ULTRAFINE-GRAINED AND NANO–STRUCTURE ALUMINIUM ALLOYS PRODUCED BY CYCLIC EXTRUSION COMPRESSION

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Aluminium alloys are very popular materials using for production of ultrafine-grained and nano-materials produced by Severe Plastic Deformation (SPD) methods [1,2]. They characterize relatively low hardening which allow exerting very large strains necessary for transformation of common structure into the nanostructure. Till now in aluminium alloys, only sometimes it was possible to obtain mean grain size below 100 nm and it also depended to the using SPD method. Good results were obtained in High Pressure Torsion (HTP) deformation [1] (Fig.1A). A lot of results connecting with the production of ultrafine-grained materials and near nanocrystalline materials come from Equal Channel Angular Pressing (ECAP) investigations (Fig.1B). Cyclic Extrusion Compression (CEC) method belongs to the SPD processes that allow obtained arbitrarily large deformations with the preservation of the initial shape of the sample. The method was invented in 1979 (Fig.1C) [3]. The high hydrostatic stresses exerted during the CEC process prevent the sample cracking.

Three aluminium alloys were deformed by CEC do the true strain $\varphi = 16$. The investigations show that only in AlMgSi alloy after the $\varphi = 16$ the nanostructure appears in about 75% of sample volume. In other alloys the ultrafine-grained structure with the mean grain size 125nm (AlCu4Zr) and 157 nm (AlMg) has bee found. Fig.2 shows the examples of the structures observed in the deformed aluminium alloys. The misorientation between the nanograins and surrounds is shown by figures. The large misorientation proofs, that the observed nanovolumes have features of grains. The microtexture is shown in the left upper corner of Fig.2A. The results indicate that the obtained grain size depends not only on the value of the exerted strain but also on the kind of the deformed material.

The Hall Petch relation was determined for the investigated alloys (Fig.3). It was found that the inclination of the diagrams depends on the kind of the alloy. It is characteristic that the slope of the AlMgSi diagram to the axis is largest than the other alloys. On the other hand the AlMgSi alloys as only contains 75% of the nanostructure. It could be suggested that the additional mechanism of deformation appears in this alloy [4]. However on the other hand it is also possible that the material softening appears due to the more intensified progress in the recovery processes.

The obtained results indicate that using the CEC method, the nanocrystalline materials with the mean size dimension of nanograins below 100 nm can be produced.

References:

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[4] K.S.Kumar, H.Van Swygenhoven, S.Suresh, Acta Materialia, **51, 19** (2003) 5743-5774.

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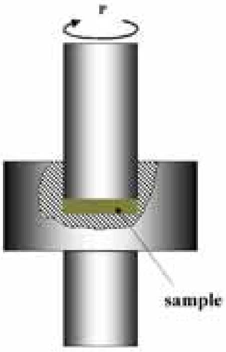
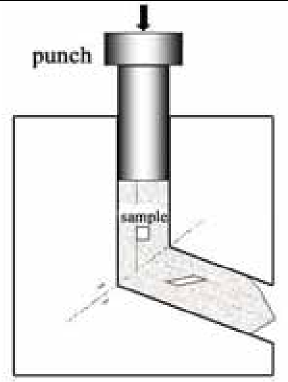
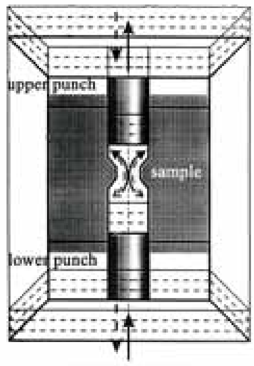
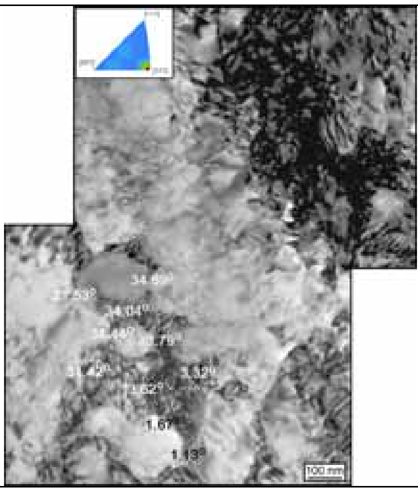
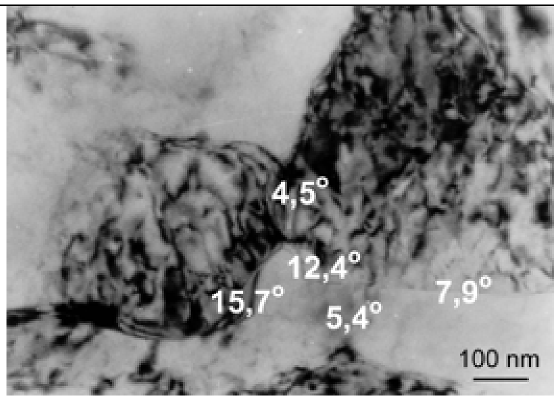
Figures:

		
A) High Pressure Torsion	A) Equal Channel Angular Pressing	C) Cyclic Extrusion Compression
Fig.1. Scheme of different SPD methods		

	
A) nanograins in AlMgSi after the φ = 16	B) nanograins in AlCu4Zr after φ = 14
Fig.2. Nanograins with the large misorientation in aluminium alloys	

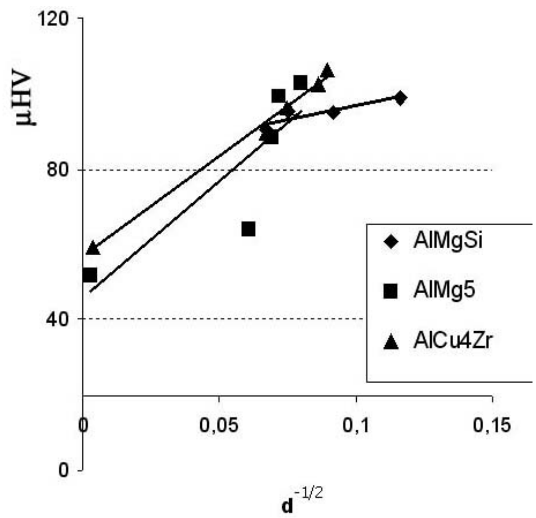


Fig.3. Hall-Petch relation of the aluminium alloys deformed by the CEC