# Exploring the Medium: The Indexical Function of Artistic Photomicrography Made by the Scanning Electron Microscope

**Anastasia Tyurina**
Griffith University
anastasia.tyurina@griffithuni.edu.au

**Abstract**

Photography used as proof of scientific data often has to deal with problems arising from its overlapped indexical and iconic features. This paper is concentrated in the specific area of photography made by the Scanning Electron Microscope (SEM), which has expanded the boundaries of observation and representation of the micro world since it was introduced to scientific research in the mid-1960s. With the emergence of the digital era, photography's status as independent indexical register of reality began to be undermined by computerized imaging processes. Nevertheless, scientific photomicrographs aim to provide scientific evidence of data as accurately as possible. However, the results obtained with the SEM can be disorientating because the process of producing a picture is camera-less. The apparatus tries to recreate a reality that is not a visual phenomenon, which scientists try to analyze from its image that is captured through the SEM technology. This paper considers some of the ways in which SEM microphotographs can be used in an artistic practice, and argues that there is an urgent need to rethink the indexical function of SEM photography. The author's artistic practice can be seen as rejecting the traditional practice of minimizing noise in scientific representation and, instead, embracing experimentation that encourages the unexpected over the predictable.

## Preface

In the late 1980s, with the escalating availability of new technologies, photography's privileged status as marker of truth and measurement of reality began to be undermined by computerized imaging processes. [1]

With the initiation of digital technologies of reproduction, the model of indexicality as an inherent ontological condition for photographic images lost its functionality. Media theorist Fred Ritchin explains: "Photography in the digital environment involves the reconfiguration of the image into a mosaic of millions of changeable pixels, not a continuous tone imprint of visible reality." [2]

Despite photographs being no longer considered literal traces and often susceptible to manipulation, it is important to account for the social function of digital photographs. Many digitally generated images "look like" analog photographs. Damian Sutton deemphasizes the loss of indexicality in digital technology because digital images are perceived in the way a viewer understands analog photography. Although Sutton acknowledges that analog photography's connection with indexicality was always challengeable, he argues that perceiving an analog photograph as an image connected to reality is an ideological function of photography based on its indexicality. In his essay "Real Photography", he explains: "Digital photography, and especially its apparently invisible manipulability, destroyed the photograph's privileged connection to the object. Without this anchor to reality, the semiotic relationship seemed over-balanced towards the iconic and the symbolic i.e. representation. Yet the concerns expressed in the 1990s, that the digital image equates photography with fallibility and distrust, now seem caught up in the historical moment of digital technology's first real flourishing; photography has always been 'dubitative' ... and this characteristic is not the province of the digital image alone." [3]

## Photographs Made by a Scanning Electron Microscope

Scientific photomicrographs aim to provide scientific evidence of data as accurately as possible. The quality of scientific representations depends largely on reducing any stain and artifacts. However, the results obtained with the SEM can be disorientating because the process of producing a picture is camera-less. Additionally, there is no light or light-sensitive surface involved. The apparatus tries to recreate a reality that is not a visual phenomenon, which scientists try to analyze from its image that is captured through the SEM technology.

Dee Breger explores 'compound reality' in the nature of SEM photomicrographs in her book *Journeys in Microspace: The Art of the Scanning Electron Microscope* (1995), where she states: "And yet any image created with an SEM is still real in the sense that computer-generated images are not. In another sense, the object that looks so solid on the screen or in the micrograph does not exist at all. Only electronic cables connect the image on the screen with the object in the sample chamber. In other words, though we experience the effect of direct observation, we are not even looking at the object we see. Electron microscopy is indirect and

so we can be disorientating. It is a matter of illusions echoing across dimensions, of technology-induced surreality." [4]

## Exploring the Medium

SEM work is based on the very precise scanning of the surfaces of objects using an electron beam that provides a deep focus effect. In the SEM, electrons from the electron gun are focused to a fine point on the specimen's surface by means of a lens system. This point is scanned across the specimen under the control of currents in the scan coils situated within the final lens. Secondary electrons are emitted from the specimen surface and are attracted to the detector. The detector relays signals to an electronic console, and the image appears on a screen. [5]. However, colors cannot be reproduced.

The interpretation of the imagery produced by SEM is confusing because the microscopic sample seems as if it is illuminated by the detector and observed in the eye aperture. Despite the fact that light seems to come from a particular illuminant, the contrast actually depends on atomic weight, chemical surface properties, crystallographic properties, the microtopography of the sample and the tilt of the plate, with a sample positioned to the electron beam that hits it.

There are a few problems that electron microscopy encounters during the process of imaging, which can be considered as 'noise'. The image may go out of focus because of the high magnification. Another problem could be a vibration caused by the movement of the sample during the scanning by the electron beam. This effect mostly appears on the edges of the sample in the form of a waving flag. A further problem is an accumulation of charge that can be divided into four types. These include the artifact's beam interaction, stains, image artifacts (the accumulation of positive and negative charge) and spontaneous emission.

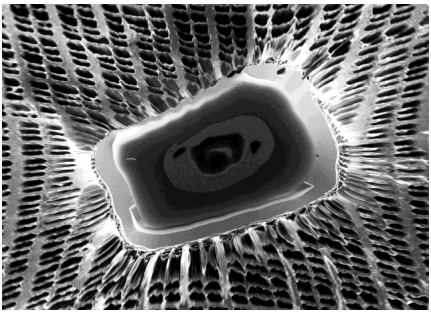

Fig 1. *Artifact on a non-covered plate,* 2015, Anastasia Tyurina, photomicrograph. © Anastasia Tyurina

An example of the artifact's beam interaction that can be observed is the "fish-eye" effect, where some areas look more zoomed than other parts of the image. This is caused by charges accumulated on the surface of the sample due to ground noise.

Images do not represent the true mathematical projection because of such factors as lens aberration, the scattering of electrons, and defocusing.

## SEM Indexicality

Scientific microphotographs often record too much information, such as dust, scratches and other 'noise', and, as Peter Galison points out, scientists discuss whether to remove this unnecessary information or to accept it [6]. Moreover, the same sample can look completely different across two pictures of it. It depends on the interaction between various methods of sample preparation, the way the microscope is used, image-capturing settings, etc. Breger also notes that two different microscopists using the same instrument and sample will produce different micrographs, and the results by the same microscopist can also differ [7].

Some manipulations can be carried out through adjusting the microscope settings and others through the interface of its supporting software.


Fig 2. *Adjustment control panel,* 2015, Anastasia Tyurina, print screen. © Anastasia Tyurina

The most illustrative manipulation in this case is changing the electrical stress/tension, which allows one to see the image with different stages of contrast and to make an accent at completely different details, which in turn affects the cognition from picture to picture.

The accumulation of a positive charge (a positive electric field on the sample surface) results in a reduced overall image contrast.

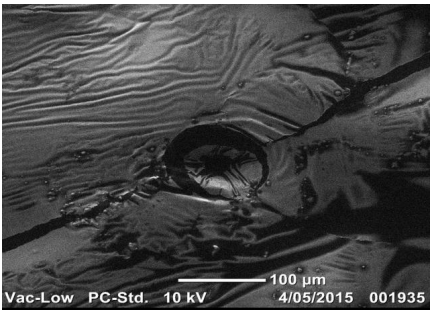


Fig 3. *10 kV*, 2015, Anastasia Tyurina, photomicrograph. © Anastasia Tyurina

Accumulation of a negative charge leads to the opposite result, with the image becoming brighter.


Fig 4. *5 kV*, 2015, Anastasia Tyurina, photomicrograph. © Anastasia Tyurina

In addition, scientific text information is automatically generated by the software when working on the SEM, which appears on the photographs as a type of labeling.

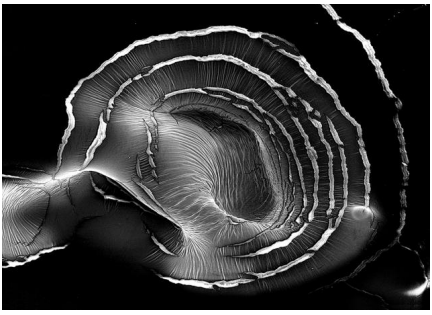

Fig 5. *Brown Lake, North Stradbroke Island*, 2015, Anastasia Tyurina, photomicrograph. © Anastasia Tyurina

Erasing this text from the images removes them from scientific style identification and potentially opens them up to more intriguing interpretations (Figure 5).

SEM is capable of representing its own traces by a specific way of producing an image and by its scientific text information incorporated with the image. These traces could be considered as a form of index, because they have physical and material connections to the SEM apparatus.

## Artistic microphotography

Working on SEM is a real-time process when images are captured instantly by the decision an operator makes. In his fundamental text *Logic as Semiotic: The Theory of Signs*, Charles Sanders Peirce defines an index as category of sign that has a physical connection to its referent. He writes: "Photographs, especially instantaneous photographs, are very instructive because we know that they are in certain respects exactly like the objects that they represent." [8]

The earliest techniques of digital manipulation began to emerge in the 1970s, when photography was still largely considered a less significant form of art than painting because of its mechanical nature. Writing in the catalogue to the exhibition *Before Photography*, Peter Galassi explains: "Regarded essentially as a child of technical rather than aesthetic traditions, the medium is inevitably considered an outsider, which proceeded to disrupt the course of painting….Devotees of the camera obscura explain the machine's growing popularity as a symptom of a new thirst for accurate description". [9] This suggests that photography was not perceived as an art form precisely because of its indexicality. It was not considered possible for photography to admit the possibility of a subjective view of the author of the image.

Although scientific photography can be considered non-aesthetic since its main purpose is not to convey beauty but rather to convey accurate information, its ability to record material in addition to that which is merely informative allows it to also serve expressive, subjective and aesthetic purposes. Microphotography in particular has the potential to communicate to a general public from both a scientific and a cultural perspective.

This is what my artistic practice aims to do; through my experimental approach, I embrace unpredictability over accuracy, and 'noise' over 'purity'. To engage effectively with microphotography as a social phenomenon, it is crucial for an artist to demonstrate an understanding of its 'scientific' protocols of representing. At the same time, the artist who works with the SEM becomes an instrument, leaving traces of his/her intuition, choice, and interpretation. Janet Vertesi points that early modern communities believed all that was needed for accurate image production of microscopic observation was a 'sincere hand and faithful eye', whereas with advances in technical and mechanical

representation, the human was no longer believed to be an accurate instrument; the informant was excluded from the process. She also raises questions: "should the object 'speak for itself'? Must the artist depict a universal type, or is interpretive intervention required to highlight the important aspects of the picture?" [10]

Today, artistic SEM microphotographs can be seen as indexical of not only an object of study but also of a unique and subjective author who sits behind the microscope device. Making pictures should be considered more an indexical decision made by the artist than an index of what lies in the chamber of microscope.

In some ways, SEM photography remains indexical but the notion that mechanical images can be objective representations of reality is deeply flawed. Advanced scientific technologies provide artists working with the SEM with new ways of representing subjectivity through images. By exploring the interplay between the indexical and iconic modalities in the process of evaluating scientific photomicrographs, it may be possible to attribute new meanings to them and thus turn scientific photography into a creative source of communication to a general public.

## References

1. David Green and Joanna Lowry, "From Presence to the Performative: Rethinking Photographic Indexicality," in *Where Is the Photograph?* ed. David Green (Maidstone: Photoworks; Brighton: Photoforum, 2003), 47–60.
2. Fred Ritchin, *After Photography* (New York and London: W.W. Norton & Company, 2009), 18.
3. Damian Sutton, "Real Photography" (2007) in *The State of the Real: Aesthetics in the Digital Age*, ed. Damian Sutton, Susan Brind, and Ray McKenzie (London: I.B. Tauris & Co. Ltd., 2007), 165. Sutton cites Peter Lunenfeld, "Art Post-History Digital Photography and Electronic Semiotics (1996)," in *Photography after Photography: Memory and Representation in the Digital Age*, ed. Hubertus con Amlunxen (Munich: G&B Arts, 1996), 95.
4. Dee Breger, *Journeys in Microspace: The Art of the Scanning Electron Microscope* (New York: Columbia University Press, 1995), 11.
5. Jeremy Burgess, Michael Marten, Rosemary Taylor, Mike McNamee, and Rod Stepney. *Under the Microscope: A Hidden World Revealed* (Place: CUP Archive, 1987), 197.
6. Peter Galison, "Judgment against Objectivity," in *Picturing Science Producing Art*, ed. Caroline A. Jones and Peter Galison (New York: Routledge, 1998), 327–59.
7. Breger, *Journeys in Microspace*, 9.
8. Charles Sanders Peirce, "Logic as Semiotic: The Theory of Signs," in *Philosophical Writings of Peirce*, ed. Justus Buchler (New York: Dover Publications, 1955), 106.
9. Peter Galassi, *Before Photography* (New York: The Museum of Modern Art, 1981), 12.
10. Janet Vertesi, "Visual Testimony: An Epistemology of Scientific Illustration" (Paper presented at Symposium International Knowledge and Testimony, University Sherbrook, Canada, 30 September–1 October 2005), http://www.oocities.org/jvertesi/testemony.