Development of a new technologies of manufacturing of functional materials at the Institute of Metallurgy and Materials Science Polish Academy of Sciences

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In the Laboratory of Functional Materials of the Institute of Metallurgy and Materials Science were developed two basic technologies; The first one was consolidation of nanocrystalline powders after ball milling and the second one was rapid solidification in the form of melt spun ribbons. Fig.1 shows the planetary ball mill produced by Fritsch company used for high energy ball milling. It has four containers (either steel or ceramic) where steel or ceramic ball can be used

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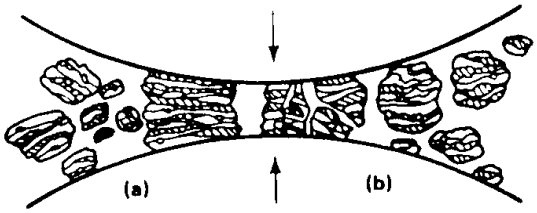
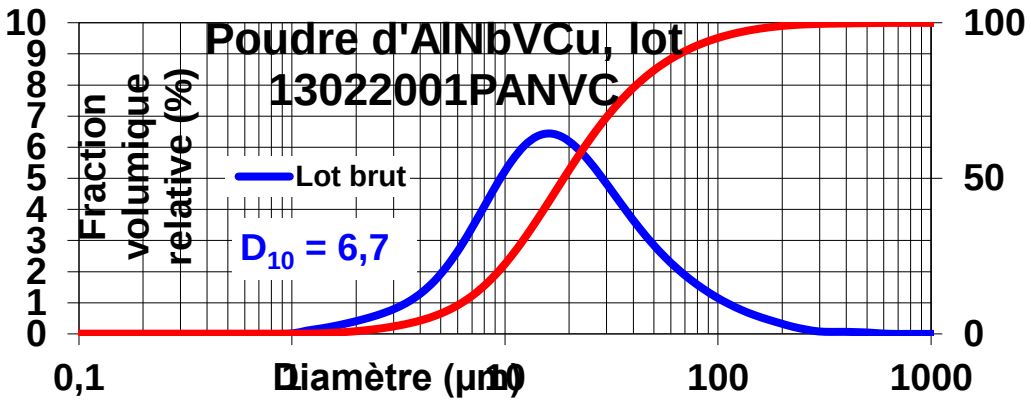


Fig.1 Planetary Frisch mill used for crushing of ribbons to obtain powders and above scheme of powder's refinement during

Fig. 2 Atomization facility at UTBM Belfort where metallic powder-atomizing in neutral atmosphere (argon) facility was erected in May 2003 at the original LERMPS facility where thermal spraying is performed.

One can see also in Fig.1 the scheme of ball action allowing multiple welding and crushing of powders particles leading finally to refining of particles and decreasing their grain size up to nanometric size. Fig.2 shows installation of the powder production at UTBM Belfort (cooperating with IMIM PAN) where amorphous powders were produced. The installation allows relatively high cooling rate to Fig.4 shows photograph of the amorphous powder produced at UTBM



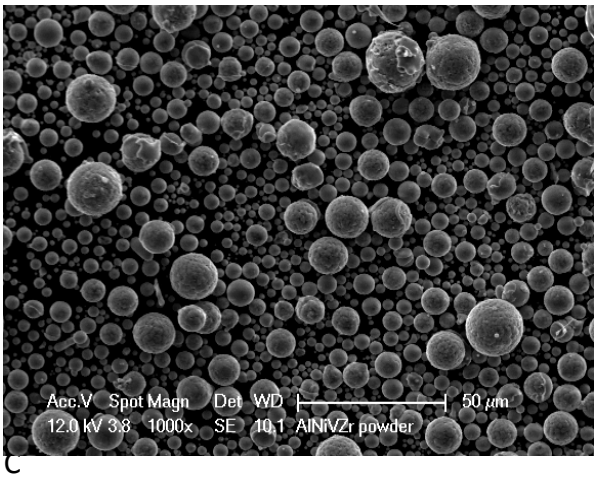


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Fig.3 On the left SEM micrograph of the spray formed powder from $Al_{84}Ni_6V_5Zr_5$ alloy from the installation in UTBM Belfort and above distribution of the size of particles within the powder and presentation of the total amount of the all sizes

Fig.4 shows a photograph from the installation constructed at IMIM PAN where powders can be consolidated. The chamber allows to obtain the vacuum 10^{-2} bar and temperature up to 1000°C at uniaxial pressure of maximum 200 MPa and 600 MPa at temperature below 550°C. the average consolidation time is 10 minutes. Fig.5 shows heat resistant steel dies used for consolidation of powders at 600°C and pressure of 600 MPa and the examples of consolidated 20 and 30 mm discs from composites based on the alloy : 6061 + 20% ZrO2, 6061 + 20% Al2O3, Ax431 +10 % ZrO2 i Ax431 + 10% ZrO2 (30 mm). an example of TEM microstructure of a composite based on aluminum alloy 6061 strengthened with nanocrystalline ZrO_2 powder and Zr particles , which can attain the strength of 750 MPa as can be seen from the compression curve of the consolidated sample.

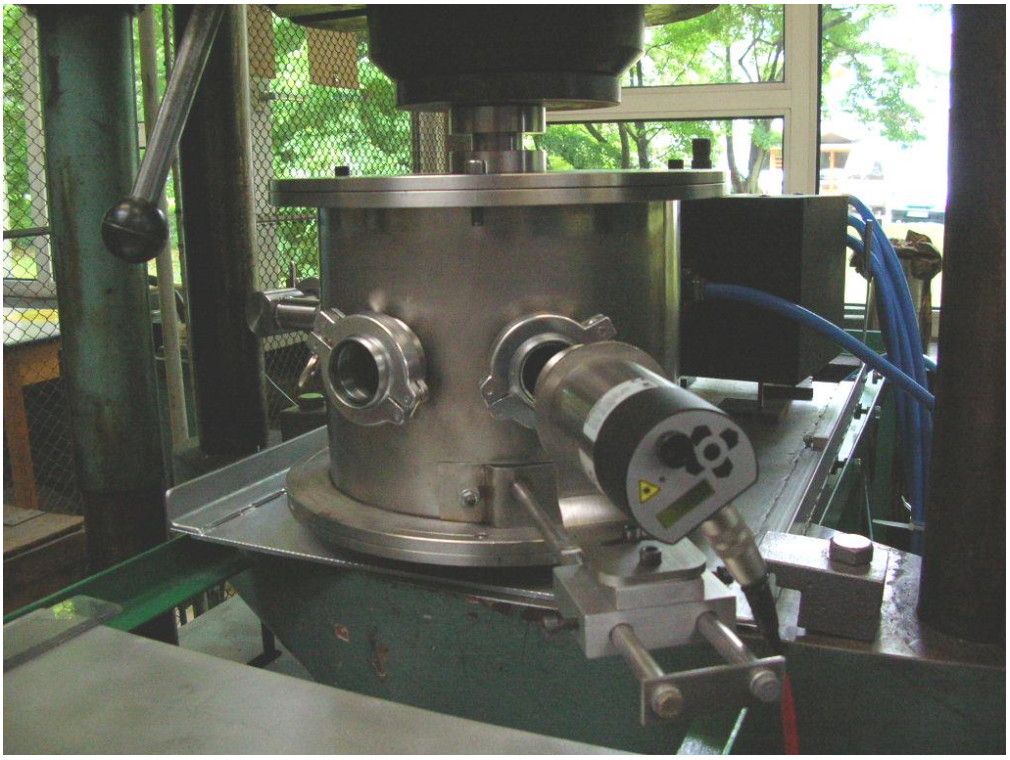

Fig.4 Instrumentation for uniaxial hot pressing in vacuum IMIM constructed at IMIM PAN; Parameters of the process : time: 5-12 min, pressure : 200-700 MPa, Temperature: 200-1000ºC, vacuum $2.5x10^{-2}$ bar

Fig.5 On the left heat resistant steel dies used for consolidation of powders at 600°C and pressure of 600 MPa On the right 20 and 30 mm discs consolidated at chamer shown in Fig.3 : 6061 + 20% ZrO2, 6061 + 20% Al2O3, Ax431 +10 % ZrO2 i Ax431 + 10% ZrO2 (30 mm).

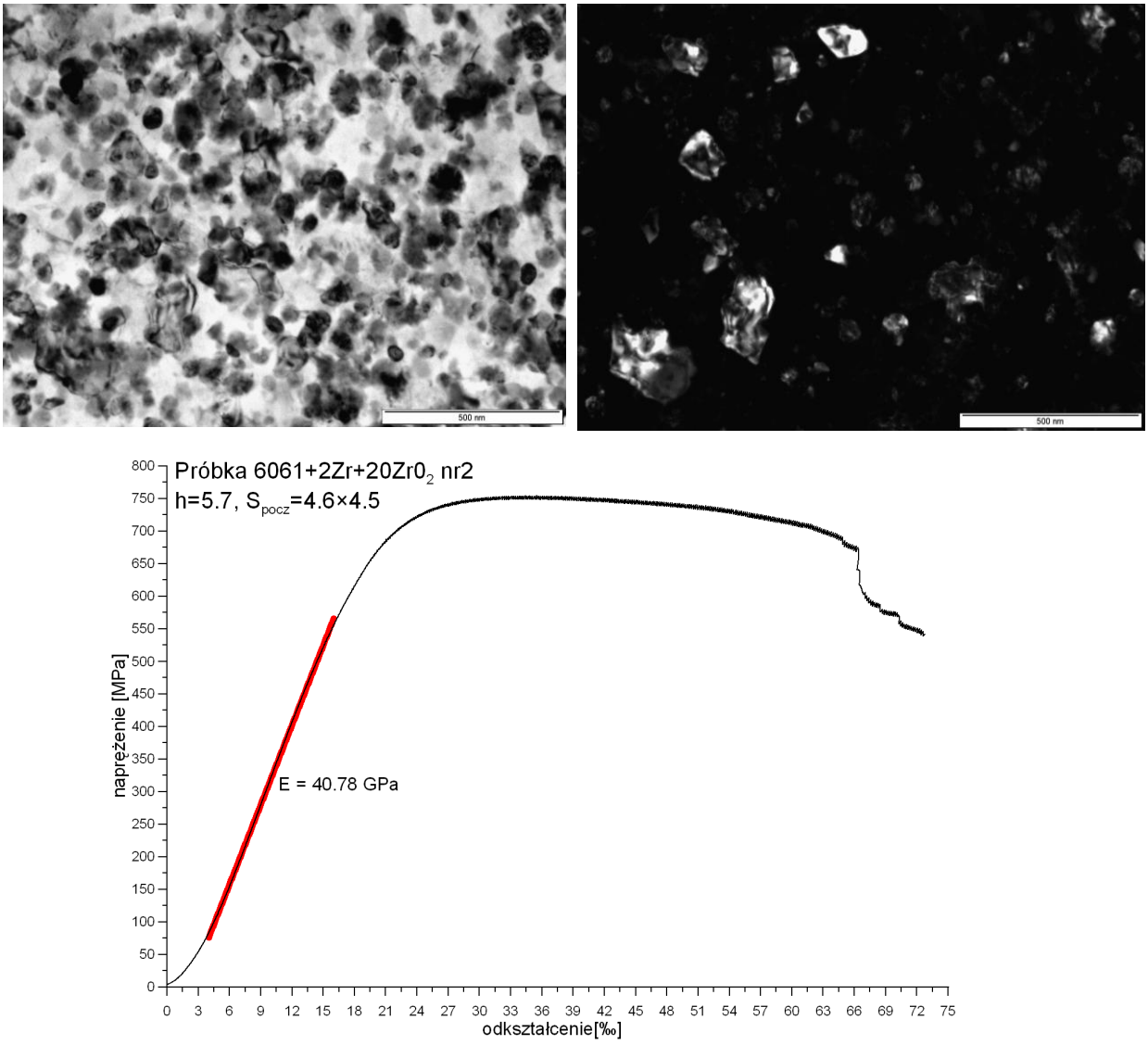

Fig.6 On the top bright and dark field TEM micrographs showing 6061 + 20% ZrO2 composite with homogeneous distribution of nanocrystalline ZrO2 particles. Belo compression curve 6061 + 2%Zr + 20 % ZrO2 dla próbek o przekroju kwadratowym 4.5x4.6 mm h = 5.7 mm Rm = 750 MPa

Next photograph (Fig.7) shows the apparatus for ribbon production produced by Artvac company, which can produce ribbons of thickness 20-100 μm and 3-10 mm broad. As an insert is shown o photograph of the aluminum alloy ribbon.

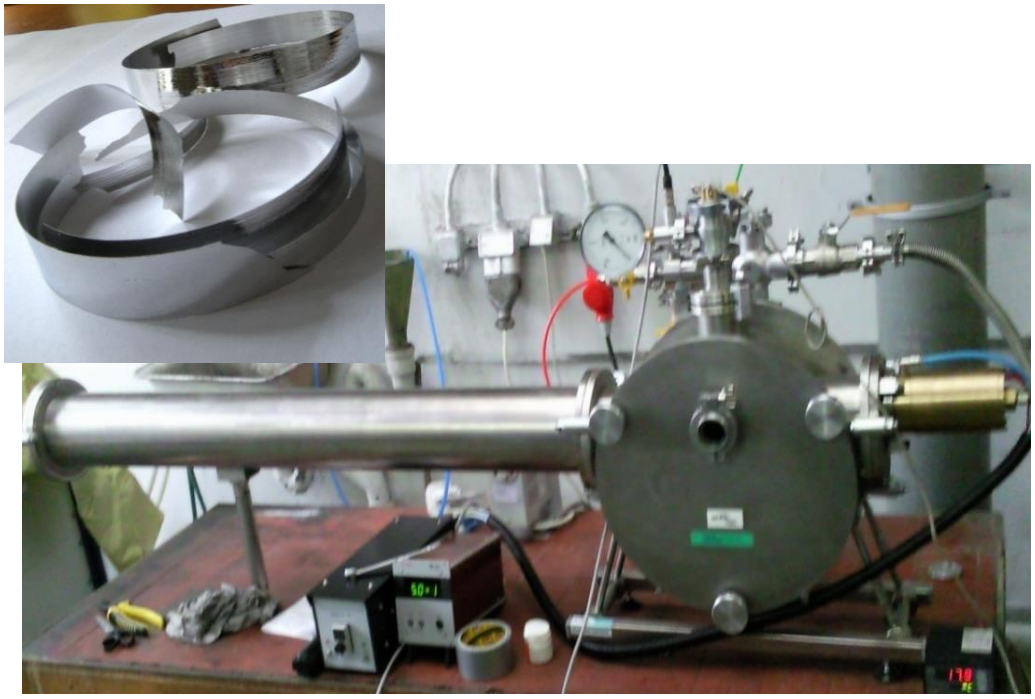

Fig.7 Melt spinning equipment produced by ARTVAC. at IMIM PAN and photograph of the ribbon from an aluminum alloy.