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METHODS OF CORRECTION OF TYPICAL DEFECTS IN THE DIGITAL IMAGES ON THE EXAMPLE OF SEM IMAGES OF ANODIC OXIDE LAYERS

METODY KOREKTY TYPOWYCH WAD OBRAZÓW CYFROWYCH NA PRZYKŁADZIE ORAZÓW SEM ANODOWYCH WARSTW TLENKOWYCH

A b s t r a c t

The paper proposes one of the possible methods of image quality improvements. There are materials whose preparation for microstructure observation is difficult and, despite the effort, poor quality images are obtained. Computer image processing techniques allow for image transformation by means of various tools and obtaining much better images, with much more visible details than in the raw image. When it is impossible to prepare the sample better for microscopy observation and microstructural analysis, proper image processing is the only solution to gather information about the tested material.

Keywords: *image processing*, *image analysis*, *shade correction*, *noise*, *microstructure*

S t r e s z c z e n i e

W artykule zaproponowano jedną z możliwych metod poprawy jakości obrazu. Istnieją materiały, których przygotowanie do obserwacji mikrostruktury jest trudne i w efekcie, pomimo najwyższej staranności, otrzymujemy obrazy o słabej jakości. Komputerowe techniki przetwarzania obrazu pozwalają na przekształcenie obrazów za pomocą różnorodnych narzędzi cyfrowej obróbki i uzyskanie obrazów o znacznie lepszej jakości niż obrazy bazowe. Techniki komputerowego przetwarzania i poprawy jakości obrazów stanowią cenne narzędzie w sytuacji, gdy nie jest możliwe powtórne przygotowanie próbek do obserwacji mikroskopowych i analizy mikrostruktury.

Słowa kluczowe: *przetwarzanie obrazu*, *analiza obrazu*, *korekcja cienia*, *szum*, *mikrostruktura*

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1. Introduction

Microstructure analysis of materials microstructure is a standard procedure in developing new materials. It is also a very important stage of the quality control process of material and devices production. Microstructure inspection allows to control if all technology parameters are properly adjusted and the produced material fulfills quality requirements. Depending on the material and the scale of observation, suitable observation equipment must be chosen, like the SEM or TEM optical microscope. After the acquisition of images of microstructure, the quantitative analysis of chosen structural components should be performed if the image quality allows that. Computer image analysis, and the automatic procedure in particular, requires high quality images. Otherwise the obtained detection may fail and the results may be incorrect.

Typical image defects which strongly affect detection results are a high level of noise, unsharp image and the shadow effect. At least one of these defects can be the reason for the conduct of image preprocessing.

The proposed methods for image quality improvement were tested on the SEM images of the anodic oxide layer whose observation was difficult, and working out the proper sample preparation procedure was complicated [2].The image processing procedure presented in this paper allowed for assessing the influence of sample preparation on the quantitative analysis of structure components. For the image processing, it is not the type of object on the image that is the most important issue, but its relation with the background which determines the detection, type of needed analysis, and finally the image defects which must be reduced.

2. Proposed correction method

2.1. Noise reduction

Noise is an unexpected pixel volume fluctuation that does not reflect the true intensity of objects in the frame. Noise is introduced to image at the level of the acquisition process by CCD detectors, electronic data transmission or by a choice to save the image file format. There are lot of types of noise, but the most typical is the uneven, salt and pepper type. This kind of noise can be reduced by linear filters, like the average filter or Gauss filter. Blurring the edges of objects is a disadvantage of linear filtering and can result in enlarging the objects area on the detection images and bias the quantitative analysis. Other proposed solution is to use ranking filters. Ranking filters give good results but they must be chosen according to the noise type. Minimal filter is recommended for the salt type of noise, maximal filter for the pepper type of noise, and median filter for the salt and pepper type of noise. The minimal filter changes the pixel value for the lowest in the neighborhood, while the maximal filter changes the value of analyzed pixel for the highest in the neighborhood. The median filter for a new value of the analyzed pixel chosen is that which is in the middle of the rank list of all pixel values in the neighborhood. The advantage of this filtering is that the objects are blurred inside on the result images but the edges are sharp. The impact of the filter on the image is adjusted by an adequate filter mask size which determines the area of the image, and in fact the number of pixels considered in the ranking list. Proper filter and its size may be assessed on the basis of profile analysis (Fig. 1a). The profile shows the course of pixel values along the test line, and allows for visualising the intensity of the noise. After

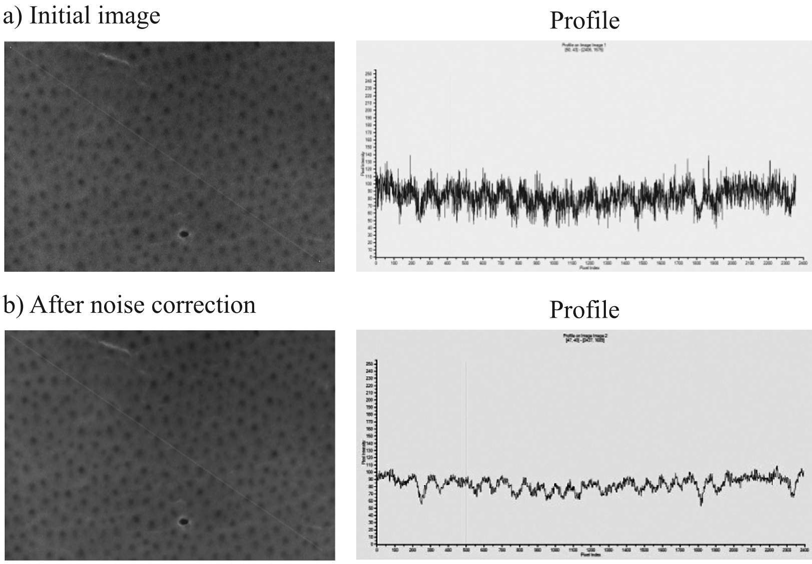

Fig. 1. Noise reduction using median filtering: a) initial image, b) image after noise correction

the noise reduction by means of a median filter, the resulting image is not spectacularly different, but when we compare the profiles of both images it is easier to assess the obtained effect. The profile of the image after noise reduction is significantly smoother, and the local minimally illustrated objects are more visible.

2.2. Image sharpening

Image blurring can be caused by improper equipment adjustment or a specific object surface. Image processing software offers sharpening filters which make images sharper, but it should be taken into consideration that sharpening filters sharpen the image by increasing the local contrast. A side effect of this solution is the enhancement of noise on the image. Sharpening filters are commonly used in computer graphic applications, but for image analysis it is better to use the unsharp masking procedure. The unsharp masking procedure based on a blurred image (Fig. 2b) which is subtracted form the initial image. The obtained image (Fig. 2c) is added to the initial image (Fig. 2a).

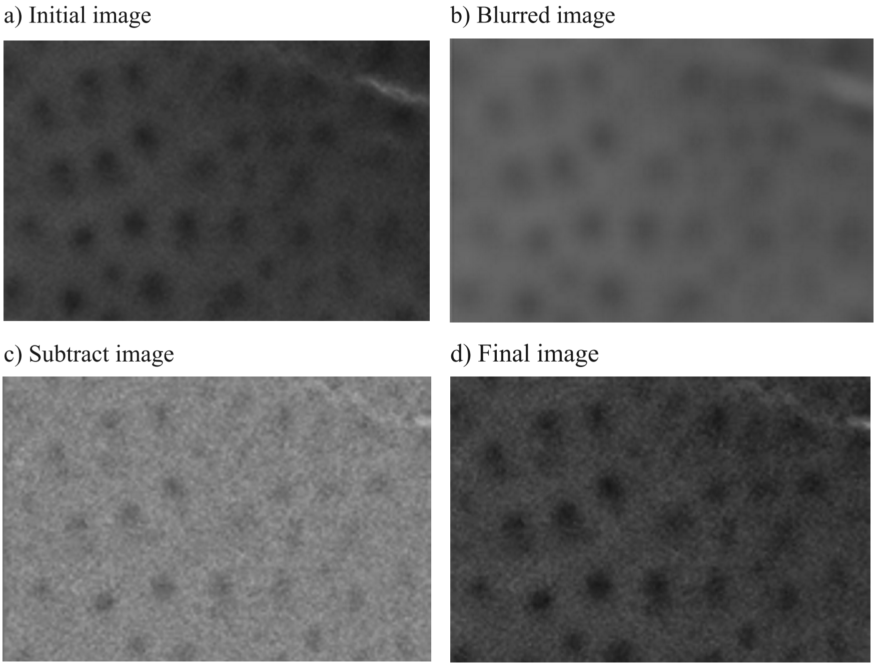

Fig. 2. Unsharp mask

2.3. Shadow correction

The shadow effect on the image is caused by uneven lightening of the object during the acquisition or by uneven surface of the analyzed sample. In both cases it is manifested by uneven background on the image, which may make object detection difficult or impossible, especially when the pixels value of the objects and background is insignificant.

In the literature there can be found numerous methods of shadow correction [1, 3, 4]. The shadow effect can be reduced by bringing out and subtracting the image of the shadow

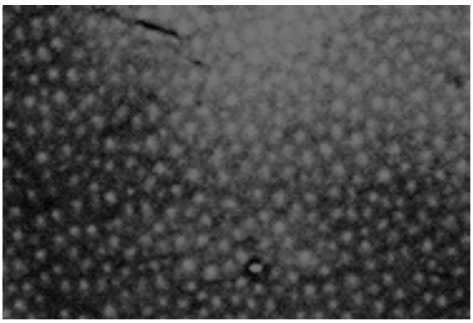

Fig. 3. The result of the detection without the shadow correction

from the initial image. In general, almost all known methods of shadow effect reduction differ in the method of shadow image extraction. The image of a shadow may be generated by means of a mean filter with a large mask, enough to blur out all objects. A frequency filter may be also used, like, for instance, the Fast Fourier Transformation. The shadow might be obtained in the way of morphological transformation, closing with a large size of the matrix. In the considered example, the shadow effect is not visible for the user. However, the problem with correct thresholding and detection showed that the correction must be performed (Fig. 3).

The proposed procedure of shadow correction is so called the proportional method [1] and it starts from generating shadow image by a large closing (Fig. 4b). In the next step, the initial image is divided by the image of a shadow. The resulting image is multiplied by the inverted image of the shadow and added to the initial image. The final image of this set of procedure is presented in Fig. 4c, and the detection result in Fig. 4d.

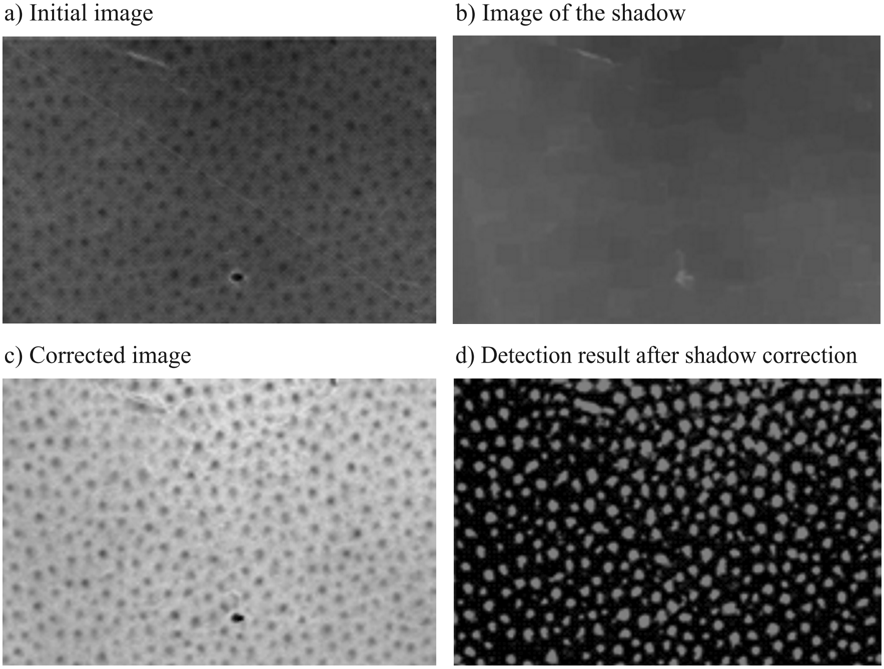

Fig. 4. Shadow correction effect

A set of images presenting an anodic oxide layer was used to test the efficiency of the proposed method of image quality improvement. The result of detection, the pores, have been drawn in yellow. It can be observed that not all pores were detected correctly, some of them were missed and not taken into consideration in quantitative analysis (Fig. 5). However, it must be stressed that without the proposed correction procedure the detection and quantitative analysis were impossible to perform due to the low quality of images.

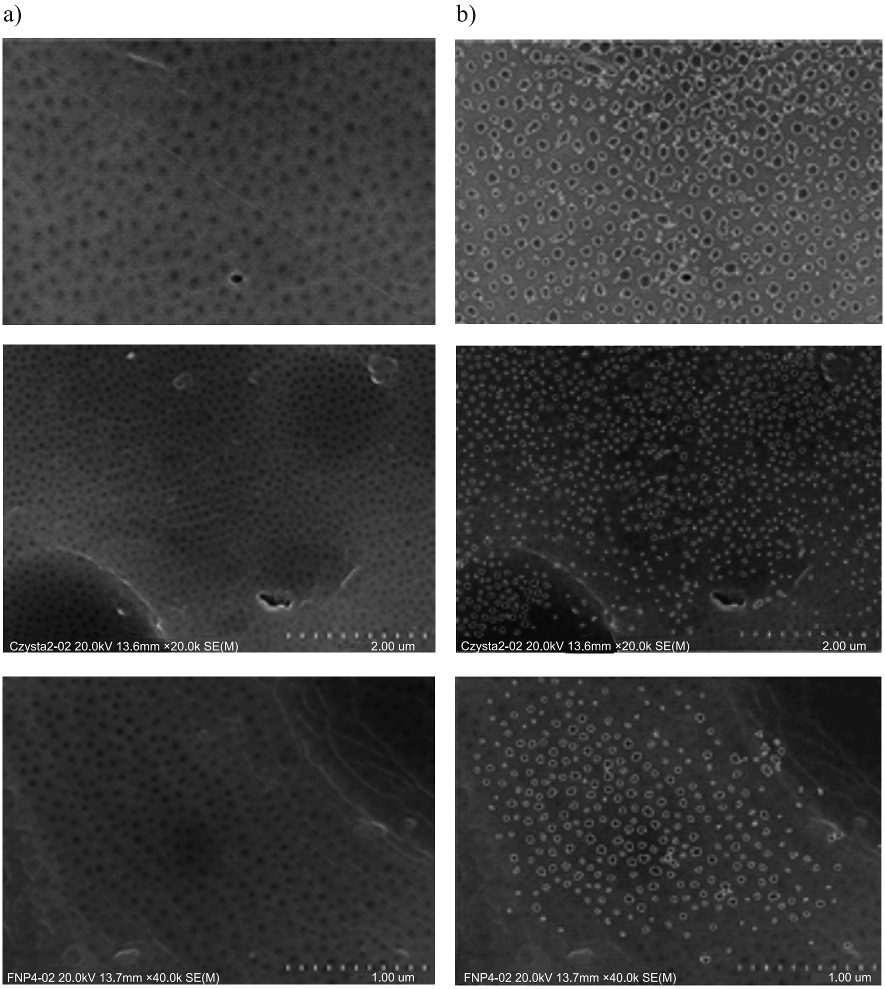

Fig. 5. Result of the detection on the set of tests images: a) initial images, b) detection result of corrected images

3. Conclusion

Advanced imaging techniques allow for obtaining better quality images, but still some problems with proper sample preparation of new materials may cause problems, which may affect the microstructure image quality. Appropriate selection of tools and methods of image processing can result in a significant improvement of image quality and the possibility to perform quantitative analysis of a microstructure.

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