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Study of membrane morphology of SEM image of polymer nanocomposite membrane by digital Image processing

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Abstract:

Various images obtain from TEM; SEM etc can be analyzed with the help of computer image analysis software. Image processing is used to describe the size, shape, surface morphology of micro or nano structure materials Digital image processing remains a challenging domain of programming for several reasons. We have implemented digital image processing using Java based programme Image J for the study of SEM image of the solid polymer electrolyte having composition [(1-x) PEO: x AgCl]. The present work demonstrates the possibility of using such methods in determining the basic parameters characterizing the morphology of the polymer electrolytes in micro- and nano-scale.

Key words: nano-crystals; grain size and shape; image analysis;

1. Introduction:

Digital image processing is required before viewing or analyzing SEM images [1-2]. If the probe used for acquisition of image is much smaller than the feature of the image to be measured then probe generated artifacts will be smaller and the measurements derived from the image will be accurate [3-4]. With the development of microcomputers, digital cameras and image digitizers allowed a major development of the image processing and its applications [5-8]. A digital image contains a discrete number of pixels, each of which has intensity value between 0 and 255. Most digital imaging operators are divided into either image processing or image analysis. Image processing operations changes one image to another and image analysis quantify some aspects of image. A digital image consists of discrete points each point's holds a number that denotes intensity, amplitude, grey level or colour for it and it can be processed according to the requirement or study. One big challenge in processing SEM images in the edge extraction. An edge is defined as continuous boundary that separates two adjacent different areas. For optical image where one pattern is dark and other is bright we can generally look for {(x,y)= half of maximum grey level} where p(x,y) image pixel value (grey level) of location (x,y) [9-11]. In the present paper Image J software which is in the form of plug-in [12]. Image J is widely used open source software in scientific communities and release under GPL license [13].

2. Material synthesis in the form of thin film:

For the casting of Ag+ ion conducting solid polymer electrolyte membrane of composition (1-x) PEO: x AgCl solvent free/dry hot press technique is used [14]. Here x = 5, 10, 15,20,25,30,35,40,45 etc (wt %) ratio. For this precursor grade chemicals poly (ethylene) oxide (PEO) (106 Mw, Aldrich, USA); Silver Chloride (AgCl) are used. Powders are mixed in appropriate wt % ratio in agate pestle and mortar for 20 minutes at room temperature. Mixture of different compositions is heated in a crucible at 70^0C (close to melting point of PEO) for 20 minutes. Soft slurry so obtained is hot pressed between two blocks of stainless steel at pressure of ~1.25tons/cm^2 to obtain film of uniform thickness 0.03cm. Through the conductivity (σ) measurement optimum conducting composition (OCC) is

obtained and SEM image of OCC of SPE membrane is used for morphological characterization by digital image processing using Java based programme Image J.

3. Characterization of SEM image of SPE (OCC) membrane by digital image processing:

3.1 Image processing:

Before analyzing the image some pre-processing is necessary in order to enhance micro structural features to be analyzed to separate agglomerated particles or to reconstruct incomplete grain boundaries etc. The aim of image processing is to improve the image and during processing original image is changed and in processed image some artifacts are introduced. Image processing operates on entire gray scale of image and transforms the contrast. An image consists of various sub regions these sub regions are called region of interest (ROI) and are processed independently or not depending upon the requirements. Frequently used operators includes [15] -

- Brightness/contrast adjustment
- Histogram equalization
- Binary operations
- Morphological operators- dilation and erosion
- Morphological smoothening- enhancing and edge detection
- Thresholding and binarization

The processing of SEM images involve following steps-

Histogram equalization:

It is the process in which histogram of all the images to be processed are normalized to obtain the peaks of phase aligned with each other. Figure 1(a) shows original figure with histogram and figure 1(b) is with image enhancement with its histogram.

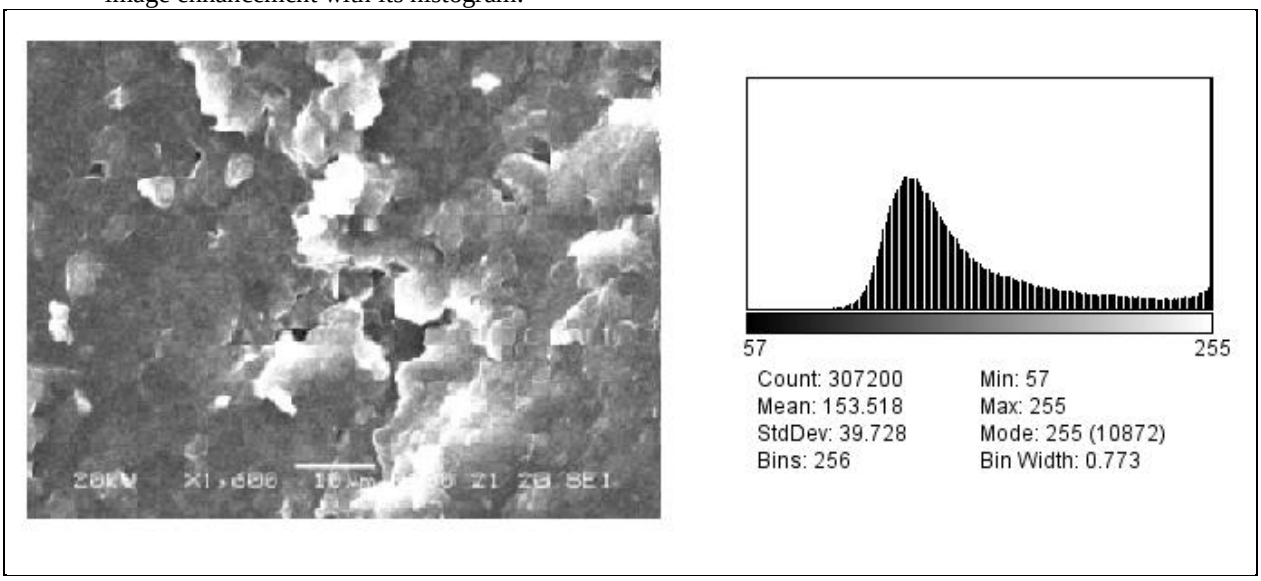

Figure 1(a): SEM image of SPE (OCC) membrane with histogram curve.

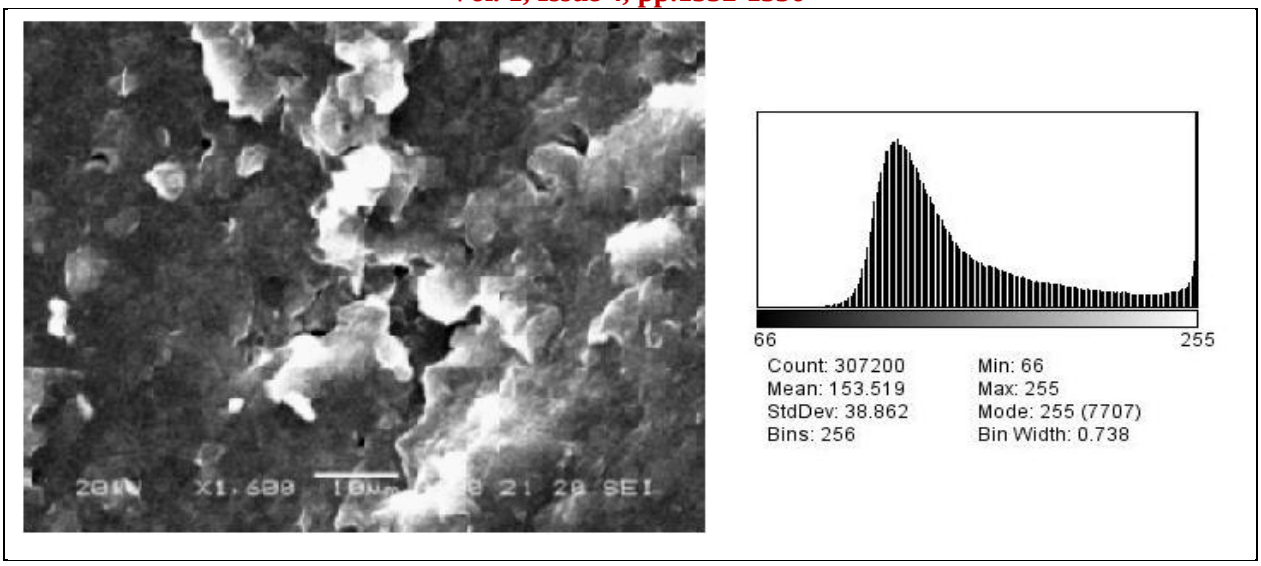

Figure 1(b): SEM image of enhanced SPE (OCC) and its histogram

In histogram X- axis represents the possible gray values and Y- axis shows the number of pixel found for each gray value. For the purpose of quantitative analysis image are transformed into binary ones which determine the grains of the composite. Most systems require the used to binarize the image before making measurements. Figure 2 shows the binary image of the SPE (OCC). Binarization means in multiphase structure only one phase can be measured at a time.

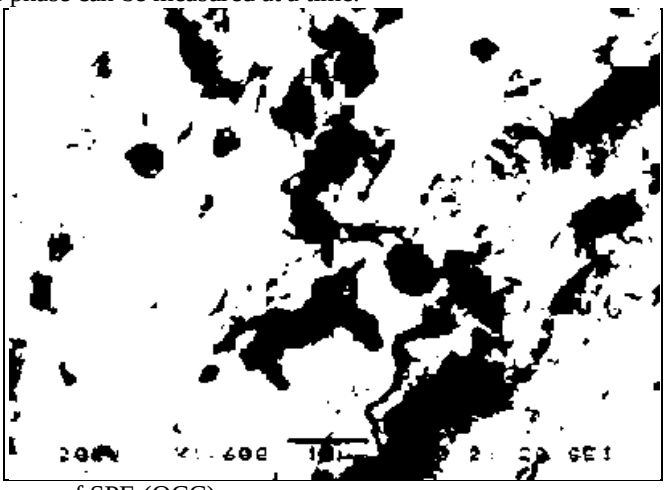

Figure 2: binary image of SPE (OCC)

3.2 Image analysis:

Figure 1(a) is the SEM image of the SPE(OCC) which is to be processed and analysed for amorphosity of the membrane because more amorphous is solid polymer electrolyte membrane more will be the ionic conductivity hence amorphosity is important characteristic for the ion conducting polymers. Th main aim of dispersing filler to the polymer to enhance amorphosity of the membrane. The study of dispersion of the filler in the matrix nad interfacial regions is the basis for developing structure property correlations.

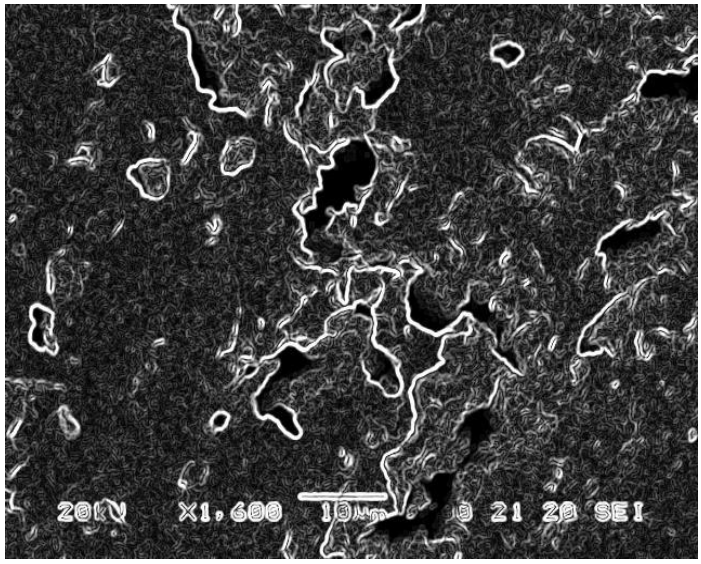

Figure 3: Edge detection of SEM image

Some regions in figure 1(a) are flat and exhibits low pixel intensity (dark contrast) in SEM image. These regions of low pixel intensity are attributed to regions composed principally of PEO polymer host. Also certain regions of figure 1(a) are associated with very high pixel intensity (light contrast) represents agglomerates of salt AgCl. From the edge detection figure 3 one can easily identify fibrous nature of the membrane which enhances amorphousity of the membrane.

Conclusion:

Powerful image display and analysis software is essential for viewing and analyzing the images from scanning electron microscope (SEM)**.** Before analyzing SEM image it is preprocessed in which image is enhanced in terms of contrast and brightness. Image is analyzed in terms of pixel intensities.

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