Failure of a Security System Due to Motion Sensor Cover Failure

By Bryan Burnett

Abstract: Six security motion devise covers were received for analysis following apparent failure of the security system in a tire/ brake store burglary. Four of the covers of these thin plastic sheets were from failed devices and two were controls from normally operating devises. The covers were examined by normal light, ultraviolet light and scanning electron microscopy/elemental analysis. The submitting party suspected that some sort of material was sprayed on these covers, rendering them inoperative. The results of these analyses provided no evidence of human manipulation. Rather, it is apparent that environmental factors likely caused the degradation of the plastic covers which resulted in the failure to allow the radiation specific to the motion detector to pass.

Introduction

A tire/brake store located in a coastal city in Oregon was burglarized resulting in loss of a number of high value items. It was determined that the security system had failed. The investigation of this security system focused on the motion sensors where it was found that the detector cover elements actually blocked the function of these sensors. The suspicion was expressed by the investigator of the burglary that a material was painted or sprayed on the covers to render them inoperative. The covers were examined by the author to determine the nature of that material.

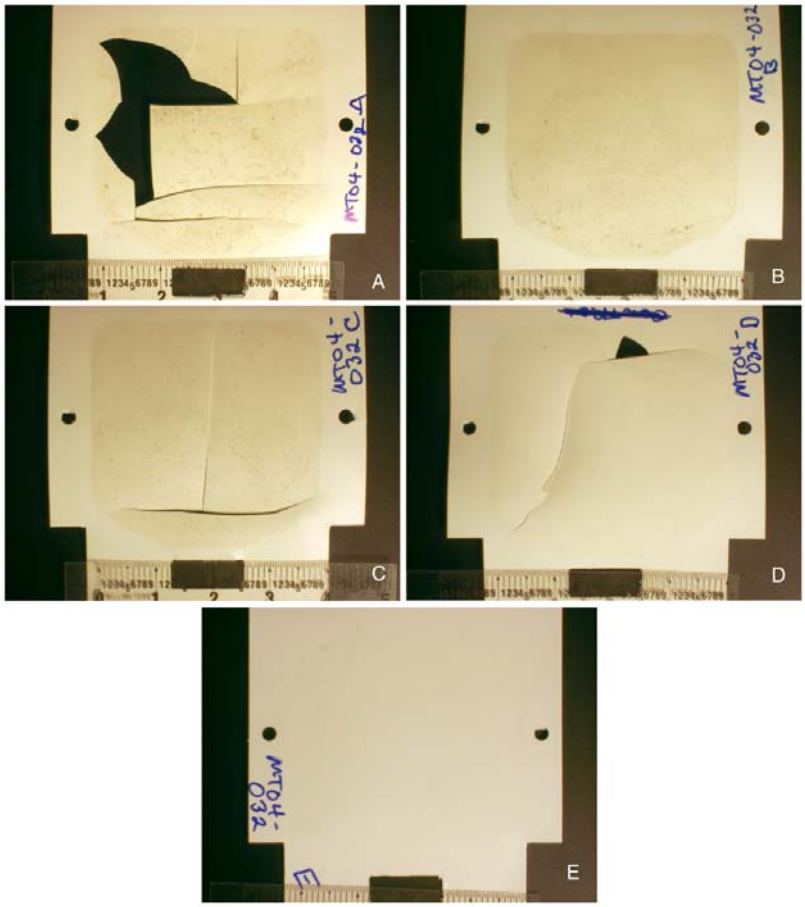

Figure 1. *Images of five of the six plastic sensor covers. A through D: the covers from the sensors that were described as having failed. E : the control cover from a normally operating sensor that was included with the other covers.*

Materials & Methods

Samples A through D: the covers from the units that failed.
Sample E: control that was included with the failed covers
Sample F: an additional control cover received after the other covers.
These covers, except for sample F, are shown in Fig. 1.

These samples were examined and imaged through a stereo microscope (Fig. 2) and by shining UV light through the covers (Fig. 3). A Pixera 600CL was used to take these images, the UV series through a Computar macro zoom lens. For the scanning electron microscopy, a piece of each motion sensor was mounted on double-stick graphite tape and placed into the scanning electron microscope. There was no coating needed. Backscatter electron images as well as elemental spectra were taken of each sample (Fig. 4). Elemental maps of samples from sensors A, C, D and E (Fig. 5).

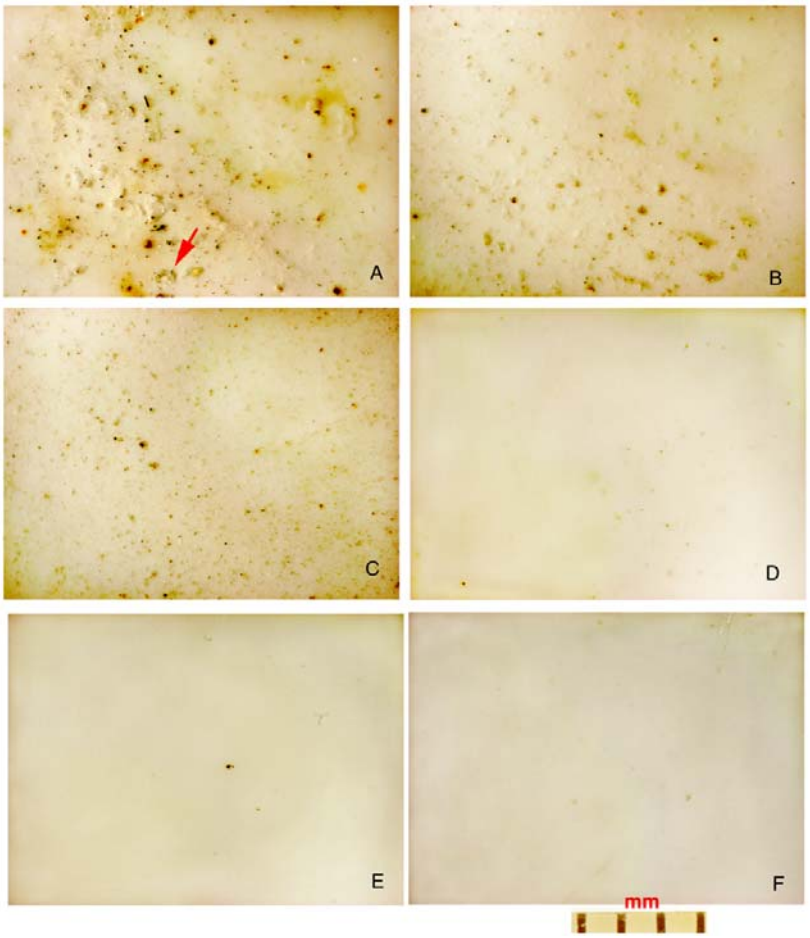

Figure 2. *A through D: Stereo microscope images of the exterior surface of the four failed covers. Arrow, an apparent salt crystal. E: The control sample surface of the cover that was included with samples A through D. F: The second control sample surface.*

Results

1. Three of the four failed covers were excessively brittle (Figs. 1A, 1C and 1D).

2. Three of the covers surfaces (Figs. 2A, 2B and 2C) were discolored and had embedded debris. Sample D's surface (Fig. 2D) appeared similar to the controls (Figs. 2E and 2F).

3. The transmittal of UV light through the plastic covers was variable. Samples A and D (Figs. 3A and 3D) allowed some passage. Sample B (Fig. 3B) appeared to be opaque in comparison to the others. Sample C (Fig. 3C) appeared to transmit a little more than the control sample E (Fig. 3E).

4. Backscatter electron images and associated spectra are shown in Fig. 4. Zinc (Zn) and sulfur (S) with oxygen (O) predominated in all the samples, including the controls. These images and spectra show the zinc and sulfur are usually associated by having near constant relative elemental concentrations throughout most of the sample spectra. There is, however, an apparent redistribution of these elements in some samples (e.g., Fig. 4B) where the amount of sulfur and zinc off the particles was much less than that on the particles. The controls (Figs. 4E and 4F) show that Zn and S are a normal part of these covers. There are obvious contaminate particles mostly composed of sodium (Na), silicon (Si) chlorine (Cl) and Potassium (K). A few particles were found that had titanium (Ti). All of these particles were rare, on the scale (at 1000x) examined in the Scanning electron microscope. Sample A appeared to have crystals of sodium chloride scattered on its surface (Fig. 2A, arrow).

5. Element maps of the two principle elements, zinc and sulfur, are shown in Fig. 5. How this is performed is the beam in the electron microscope is slowly traversed across the specimen. When X-rays of the sulfur and zinc are recorded, a dot is placed on the sulfur or zinc map image. It takes approximately 15 minutes to complete a map. Map samples A and D, which are from the suspect covers, show that both sulfur and zinc are capable of redistribution. The particles, especially in sample D, show concentrations of zinc and sulfur. Sample D also shows that these elements are not correlated in parts of the map. Sample C appears more like E (the control) where sulfur and zinc are fairly evenly distributed.

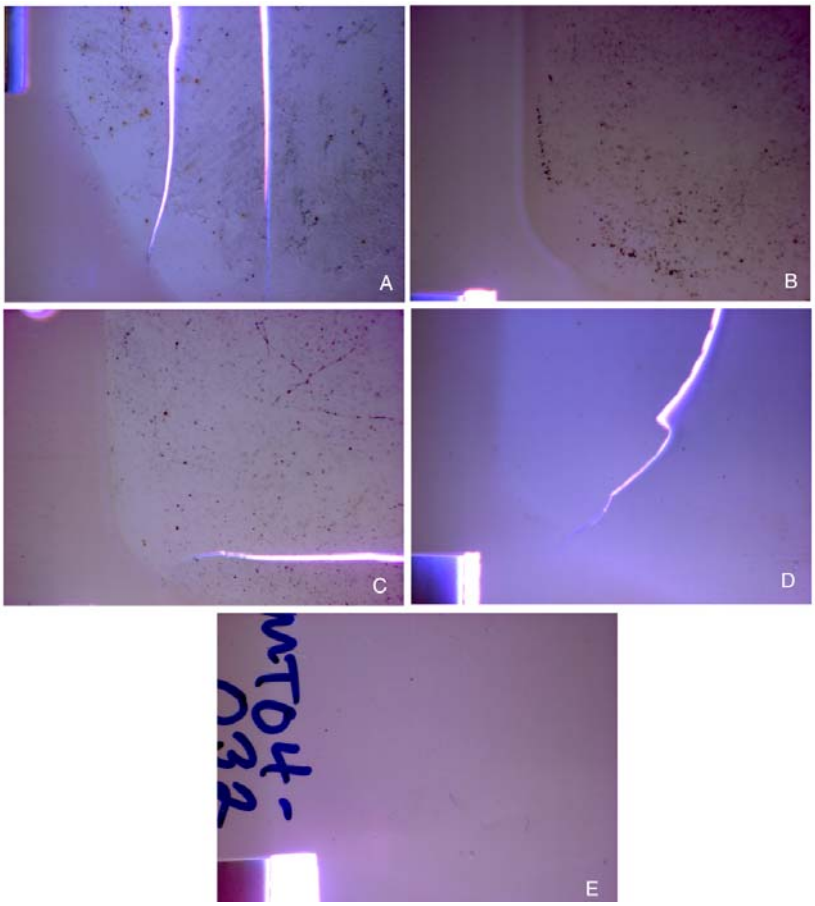

Figure 3. *Ultraviolet light transmission through the covers. A through D: the failed sensor covers. E: the control sample. The Pixera 600CL digital camera's auto gain was fixed at a constant sensitivity for all these images.*

Discussion

1. There is no evidence that any material was painted or sprayed on the covers.

2. The accumulation of apparent foreign material on three of the covers (Figs. 2A, 2B and 2C) does not provide an explanation for the failure because cover D (Fig. 2D) appears free of debris.

3. The covers were variable in transmittance of UV light, where covers A and D (Figs. 3A and 3D) showed the most transmittance. Cover B (Fig. 3B) appeared to overly block transmittance. Cover C (Fig. 3C) is similar to the control (Fig. 3E) in this regard. The changes in the properties of the covers affecting UV transmittance do not provide an explanation for the apparent failure of these covers.

4. The zinc-sulfur (likely zinc sulfate) was probably applied to the cover plastic by the manufacturer to inhibit microorganism growth when in moist environments. Apparent movement of the zinc into accumulations (in a different form) on the cover surface may cause a transmittance problem for a motion detector. But, this apparent transformed material is found more on three covers (Figs. 4B, 4C and 4D) than on cover A (Fig. 4A) and the control (Fig. 4E). Thus, changes in zinc and sulfur distribution on the covers cannot offer an explanation for the cover failure.

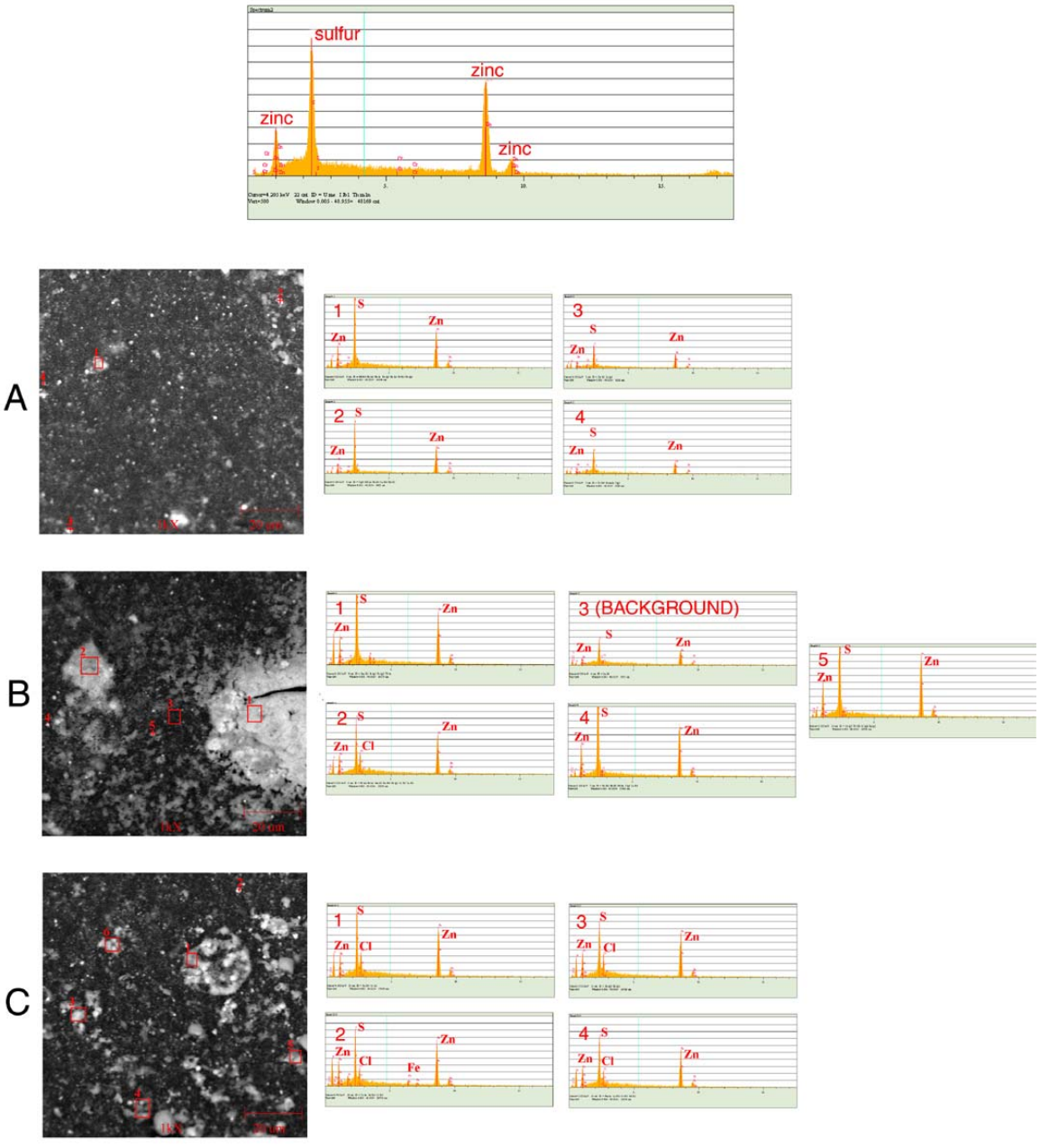

Figure 4. *Backscatter electron images of the sample surfaces and associated spectra for the samples. Top: sample spectrum showing the locations of the element peaks of interest (sulfur and zinc) in these samples. A through D: Samples from the failed sensors. E: control sample. F : second control sample (spectrum only). The light areas in the images are areas of more dense accumulation material (backscatter electron detection displays differences in density, or atomic number, of a subject)*

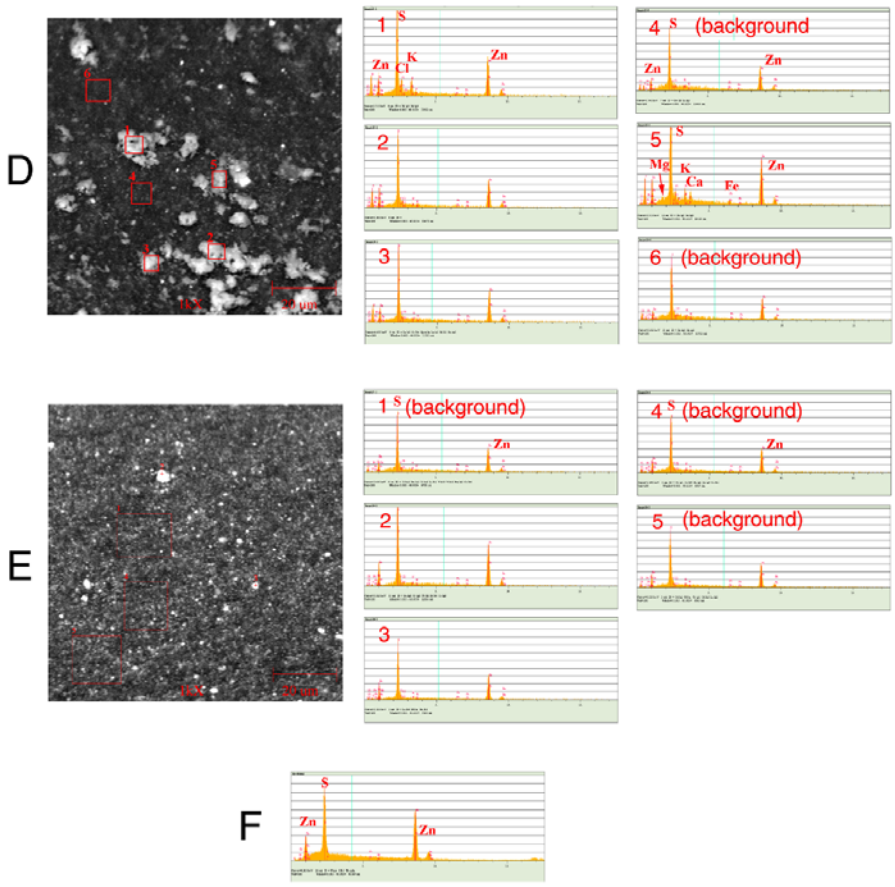

Figure 4. *Continued*

Conclusion

It is apparent that the sensor covers at issue were in an environment that has changed the properties of the cover plastic. A feature of this change is the cover plastic has become brittle (Figs. 1A, 1C and 1D) which suggests a loss of plasticizers. Such a loss likely changed the optical properties of the plastic. Other attributes examined (UV light transmittance and scanning electron microscopy) do show differences between covers and may factor into transmittance by the covers. But, these may be secondary to plasticizer loss. The bottom line is that these covers lost their ability to transmit the wavelength of radiation necessary for the proper functioning of the motion detector without an apparent foreign substance coating the surface.

Thus, the failure of these covers is likely due to environmental factors and not due to human intervention (i.e., painting or spraying).

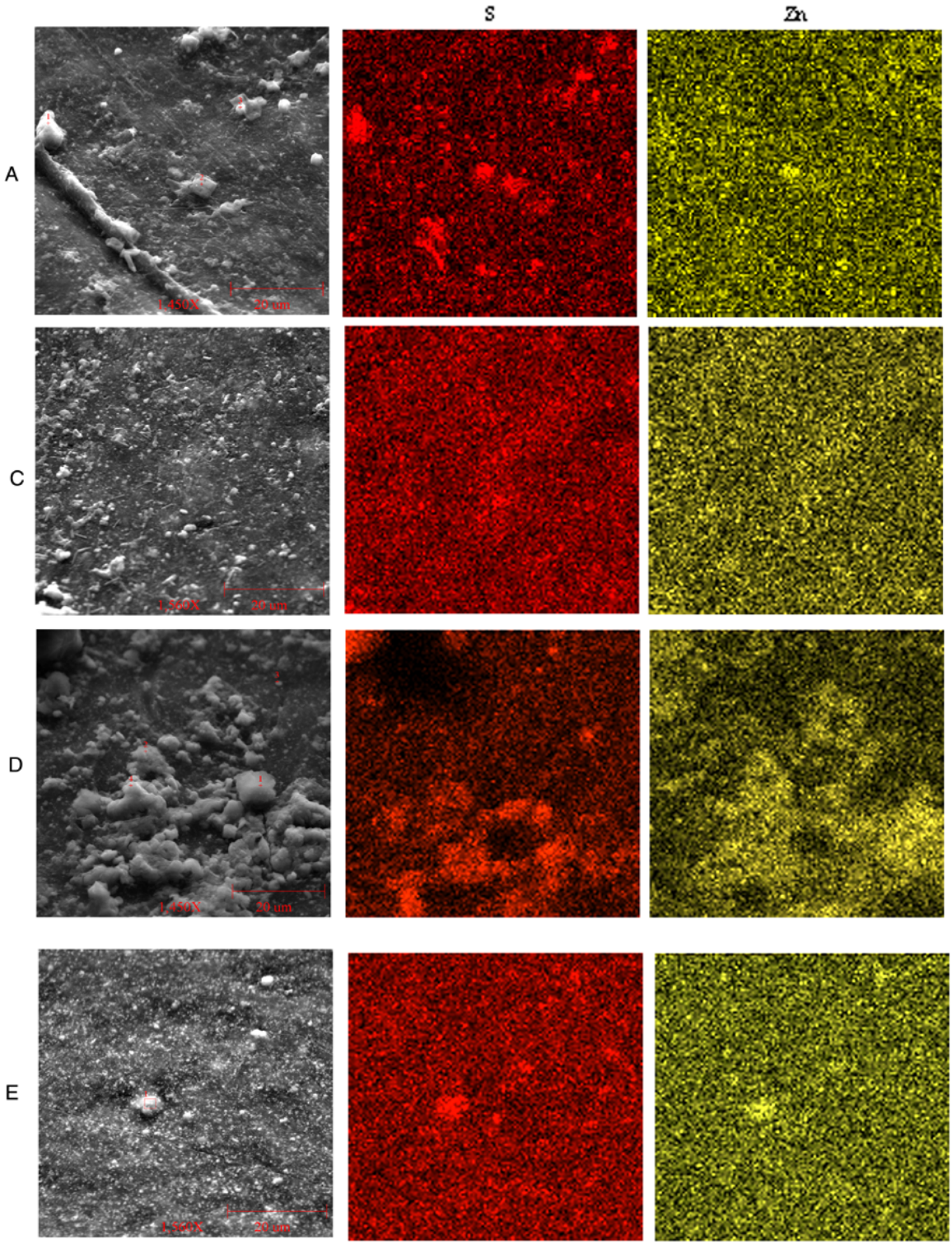

Figure 5. *Elemental maps of samples A, C, D and E. The secondary electron image (real images of the surface) is on the left, the sulfur map is middle and zinc map is on the right. A ,C & D : samples from the failed sensors. E : control sample.*

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