ANADOLU ÜNİVERSİTESİ BİLİM VE TEKNOLOJİ DERGİSİ –A
Uygulamalı Bilimler ve Mühendislik
**ANADOLU UNIVERSITY JOURNAL OF SCIENCE AND TECHNOLOGY –A**
**Applied Sciences and Engineering**
Cilt/Vol.: 13-Sayı/No: 2 : 121-126 (2012)

ARAŞTIRMA MAKALESİ / **RESEARCH ARTICLE**

# DETECTING GLASS SURFACE CORROSION WITH IMAGE PROCESSING TECHNIQUE

**Rafet AKDENİZ [1], Oytun OKTAY [1], Mustafa Bilge SATKIN [2], Hasan DEMİR [1]**

***ABSTRACT***

Glass is a kind of amorphous materials that exhibits a transition from rigid to viscous state and finally liquid state when heated. For daily usage, it is desirable to have different forms and different transparencies for different purposes. Most widely used one is the one with high transparency and flat surface.

One of the detrimental effects that glass is undergone during the storage or usage periods is corrosion. In this work, a way for detecting corrosion on the glass surface by image processing method is presented.

**Keywords:** Glass corrosion, Image processing method, Corrosion detection.

# CAM YÜZEYİNDEKİ KOROZYONUN GÖRÜNTÜ İŞLEME YÖNTEMİYLE TESPİTİ

***ÖZ***

Cam, ısıtıldığında kademe kademe katı halden önce akışkan hale ve sonrasında da sıvı hale geçen kristalin olmayan (amorf) bir malzemedir. Günlük kullanımda farklı amaçlara yönelik farklı yapı ve geçirgenlikte olması istenir. En çok kullanılanı ise yüksek geçirgenlikli düz yüzeye sahip olanıdır.

Camın kullanımında veya depolanma sürecinde maruz kaldığı zarar verici etkilerden biri korozyondur. Bu çalışmada cam yüzeyindeki korozyonun tespiti için bir görüntü işleme yöntemi önerilmektedir.

**Anahtar Kelimeler:** Cam korozyonu, Görüntü işleme yöntemi, Korozyon tespit.

[1,] Namık Kemal Üniversitesi Çorlu Mühendislik Fakültesi, Elektronik ve Haberleşme Müh. Bölümü, 59860 Çorlu/Tekirdağ.
[2,] Marmara Üniversitesi Güzel Sanatlar Fakültesi, Fotoğraf Bölümü, Küçükçamlıca Acıbadem 34660 Kadıköy/İstanbul.

**Recieved:** 2 February 2012; **Revised:** 26 April 2012; **Accepted:** 5 May 2012

## 1. INTRODUCTION

Glass corrosion means decomposition of the glass to its components under the effect of environmental conditions while being in service or in the manufacturing processes or due to storage conditons. Detection of corrosion before application is important because it affects aesthetics, toughness and transparency of the glass adversely. In this work, detection of the glass surface corrosion at large scales was studied. Glass surface corrosion was tried to be detected by a digital camera. Corrosion made apparent by illuminating the background of the glass and the glass with different light sources. After capturing the photograph of the glass, digital image was enhanced by different techniques to make the glass corrosion apparent. Four different glasses in two different photographing arrangements were used to detect two different kinds of corrosion. Also corrosion on the glass was observed by a SEM (Scanning Electron Microscope) to validate the consequent findings.

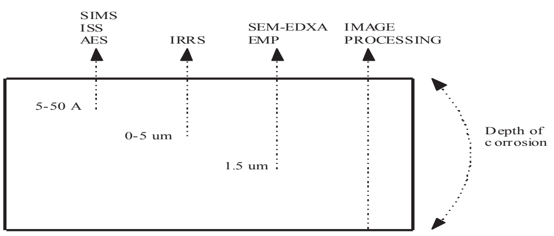


Figure 1. Methods for detecting glass corrosion by their effective depths.

For detecting corrosion on the glass, there are several methods proposed with different effective depths. These are IRRS (Infrared Reflection Spectroscopy), AA (Atomic Absorption), AE (Atomic Emission), EMP (Electron Microprobe Analysis), SEM-EDXA (Scanning Electron Microscopy conducted with Energy Dispersive X-Ray Analysis), ESCA (Electron Spectroscopy for Chemical Analysis), SIMS (Secondary-Ion Mass Spectroscopy) (Feldmann and Weiβmann 1997, Clark and Zoitos 1992) and their effective depths are shown in Figure 1. Devices that perform these methods use high technology with complex set-up and they are expensive and not appropriate for large scales.

## 2. METHOD

A digital image captured with a digital camera or created in computer environment is represented by NxM dimension matrix as given in Figure 2 (Gopi 2007). Every value in this matrix corresponds to a pixel value. If the image is multicolor, one matrix for every color band, red, green, blue, will be achieved.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A(1,1) | A(1,2) | ... | | | | ... | A(1,M) |
| A(2,1) | A(2,2) | ... | | | | ... | A(2,M) |
| ⋮ | ⋮ | | | | | | ⋮ |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| ... | ... | | | | | | ... |
| A(N,1) | A(N,2) | ... | | | | ... | A(N,M) |

Figure 2. The representation of a digital image by a matrix.

Canon EOS 5-D, 21 Megapixel digital camera, with a 24-70 mm variable lens was used for capturing images. It enables one to achive up to 0.69 $mm^2$/px resolution in the experimental all setups.

Python programming language in conjunction with Numpy, Matplotlib and Python Imaging libraries was preferred for image processing tasks because they are open source and require no license fee.

First experimental setup is presented in Figure 3, where;

(1) is the high intensive cool light source for revealing corrosion.

(2) is the glass sample under examination.

(3) is the surface used as a stand and also served as a light blocker for the camera.

(4) is the camera positioned to capture the corrosion trace revealed by (1) and also to avoid direct light from (1). For the sake of clarity two warm light sources are not shown in the Figure 3. They are used to achieve equally illuminated background for the scene captured by the camera and also enable one to easily discriminate corrosioned and non-corrosioned sections of the glass.

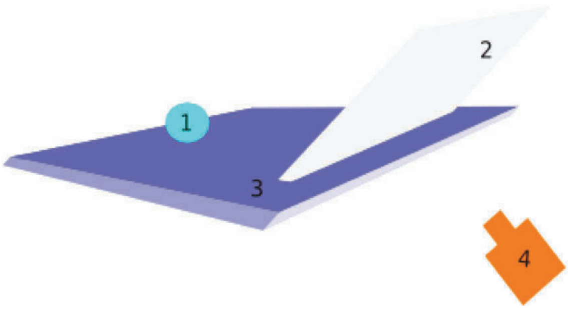


Figure 3. Experimental Setup 1 for obtaining images from different angles.

There were four samples, in which two of them have the same kinds of corrosion detected by experimental setup 1. One of them has a different kind of corrosion leading to the change in the setup to detect corrosion. And the last sample has no corrosion on the surface.

The digital images that are acquired in two different experimental setups are shown in Figure 4 (arranged in top to bottom orientation).

It was mentioned that the corrosion on the third glass sample is a different kind of corrosions that can not be detected by the setup given in Figure 3. So experimental setup to be used for the third and the fourth samples was changed as shown in Figure 5.

Different image enhancement techniques sequentially applied to make the trace left by corrosion apparent in captured images. After several trials it was decided to use the algorithm explained in Figure 6.

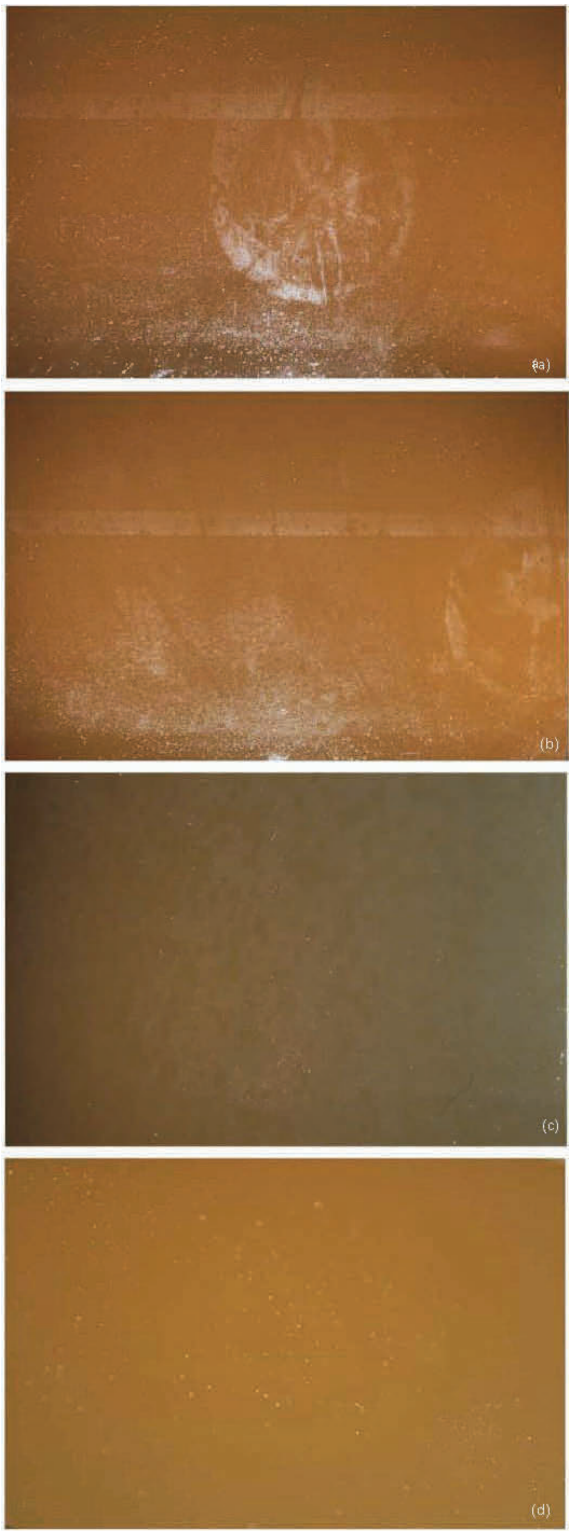


Figure 4. The images of samples in the experimental setups arranged in top to bottom orientation. (a-b) acquired in first experimental setup and (c-d) acquired in second experimental setup. Sample (d) is a corrosion free glass sample.

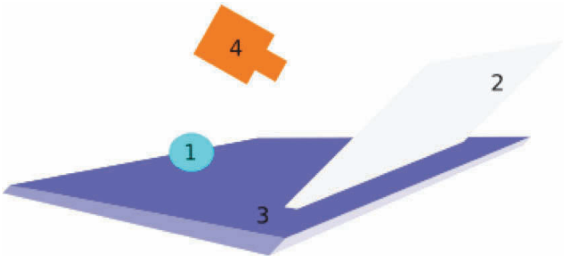


Figure 5. The second experimental setup for the detection of different kinds of corrosion.

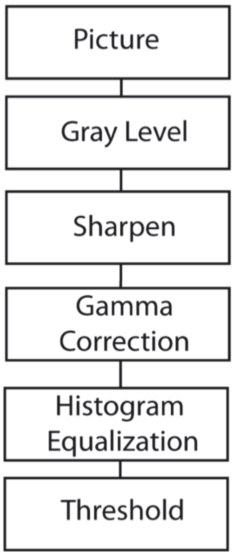


Figure 6. The algorithm applied for corrosion detection on flat glasses.

Thresholding step is the key one for this algorithm. Two different thresholds are used in this step. One is the mean value of enhanced image illumination values and the other is sum of the mean and the standard deviation of illumination. Results obtained from algorithms are shown in Figure 7. On the left hand side of Figure 7 pixels correspond to larger than the threshold value which is equal to illumination mean are marked while on the right hand side pixel values larger than threshold value equals to the sum of mean and standard deviation of the illumination values are marked on the images.

## 3. RESULTS

It was tried to detect corrosion that can be revealed by high intensity light in computer environment. The region that we marked as corrosion was also examined under SEM, which is Phenom brand G2 Pro model Desktop Scanning Electron Microscope was used. Images obtained from 5 mm x 5 mm sized samples are shown in Figure 8. Sample on the top is taken from a glass with corrosion and the sample on the bottom taken from a corrosion-free glass.

Output of the algorithm with two different thresholds that are derived from data one of which is the mean values of the pixel values and the other is the sum of mean value and standard deviation for four glass samples is shown in Figure 7. Markings on the figures indicate the pixel values over the threshold value. In Figure 7 (a-d), marked pixels are that they have light intensity values more than the mean value of the whole pixels while in Figure 7 (e-h) pixels that have illumination values more than the sum of the mean and the standard deviation of the whole pixels are marked.

Results are showing that the first threshold giving rise to excesity of false positives by marking the regions which are not really corresponding to corrosion as can be seen in Figure 7 (a-d). This gives rise to find a stricter threshold value. Second threshold is determined by summing the mean and the standard deviation of the pixel illumination values. This threshold value lowers the false positives while increasing the number of false negatives. Results of this threshold for four samples are shown in Figure 7 (e-h).

## 4. CONCLUSION

It was validated that high intensity light is really revealing corrosion on the glass surface. But using a SEM for glass samples at large scales is not an option and cannot be applied practically.

Output of the algorithm applied is given in Figure 7. Results are encouraging but not exact. And also it is encountered a type-I error, false positive, that can be observed form the last two results belonging to a clear glass in Figure 7.

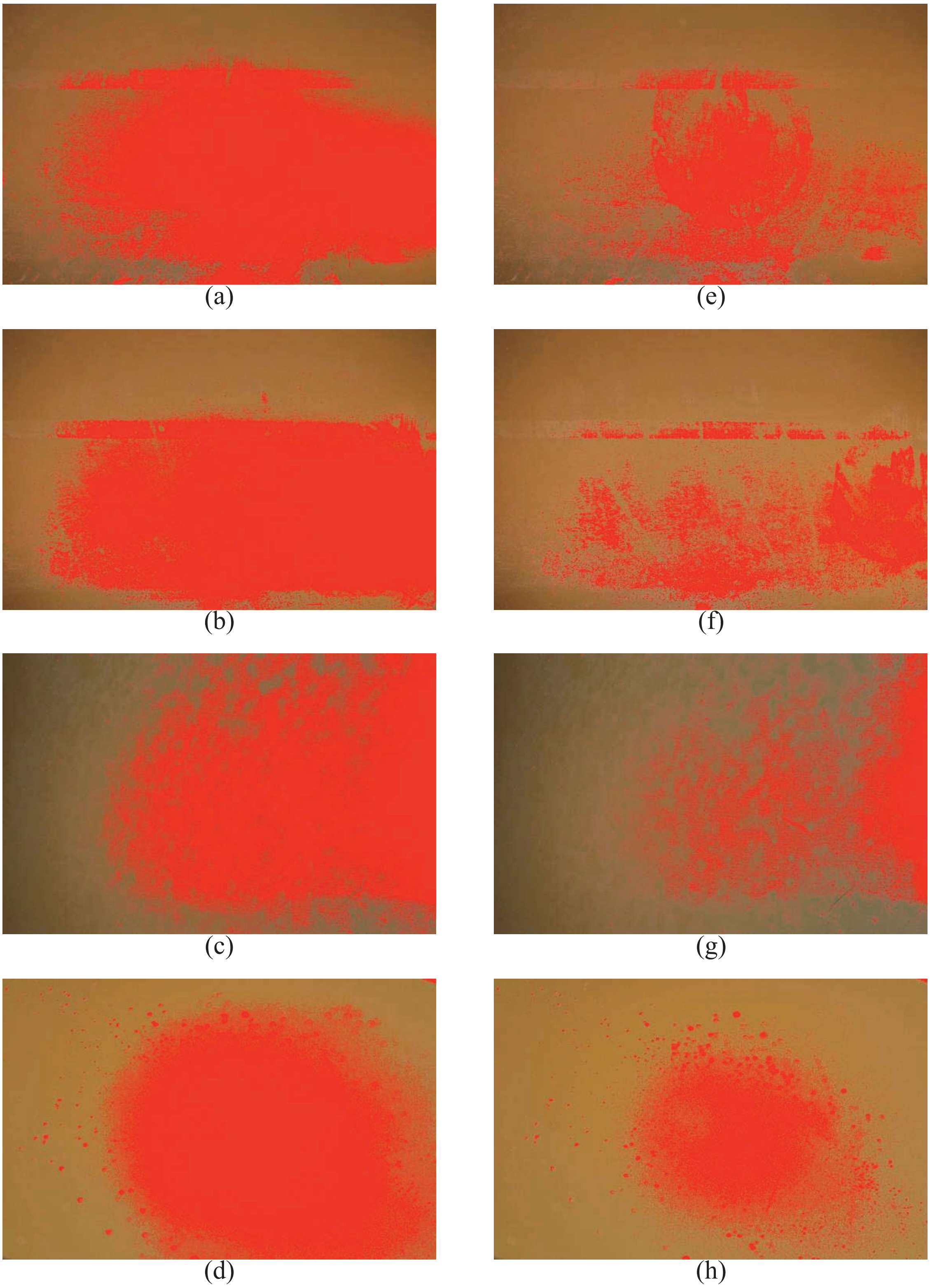

Figure 7. (a-d) are obtained by mean thresholding, (e-h) are obtained by the sum of mean and the standard deviation thresholding for four glass samples.

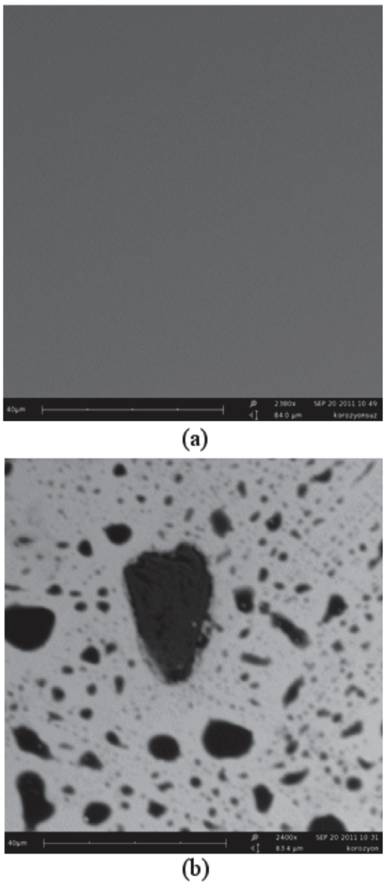

Figure 8. The images of the glass samples taken from a Scanning Electron Microscope. (a) is the observation of non-corrosioned glass. (b) is the observation of the corrosioned sample.

With this result it is understood that the mean value or the sum of the mean and the standard deviation of the illumination do not only provide corrosion information so, more works should be done for feature extraction of glass corrosion and applying statistical signal processing techniques. And also it is appropriate to add that more professional experimental setup to enhance the revealed trace of the corrosion and consequently affect the detection quality.

## KAYNAKLAR

Feldmann, M. and Weiβmann, R. (1997). "Initial stages of float glass corrosion", *Journal of Non-Crystalline Solids*, 218, 205-209, ISSN: 0022-3093.

Clark, D.E. and Zoitos, B.K. (1992). "Corrosion of Glass, Ceramics and Ceramic Superconductors: Principles, Testing, Characterization and Application", Noyes Publications, ISBN:978-0-8155-1283-7.

Gopi, E.S. (2007). *Algorithm Collections for Digital Signal Processing Applications using MATLAB*, Springer, ISBN: 1-4020-6409-8.