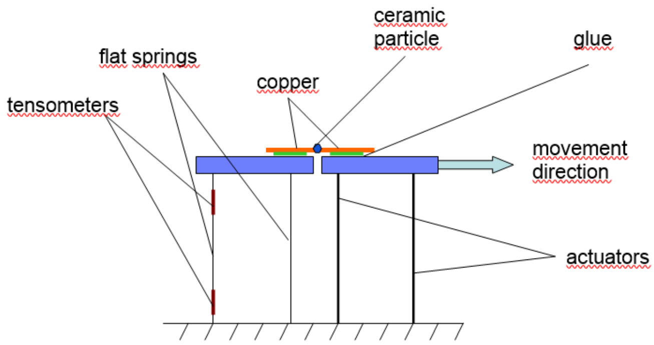

Figure 1. Microtensile tester scheme.

After the microwire had been broken, the optical microscope with multifocus images of the top of the two ends of the broken wire were used in order to precisely determine the contact area between the copper and the ceramic particle (Fig. 2). The contact area in images was measured using a dedicated computer programme. Finally the interface strength was evaluated according to the following equation:

$$\sigma = \frac{F_A}{S} \tag{1}$$

where F_A is the adhesion force between a ceramic particle and the metal matrix and S stands for the area of the interface.

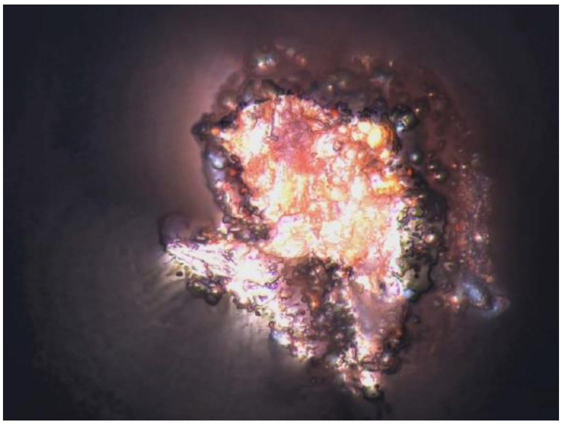
Figure 2. Multifocus optical microscope image of the top of a broken microwire.

3. Acknowledgments

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5. References

[1] D.M. Jarząbek, M. Chmielewski, T. Wojciechowski (2015). The measurement of the adhesion force between ceramic particles and metal matrix in ceramic reinforced-metal matrix composites, Composites Part A – Applied Science and Manufacturing, **76**, 124-130

[2] D.M. Jarząbek, M. Chmielewski, J. Dulnik, A. Strojny-Nedza (2016). The Influence of the Particle Size on the Adhesion Between Ceramic Particles and Metal Matrix in MMC Composites, Journal of Materials Engineering and Performance, DOI: 10.1007/s11665-016-2107-3