Investigation into the Nano-Structured Surface of the Daguerreotype

Emily Thompson, Ralph Wiegandt, Brian McIntyre, Nicholas Bigelow
Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627

Abstract

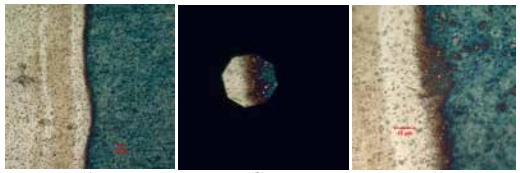
Southworth and Hawes daguerreotype. Accession Number: 1974:0193:0022.

The daguerreotype, invented in 1839 by Louis Daguerre, was the first practical form of photography. The goal of this project was to explore the properties of the daguerreotype's surface in order to improve conservation efforts and to apply what is learned to nano-science research. A daguerreotype is made by polishing a silver plate and sensitizing it with iodine fumes. It is exposed to light and developed using either mercury fumes or red light. Light exposure creates an image composed of silver or silver-mercury nanoparticles.

This project investigated the effects of light, gilding, and biological activity on the surface. We found that visible light only affects tarnished areas of the daguerreotype, while UV light affects all areas. Gilding forms Kirkendall voids just below the surface which we believe to be the cause of surface exfoliation. Biological interaction is still in the process of being investigated.

Light

Several daguerreotypes were exposed to tungsten light under a microscope for 5 to 60 minutes. Only tarnished areas of the daguerreotype were affected by visible light. Figure 1 shows the effect of 20 minutes of tungsten light on an interface between a tarnished and thiourea cleaned area.



(a) (b) (c)

Figure 1: (a) Image (500X) of surface before exposure to tungsten light. (b) Field of view of tungsten light. (c) Image (1500 X) of surface after 20 minutes of tungsten light exposure.

A daguerreotype was exposed to 365 nm UV light for 10 minutes. The image particles in the exposed area grew in size and changed morphology. Figure 2 shows images taken with a microscope. Figure 3 shows images taken in the scanning electron microscope (SEM).

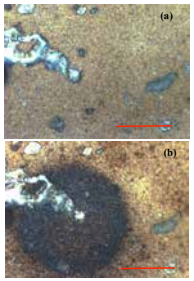
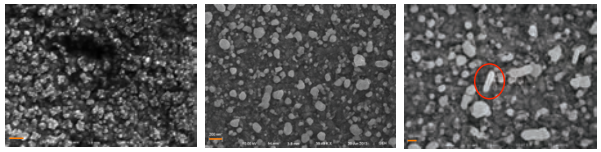


Figure 2: (a) Surface before exposure to UV light. (b) Surface after 10 minute exposure to UV light. Scale bars are 25 µm.

Light (continued)



(a) (b) (c)

Figure 3: (a) SEM image of surface not affected by UV light. Scale bar is 200 nm. (b) SEM image of surface affected by UV light, showing increase in image particle size. Scale bar is 200 nm. (c) SEM image of surface affected by UV light. Scale bar is 100 nm. Particle circled shows change in morphology.

Gilding

A daguerreotype is gilded by pouring on a solution of gold chloride and sodium thiosulfate onto the surface and heating it.

While heating, drops of the gilding solution were added to the surface until it started to peel off. Focused ion beam (FIB) SEM revealed a double void – something never observed before (figure 4). EDX analysis shows a gradient of gold concentration. (figure 5). Transmission electron microscopy (TEM) was used to analyze the exfoliated surface (figure 6).

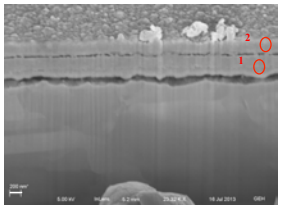


Figure 4: SEM image of double void. Scale bar is 200 nm. Larger void depth is approximately 600 nm.

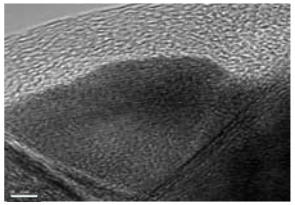


Figure 6: TEM image of removed surface. Scale bar is 2 nm.

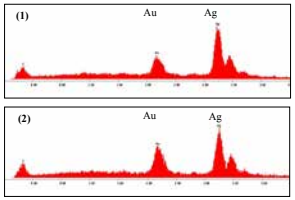


Figure 5: (1) EDX spectrum of location 1 on figure 4. (2) EDX spectrum of location 2 on figure 4.

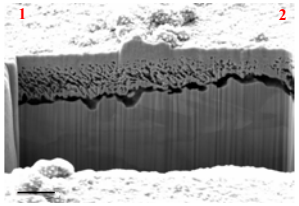


Figure 7: SEM image of gilded section showing porous voids. Scale bar is 1 µm. Void depth on side 1 is approximately 1 µm.

Figure 7 shows a FIB that was done on a plate that had a thicker AgI layer. Drops of gilding solution were added while heating. The void is deeper where it was gilded longer (side 1). The average void depth is greater than normally iodized plates (refer back to figure 4). A porous section above the void was also observed for the first time.

Biology

One of the main deteriorations on daguerreotypes is the growth of biological fibers. The goal of the following experiment was to grow fibers in a controlled manner on a daguerreotype and take the fiber off so it could be further tested.

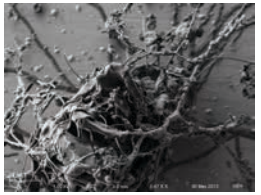


Figure 8: SEM image of biological growth on a daguerreotype. Scale bar is 10 µm.

Nanoparticles were synthesized using gold chloride ($AuCl_3$), silver nitrate ($AgNO_3$), and biological material. Solutions of spinach, blueberries, and carrots were combined with .001 M $AuCl_3$, .001 M $AgNO_3$, and .015 M $AgNO_3$, seperately. The color change of the solutions after 24 hours indicated the presence of synthesized nanoparticles (figure 9). A drop of each solution was deposited on a daguerreotype. After 72 hours, light scattering fibers had formed on the plate that received the .015 M AgNO3 and blueberry drop (figure 10).

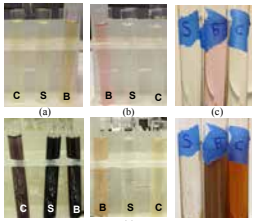


Figure 9: (a)(b)(c) Initial solutions of .001M $AuCl_3$, .001M $AgNO_3$, and .01 M $AgNO_3$. (d)(e)(f) Solutions (same as above) after 24 hours.

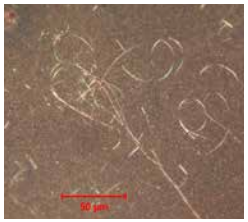


Figure 10: Possible biological strands forming on the drop containing .015 M AgNO3 and blueberry. Scale bar is 50 µm.

Conclusions/Future work

Visible light was found to affect only tarnished areas of the daguerreotype, while UV light affected all areas. Gilding has been shown to be a cause of surface exfoliation – a form of deterioration where the surface comes off. Gilding a daguerreotype having a thicker AgI layer causes a deeper Kirkendall void, and increasing the amount of gold in gilding can create secondary voids. We now have a better understanding of gilding, but further investigation is needed. Biology is still in the process of growing. We intend to continue investigating the daguerreotype to improve preservation techniques, and advance current nano-science research.

Acknowledgements

I would like to acknowledge the National Science Foundation, University of Rochester and the George Eastman House for making my REU experience possible. I would also like to thank Ralph Wiegandt, Brian McIntyre and Dr. Nick Bigelow for helping and guiding me this summer. Finally, I would like to acknowledge Connie Jones and Arie Bodek for all the hard work they have put into organizing this amazing program! Thank you!