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The Effect of Acidic Solution (H_2SO_4) on the Nano Composites Materials (EP/ Nano-SiO_2): Image Analysis Study

El efecto de la solución ácida (H_2SO_4) en los materiales de nanocompuestos (EP / Nano-SiO_2): estudio de análisis de imagen Abdul- Adheem dheem Zaily Hameed y Muzhir Shaban Al-Ani

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ABSTRACT/ Nanotechnology is a new technology that are used in wide range of applications and a nanomaterial having tiny particles of nanoscale sizes that produced and processed by nanotechnology. Mixing of physical and information technology issues will produce a powerful approach for processing and analyzing. Image processing is an efficient tool for processing and analyzing the material surface. This work is implemented via many stages: preparing the materials, molding the samples, image acquisition of the molding surface, enhance the image surface and measuring many parameters to ensure the surface enhancement. The obtained results are obtained from surface images before and after immersion with and without filter. Average filter, Gaussian filter, median filter and standard deviation filters are applied in this approach. Standard deviation filter leading to high performance method comparing other types of filters in which have maximum value of Peak Signal to Noise Ratio (PSNR) and minimum value of Mean Square Error MSE. Image analysis tools leads to good results of texture surface analysis and that is identified in image enhancement procedures. It is clear that the porosity of image surface of the samples at thickness (8mm) by weight fraction (0.05) is increased after immersion in acidic solution (H2SO4). The obtained results indicated that there is an efficient modification of surface image via applying different types of filters. In addition, standard deviation filter achieved high performance with high value of PSNR (54) and low value of MSE (0.25). Key Words- Composite Material; Image Enhancement; Nano Silicon Dioxide (Nano-SiO_2); Image Analysis. **RESUMEN /** **La nanotecnología es una nueva tecnología que se utiliza en una amplia gama de aplicaciones y un nanomaterial que tiene pequeñas partículas de nanoescala producidas y procesadas por nanotecnología. La combinación de problemas físicos y de tecnología de la información producirá un enfoque poderoso para el procesamiento y análisis. El procesamiento de imágenes es una herramienta eficiente para procesar y analizar la superficie del material. Este trabajo se implementa a través de muchas etapas: preparación de los materiales, moldeo de las muestras, adquisición de imágenes de la superficie de moldeo, mejora de la superficie de la imagen y medición de muchos parámetros para garantizar la mejora de la superficie. Los resultados obtenidos se obtienen a partir de imágenes de superficie antes y despúes de la inmersión con y sin filtro. El filtro promedio, el filtro gaussiano, el filtro mediano y los filtros de desviación estándar se aplican en este enfoque. Filtro de desviación estándar que conduce a un método de alto rendimiento que compara otros tipos de filtros en los que tienen un valor máximo de señal máxima a relación de ruido (PSNR) y un valor mínimo de error cuadrático medio MSE. Las herramientas de análisis de imagen conducen a buenos resultados del análisis de superficie de textura y eso se identifica en los procedimientos de mejora de imagen. Está claro que la porosidad de la superficie de la imagen de las muestras con un grosor (8 mm) en fracción de peso (0,05) aumenta después de la inmersión en solución ácida (H2SO4). Los resultados obtenidos indicaron que hay una modificación eficiente de la imagen de la superficie mediante la aplicación de diferentes tipos de filtros. Además, el filtro de desviación estándar logró un alto rendimiento con un alto valor de PSNR (54) y un bajo valor de MSE (0.25).**
Palabras clave: material compuesto; Mejora de la imagen; Nano Dióxido de Silicio (Nano-SiO2); Análisis de imagen.

1. Introduction

ISO/TS 80004 is a series of standardization to describe nanotechnology and their applications, which issued by International Organization for Standardization (ISO) [1,2]. These standards are largely used in many applications such as: health, biomedical, safety, industrial, agriculture, food …etc [3,4]. On the other hand, nanomaterials including tinny size particles up to 300 Nano meter (300 *10 -9) [5,6]. Nanomaterials are developed to increase the specification and features of the same material including mechanical, physical and chemical characteristics [7,8].

Nanocomposite materials are very important because of their role as a bridge between the conductive polymers and inorganic materials [9]. Inorganic nanoparticles existing in different sizes in the nature [10,11]. These two materials can be combined that giving rise to a multitude of nanocomposites with attractive physical properties and their significant applications [12,13].

Adapting physical characteristics and computer sciences issue leading to wide range of applications. Image processing is an advanced tool uses in many sciences including physical and computer sciences [14]. One of the important applications of image processing is optical microscope in which it is able to enlarge the image into high number times [15,16]. Now a days image processing become an important issue in many aspects including analysis, restoration, enhancement, reconstruction, filtering, feature extraction, transformation, recognition and compression [17,18].

Any image can be represented in two-dimensional matrix, and the minimum unit that has the intensity information is named pixel [19]. The pixel values in gray scale image, which represented by one byte or 8 bits that is ranged from 0 (black) to 255 (white) [20]. In color image each pixel is represented by three bytes, each byte represents the standard color (red, green or blue) [21]. As it is mentioned, an image which has M rows and N columns can be defined as an image of size M×N [22].

This approach aims to study the effect of acidic solution (H2SO4) on the nano composites materials (EP/ Nano-SiO2) using digital image analysis. In addition, a study of digital image analysis of the composites material is proposed to obtain the homogeneity and distributions of the composite.

2. Nano-Silicon Dioxide (SiO_2)

Nanotechnology can be described as the design, production and application of structures, devices, systems and materials by scaling materials and controlling their form, so that their size does not exceed the size of the atom and the molecule [23,24,25]. On the other hand, the particle size not exceed 300 Nano meter (300 * 10 -9) [26,27,28]. Nanotechnology will have a significant impact on consumer life, as evidenced by the increased availability of nanotechnology products Online [29,30,31].

In this research, NS white powder was used. Table 1 illustrates that the content of SiO_2 was 99.9%, the average size of particle was approximately 10 nm, and the specific surface area was 670 m2/g [32,33,34].

Table 1. Properties of Nano-SiO_2

Properties	Content of SiO_2(%)	Phase	Compaction Density (g/cm^3)	Average Particle size (nm)	Specific Surface Area(m^2/g)	
Content	99.9	Non-crystal white powder	0.14	10	670	
Properties	Impurity (%)					
Content	Cl	Cu	Al	Ca	Fe	Mg	Sn
	0.028	0.003	0.002	0.002	0.001	0.001	0.001

However, such a high calcination temperature inevitably leads to a considerable degree of increase and agglomeration of the particles [35,36].

Nanomaterials are classified into three types [37,38]:

- One Nano-scale dimension as in thin sheets.
- Two Nano-scale dimensions as in nanotubes.
- Three Nano-scale dimensions as in particles that either are organic or inorganic.

3. Related Work

Image surface enhancement of Nano material is an important issue and has wide range of applications. This section will be concentrated on the updated related published works.

Henrik Lieng et al. (2014) improved the intensity of the image to increase the perceived contrast without altering the original feel of the image. This enhancement of contrast can be obtained by modeling the image profiles. They demonstrated that previous profile modeling methods to improve contrast were used the diffuse mask operator that is not relevant to content of the image. This approach aims to achieve robustness so, they proposed a different approach centered on vectors surfaces. This approach is parameterized 3D surfaces that are submerged in the luminance factor to create a counter-note, which related the structure of the image. This method is robust for the topology of the edges to be improved and the relative luminance on these edges. This method was clearly chosen over the other associated methods of contrast enhancement [39].

G. Molodij et al. (2015) proposed an approach to distribute the acquired knowledge in the fields of optics and solar astrophysics image in order to improve the image of the retina in order to make a medical diagnosis. The main objective supports the health professionals by improving the spatial resolution of the images of the retina and by increasing the level of confidence in the detection of abnormal characteristics. They applied a non-linear recording method using local correlation tracking to increase the field of vision and follow the evolution of the structure by using correlation techniques taken from the experience of solar astronomy techniques. They defined the tracking movements after analyzing the local correlations to follow the movements of an image from one moment to another, such as changes in optical flow that would be of great interest for medical diagnosis [40].

Jinsheng Xiao et al. (2016) implemented a new image improvement algorithm based on an adaptive shock filter for super image resolution to solve this problem. The weight of the impact filter can be modified automatically regarding to the gradients of the high-resolution image. The diffusion of the edges of the image is suppressed and the artifacts are eliminated by direct transmission. The implemented approach deletes edge halos and irregular artifacts, while fine image structures are effectively reserved. The background analysis and the obtained results show that the proposed algorithm can achieve better results than the advanced methods, both subjective and objective in most cases [41].

Li Xiong, et al. (2017) improved the color images of the retina using diffusion model. Two parameters of this model is used based on the background and foreground extracted; background illumination and the transmission map. The complex nature of the close-up of a retina image, involving pixels of low and high intensity, posed a challenge for the correct extraction of these pixels. They proposed an approach that combines the distance discrimination of Mahalanobis and the improvement of the global contrast based on the spatial entropy to extract the foreground pixels. The background and the foreground are obtained for various intensities, and can work well in a blurred image with a very low intensity range. The proposed method is evaluated using 319 color retinal images from three different databases. The experimental results indicated that the proposed method can be effective in problems of illumination, improvement of the contrast and preservation of the color [42].

Yangyang Li et al. (2018) explained that surface-enhanced Raman diffusion nanoparticles have been widely used in biomedical applications, including thermostatic detection and biomarker determination. The development of biocompatible method of nanoparticles offers promising prospects for clinical applications. This approach can provide an real imaging modality due to its high specification of molecular, negligible auto fluorescence and high sensitivity. Mainly, composition structure and methods are developed for nanoparticles and described in this approach. The key points of research on which this article focuses are the theragnostic guided by images of tumors and bio sensitivity. The approach may apply for biocompatible nanoparticles and spectroscopic devices for clinical applications [43].

Yongteng Qian et al. (2019) explained that high surface areas nanostructures are very desired for electrochemical super capacitors which achieved large energy storage capacity. They synthesized co-doped porous TiO_2 nanostructure with a mean diameter of 450 nm through a simple solvothermal method using tetra butyl titanite acetate and cobalt as precursors and polystyrene beads as templates. Optimized supercapacitor electrodes TiO_2 nanostructures based co-doped with 7% showed a specific capacity of 352Fg-1 current density 0.5Ag while maintaining a capacity of 97.2% after 3000 cycles. This good performance can be attributed to the synergistic effects of improving the conductivity of TiO_2 with optimized co-doping with larger surface areas made by structural porosity compared to undoped TiO_2 samples. The obtained results suggested that porous co-doped TiO_2 nanostructures can be explored for possible electrochemical applications [44].

4- Methodology

Nanomaterial is new aspect that implemented for tiny particles in which that have wide range of applications. Digital image processing is an efficient tool for image surface enhancement. The hybridizing of these two aspects, leads to a powerful approach.

4.1 Preparing the Nanomaterials; Nano-Silicon Dioxide (SiO_2)

Nano-silicon dioxide (SiO_2) and Nano-silicon dioxide of grain size (30-40 nm) with a purity of 99.5%, which supplied by Nanjing Nano technology (Chinese company) as shown in table 2.

Table 2 physical specifications of Nano-Silicon dioxide (SiO_2)

Properties	Quantity
Density (g/cm^3)	2.65
Elastic modulus (Gpa)	70
Tensile strength (Mpa)	55
Compressive strength (Mpa)	2070
Thermal conductivity (W/m °C)	1.38
Coefficient of Thermal expansion (10¯6 / °C)	12.3
Melting point (°C)	1830

The implemented approach including the following four stages (figure 1): cutting of glass, preparing the mold, molding the samples and cutting the samples into specified pieces.

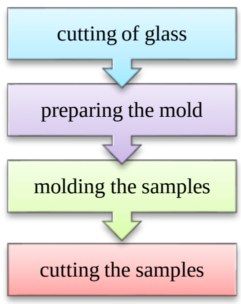

Figure 1 stages of methodology

First: Cutting the Glass

These molds are prepared to make the samples; in addition the dimensions of the molds are 10cm*10cm, so, cutting the glass into pieces with dimensions (5cm*5cm) to prepare the molds.

Second: Preparing the Mold

The mold is 8mm of thickness, and then the base of the mold is coated with thermal papers to prevent the adhesion of the resin on plate of glass.

Third: Molding the Samples

Molding process including the following steps:

- Preparing the weighted amount of required epoxy proportion and hardener that added in a ratio of (2:1).
- Preparing the weighted amount of material reinforcement (SiO_2) nanoparticles and natural hybrids according to weight.
- Mixing reinforcement material and matrix at room temperature. Where mixing the weighted ratios of reinforcement and matrix together in a special pot mixing applied and confused by the electric mixer to a maximum of (1–10) minutes. However, this method does not give a good homogeneous mixture, so noticing deposition of a large amount of material reinforcement at the bottom of the mixture.
- Pour liquid mixture to form a torrent in the middle of the template, so that the flow taken place to all areas of ongoing and regular template that the template is filled to the desired level.
- Leave the pressed into the mold for (48) hours to be hard definitively and then put it in oven with 50 °C of temperature for 5 hours to complete the formability and graduating to be ready for another picture.

Fourth: Cutting the Samples

Standard dimensions are chopping samples according to (5*5 cm) using soft-toothed band, in which it was manufactured in the lab to ensure no vibration during cutting samples and it also saw teeth smoothness to avoid distortions that may occurs during the cutting process. Then, starting the process of refinement with smooth sheets (silicon carbide) with different degrees of softness.

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• capturing special images using cannon camera of high resolution, for sample within a thickness of (8 mm) for all weights percentage of composites (0.05).

• Cutting the samples with the same thickness and dimensions of (50mm * 50mm) with one cut of the model surface to below in diagonal (45 °) in which these samples are ready to take three images for top side to bottom side and diagonal side. Then these samples are imprisoned in (H_2SO_4) acid within (14) days and then these samples are ready to take images after immersion.

• Mathlab package is used to implement digital image processing code.

5- Image Surface Enhancement

Image surface enhancement procedure including the following steps (figure 2):

- Image acquisition: after preparing the specified pieces of samples, taking many pictures of these samples with different views. Then transfer these images to the computer to start the processing process.
- Converting image into gray scale: the color image will be converted into gray scale image to start processing.
- Image preprocessing: this step including image resizing and noise removal.
- Image enhancement: this step including enhance the image surface to be more clear.
- Feature extraction: this step including extraction a specified feature on the surface.
- Statistical measures: this step including many statistical measurements to show the effectiveness of this approach.

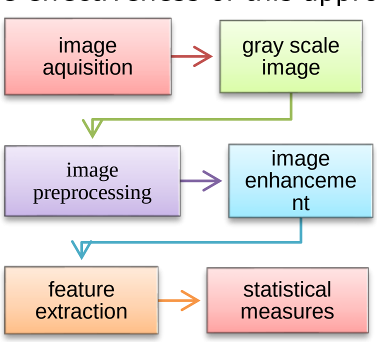


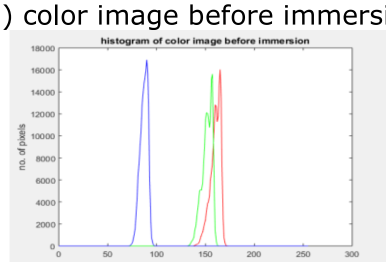
Figure 2 image surface enhancement procedure

5. Results and Discussions

In this work, Nano Silicon (Nano SiO_2) is used with epoxy resin during normal conditions and immerses the sample in H_2SO_4 acid during fourteen days. The weight fraction of the Nano Silicon is 0.05 and the thickness of the sample is(8mm). The samples are tested before and after immersion with the acid, so many images are taken before and after immersion to check the difference in the surface of the tested sample.

The first step in image processing procedure is visualizing the original surface image of the sample before and after immersion and their histograms as shown in figure 3 and figure 4. In these two figures, there are significant variations in green and blue aspects before and after immersion.

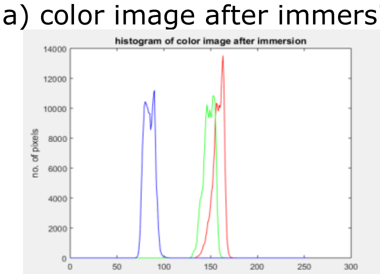
(a) color image before immersion



(b) histogram of (a)

Figure 3 surface of color image and its histogram (before immersion)

(a) color image after immersion

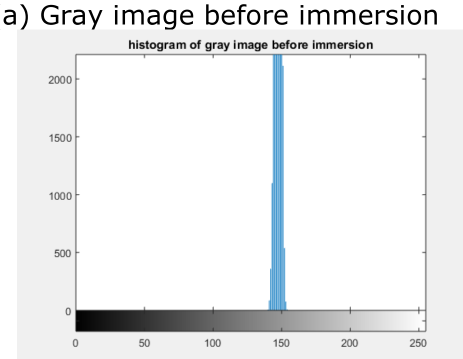


(b) histogram of (a)

Figure 4 surface image and its histogram (after immersion)

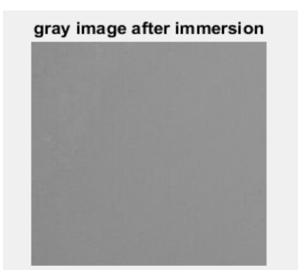
The next step in the procedure is converting both color images (before and after immersion). This step is shown in figure 5 and figure 6. These two figures show that there are differences between the distribution of pixels before and after immersion. The histogram after immersion is slightly shifted to the left side. In addition, there is a small reduction in number of pixels in each gray level denoted in histogram after immersion.

(a) Gray image before immersion

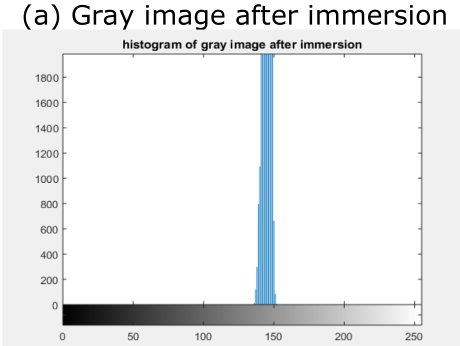


(b) histogram of (a)

Figure 5 gray image before immersion and its histogram



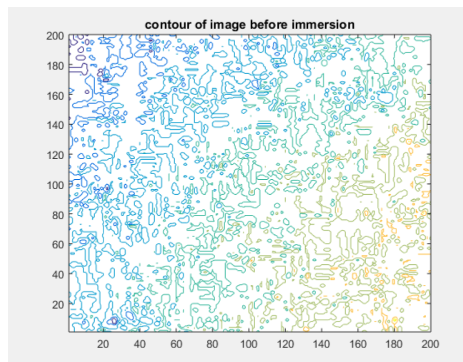
(a) Gray image after immersion



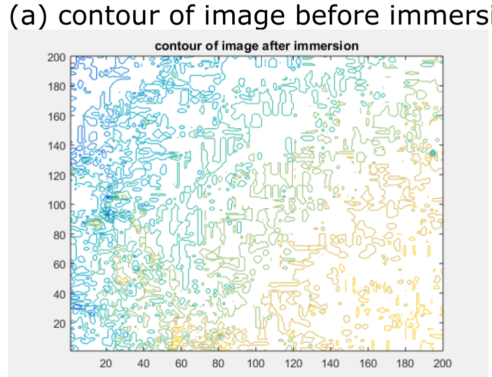
(b) histogram of (a)

Figure 6 gray image after immersion and its histogram

Contour is an important operation is used to visualize levels and the values of levels. The next step in the procedure is applying the contour of both images before and after immersion without using filter as shown in figure 7. The surface image is resized to be 200*200 in which its clear in figure 7. Figure 7b shows that there is clear wide area extended in all bands of the image after immersion. On the other hand, after applying standard deviation filter then visualize both images before and after immersion as shown in figure 8. Applying standard deviation filter caused good visualization in the surface image, in addition, after immersion it is clear that there are wide areas and gaps via the surface image.

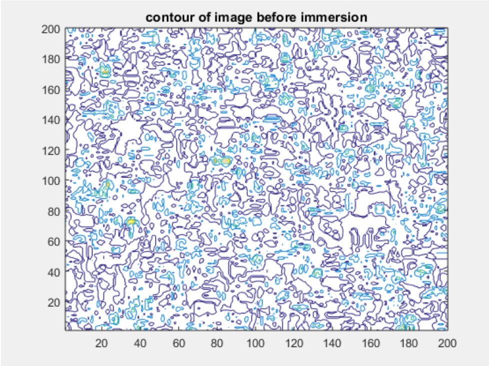


(a) contour of image before immersion

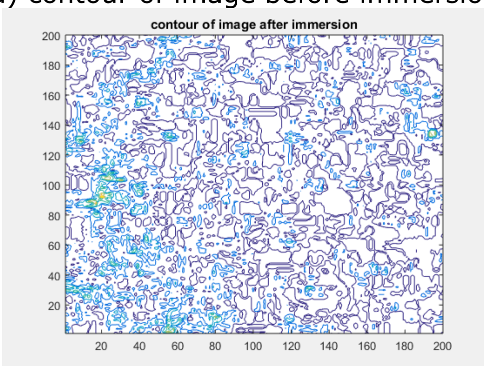


(b) contour of image after immersion

Figure 7 contour of images before and after immersion without filter



(a) contour of image before immersion



(b) contour of image after immersion

Figure 8 contour of images before and after immersion using standard deviation filter

PSNR between images before and after immersion indicated that there is slightly difference via applying filters, but there is a significant value of PSNR via applying standard deviation filter as shown in figure 9. On the other hand, figure 10 shows MSE values in which the minimum value is obtained via applying standard deviation filter. The better maximum error value is obtained in standard deviation filter as shown in figure 11. The ratio of the two images before and after immersion is shown in figure 12 in which there is a significant value via applying standard deviation filter.

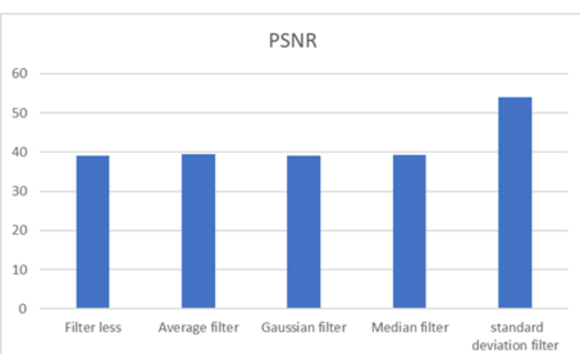


Figure 9 peak signal to noise ratio between the two images before and after immersion

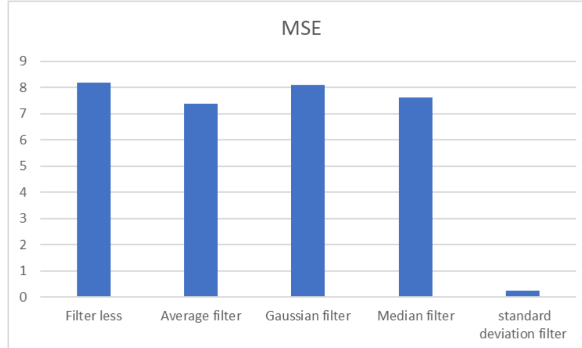


Figure 10 mean square error between the two images before and after immersion

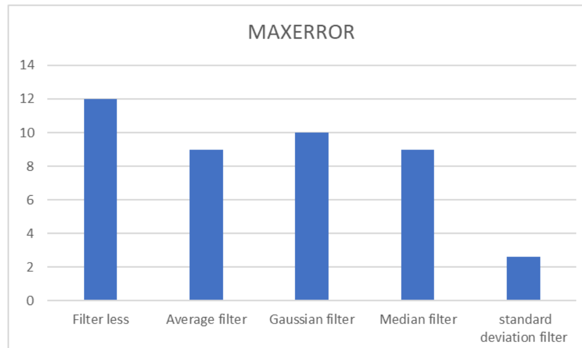


Figure 11 maximum error between the two images before and after immersion

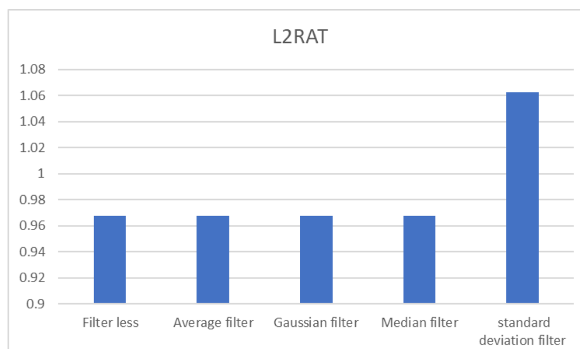


Figure 12 The ratio of the two images before and after immersion

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6. Conclusions

Based on experimental results, which presented in this work, the following conclusions can be drawn:

1- The implemented approach applied different types of filters to analysis the Nano Silicon surface image. The obtained results are applied for surface images before and after immersion with and without filters. Average filter, Gaussian filter, median filter and standard deviation processes are applied in this approach.

2- Standard deviation process leading to high performance method comparing with other types of processes in which it maximum value of PSNR (54) and minimum value of MSE (0.25) are obtained.

3- Image analysis tools leads to good results of texture surface analysis and that is identified in image enhancement procedures.

There is a clear effect of the acidic solution on the nanoparticle composites material where the porosity of the image surface of the samples increased after immersion.

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