JOURNAL OF MATERIALS SCIENCE **39** (2004) 747–748

Fracture micromechanism of Pt-Y_2O_3 composites in relation to quality factor

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In the development of Al-Al_4C_3 composites prepared by mechanical alloying, on the basis of statistical analysis of an extensive set of values of mechanical properties, the relation for a quality factor (*QF*) was stated as follows [1]:

$$QF = (R_m + 500) \cdot A_{10}^{0.219} / 1420,$$

where R_m and A_{10} are ultimate tensile strength and elongation at room temperature, respectively. The quality factor evaluates the final material quality. In the case of preparation via powder metallurgy, this depends on a lot of factors such as size, morphology and purity of starting powders, matrix and dispersoids, technology preparation of composites from powders, compaction and consolidation operations decisive about distribution of dispersed particles in the matrix and residual porosity and also predicts high temperature properties of the composite materials as well as their stability [2].

In this work the quality factor was evaluated from the point of view of optimisation of various technological preparation ways in relation to fracture characteristics for Pt-Y_2O_3 materials developed by low-energy mechanical alloying [3–8] in relationship on papers [9–10].

Experimental materials labelled A, B, C were prepared by recycling Pt wastes from linings of glass furnaces on powder and its low-energy mechanical alloying with the dispersed Y_2O_3 phase (0.5 wt%). The intensity of the mechanical alloying process of the mixtures (powder and dispersed phase) was different related to the milling time and the speed of revolutions of the attritor, respectively. Dry milling parameters in the attritor for individual materials were the following: A: 10 h/210 r.p.m., B: 48 h/410 r.p.m., C: 48 h/210 r.p.m. The materials were pressed and hot rolled under the same conditions. Detailed data about the preparation are described in [3–5]. The experimental results were compared with commercial dispersion strengthened materials based on Pt, Plativer (Pt-0.6 Y_2O_3) and ZGS (Pt-0.6 ZrO_2).

The courses of calculated *QF* values for the Pt-Y_2O_3 material in the range of 0.2–1, which were determined from the ultimate tensile strength values (R_m) and elongation (A_{10}), can be seen in Fig. 1. The material quality increases with the *QF* value increasing at optimal combination of strength and plasticity parameters as indicated by a region between the dashed lines. The combination is important due to sufficient deformability of cold formed sheets. The transcrystalline ductile fracture with dimples, being in the range 1–15 μm, for the material A characterized by high plasticity and the lowest strength at $QF = 0.5$, as well as clusters of Y_2O_3 particles situated in large dimples are shown in Fig. 2. The ductile fracture small dimples of 1 μm of the material B have a more homogeneous distribution of the Y_2O_3 phase, better mechanical properties and $QF = 0.6$ (Fig. 3).

The dimples of the material C, characterized by the 350 MPa ultimate tensile strength, the 18% elongation

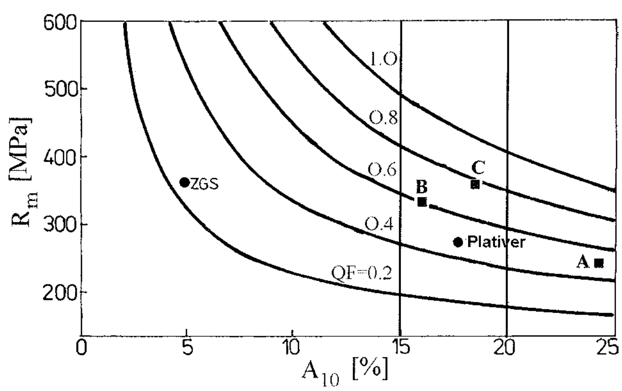

Figure 1 *QF* values determinated experimentally from R_m and A_{10} and calculated *QF* values for individual materials.

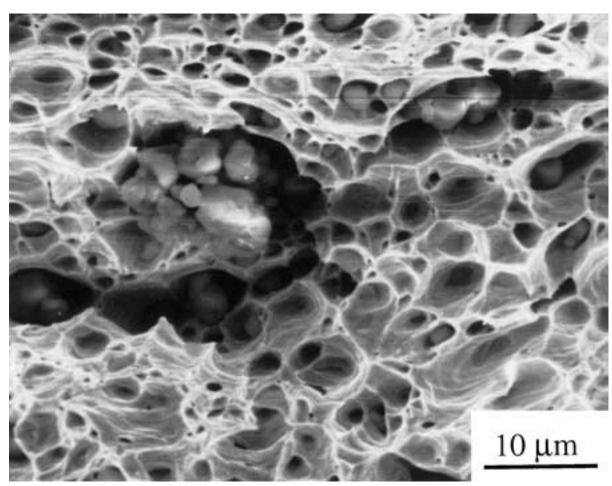

Figure 2 Transcrystalline ductile fracture of the material A.

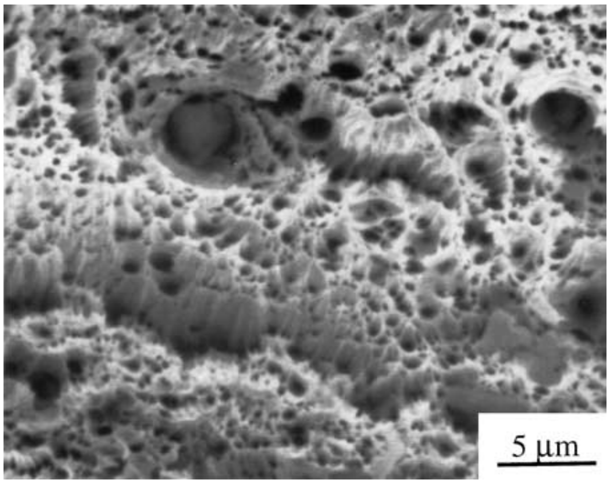

Figure 3 Transcrystalline ductile fracture of the material B.

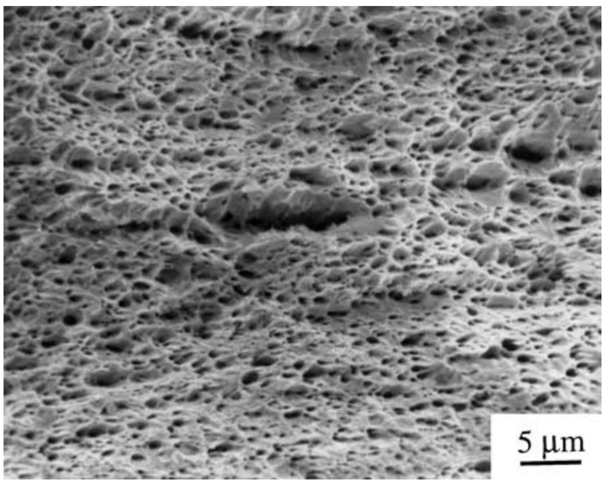

Figure 4 Transcrystalline ductile fracture of the material C.

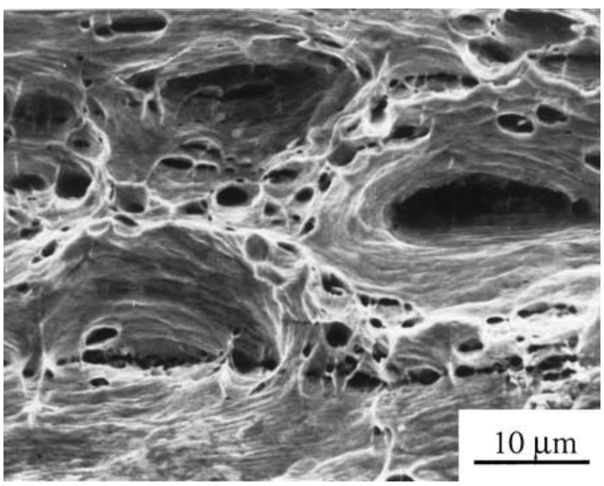

Figure 5 Transcrystalline ductile fracture of the material Plativer.

and the highest $QF = 0.8$, ranged in the 0.3–2 μm interval, can be seen in Fig. 4. The Y_2O_3 particle size (0.1–0.7 μm) is the 1/3 dimple size, corresponding to the ductile fracture theory [6]. Fig. 5 shows the dimples of the transcrystalline ductile fracture of the material Plativer, $QF = 0.45$, the smallest ones of the 0.3–1 μm range corresponding to the 100–300 nm Y_2O_3 particles, the biggest ones are over 10 μm. The dimples of

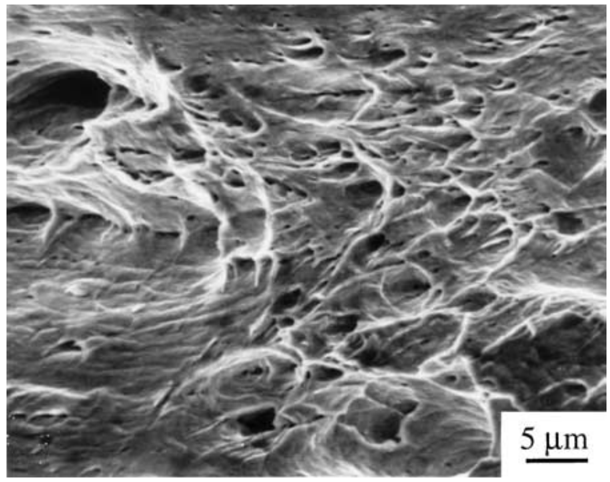

Figure 6 Transcrystalline ductile fracture of the material ZGS.

the heterogeneous size distribution of the material ZGS of the 350 MPa ultimate tensile strength, the 5% elongation and $QF = 0.25$, containing the ZrO_2 particles, are of the 5–10 μm and 0.5–2 μm ranges as the biggest and smallest ones, respectively (Fig. 6).

As evident from the analysis of transcrystalline ductile fractures, strength and plasticity parameters, the highest quality factor value of the material C corresponds to optimal combination of both strength as well as plasticity. The fracture is characterized by homogeneous dimple size distribution with Y_2O_3 dispersed particles homogeneously distributed in the matrix. The preparation of the material C is the most optimal from the point of view of used mechanical alloying technology.

Acknowledgment
The authors are grateful to the Slovak Grant Agency for Science (grant No. 2/2114/22) for the financial support of this work.

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Received 27 August
and accepted 8 September 2003