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Image Analysis in PM Aluminum Composites. Matrix/Reinforcement Characterization

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One of the major obstacles to the application of particle reinforced AMCs is reaction at matrix/reinforcement interfaces during materials processing and service at elevated temperatures[1-2]. High temperatures that are involved during the solution treatment in heat treatable aluminum alloys[3], produce a thick reaction layer at these interfaces.
Digital image acquisition and analysis is becoming a common tool in many fields. Research involving composite materials requires the effective use of image analysis methods to obtain certain numerical values describing several aspects of the studied samples[4]. The microstructure study by means of image analysis is one of the ways to characterize the composite interfaces.

Several heat-treated aluminum composites were studied in the present work. The microstructural variation results from diffusion processes as a function of the heat treatment applied.
Microestructural and interfacial examination were carried out using a JEOL 6300 SEM and Visilog 5.0 image analysis software. The prepared samples were examined using both backscattered electron (BSE) and secondary electron (SE) imaging modes. The BSE imaging (Fig. 1.) allowed reinforcement particles and matrix/reinforcement interfaces to be clearly delineated from general microstructural features for quantification purposes. The accuracy of the analytical process relied on imaging conditions remaining consistent between consecutive fields of view and between different sample zones. A systematic routine was devised to ensure reproducible image contrast and brightness.
The analytical program was set up to determine the reaction layer growth by calculating its thickness. It consists on:

1- Determine the particle number on the sample Fig. 1. by eroding two times the image, closing, dilation and finally applying the command Analysis-Individual-Analyze-Grey-In. After that we obtain the particle number of 52 for an area of 512 x 369 pixels or 188928 μm^2 (calibration parameter: 51 pixels = 50 μm), Fig. 2.
2- Determine total reaction layer growth:
    - The first step is determine total area of particles and reaction layers by the command Theresholding-Binarisation-Thereshold and a gray range from 111 to 240, Fig. 3.
    - Determine area of particles with the same command and a gray range from 140 to 240, Fig. 4.
    - Measure of perimeters of both images using Analysis-Measurements-Perimeter. We obtain 7576 μm as total perimeter and 3041 μm as partial perimeter.
    - Calculate particle radios with the expression: $R = P/_{2\cdot\pi}$. For the total and partial images we have radios of 1206 and 484 μm respectively.
    - Finally we have reaction layer zone of 1206 – 484 = 708 μm.
3- Determine particle reaction layer growth: 708 μm / 52 particles = 13.61 μm / particle.

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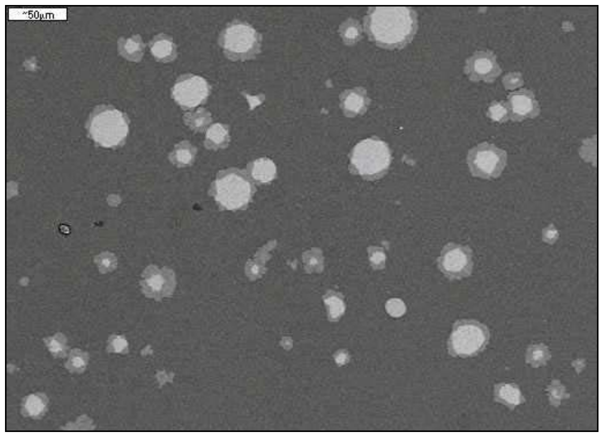

FIG. 1. BSE micrograph at 250 X. Aluminum composite reinforced with intermetallic particles after 12 h and 530ªC of heat treatment.

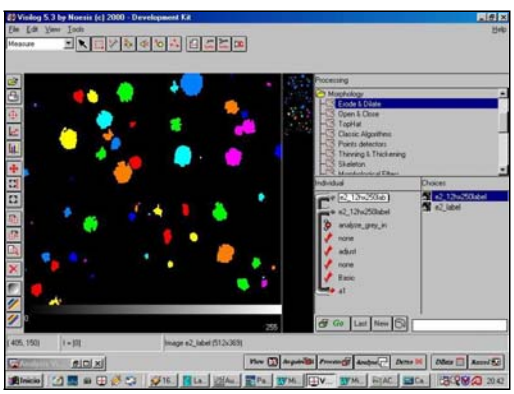

FIG. 2. Eroded, closed and dilated image. Particle number determination: 52 particles / 188928 μm^2.

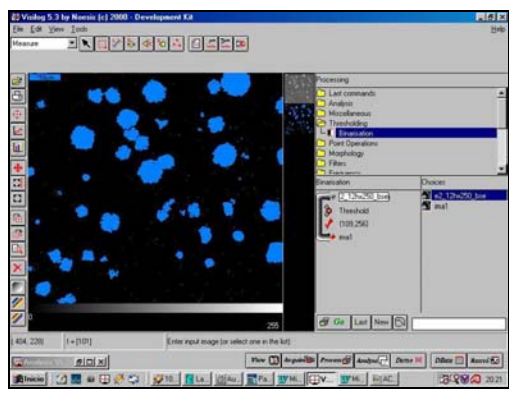

FIG. 3. Theresholded image with gray level form 111 to 240. Total area (particle+reaction layer) calculation.

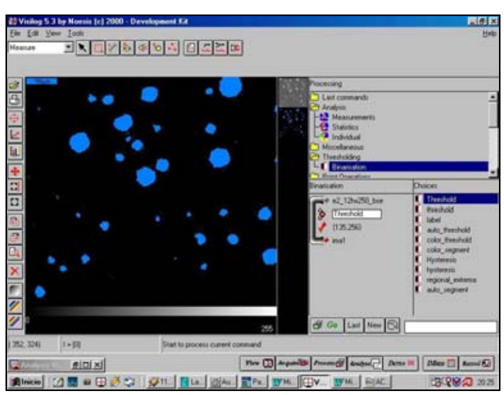

FIG. 4. Theresholded image with gray level form 140 to 240. Partial area (particle) calculation.

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