Glass Plate Applications: Past, Present and Future

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Abstract

The use of photographic glass plates as an image recording medium extends back to the early days of photography and continues today in creative, scientific and holographic applications. In some instances the glass plate is also the display medium for the final image.

The paper investigates some of the characteristics that make glass the medium of choice in these applications. It also considers the effects of the commercial environment on the availability of coated glass plates into the future. It concludes with some technological drivers, including use in digital fabrication and biochemical applications.

Introduction

Because ICIS only takes place every 4 years it is a good place to review the slowly evolving place of glass plate products in the imaging industry. The time is right too as we are at a crucial position in terms of product availability and technical ability.

Key technical attributes of glass

Plates of glass were originally used as the emulsion support of choice in the early days of photography. They can be seen as the direct precursors of sheet film. However, as film based products became available glass was rapidly replaced in most applications due to a number of disadvantages. First and most obvious, glass plates are fragile and very heavy. They also take up a large amount of storage space. However, glass does have a number of very useful properties as a photographic base and as a result there are still some applications to which glass is particularly suited. These properties are summarized below.

1. Glass has optical properties that are particularly suited to some applications. In addition to optical glass being particularly clear, colourless and low in light scatter it can also be manufactured free of birefringence effects. This is particularly important in techniques where the exposing light is polarized and required to go through the base onto the emulsion. Holography is an example of this.
2. Glass is dimensionally stable. It undergoes very little change in dimensions with humidity or during chemical processing. As a result it finds applications in scientific imaging techniques such as X-ray topography[1], where precise measurements may be made on the plates after processing which need to be equated to positions or angles in the original exposure.
3. Glass is a rigid substrate and will not cockle like a non-rigid film based product. This is another reason why glass is the preferred substrate for holography where the plate must remain stable to fractions of the wavelength of light during exposures that can last many seconds.
4. Glass contains no small, labile molecules. There are no volatiles that could leach out in a vacuum. This is important in high vacuum scientific imaging such as in the far UV where the requirement to de-gas a film product can be a significant problem. Similarly, glass can provide a chemically inert base for other chemical processes that can be sterilised and aggressively cleaned. This could be important in future applications.

Glass plates in the past

Glass plates play a major part in the early history of photography. An English inventor and sculptor, Frederick Scott Archer is credited as the inventor of the glass plate wet collodion process[2]. With the sharpness and resolution of a Daguerreotype the transparent glass support allowed copies to be made in any quantities. Announced in 1851, this was the primary photographic process for 30 years. By the mid 1880s the dry gelatin process replaced collodion but glass plates continued as the support of choice until the introduction of film based media in the late 1890s.

Although the introduction of film base precipitated the decline of glass plate production new photographic glass plate products continued to be introduced through to the mid 20th Century[3], the later products being mainly for specialist technical applications. In addition a number of artistic glass plate processes survived the introduction of film base. One of particular interest is the Goldtone process used by Edward Sherriff Curtis[2]. Here the emulsion layer on the glass plate prints was coated with a metallic backing[4].

The experience of many years saw the development of various technologies to reproducibly coat emulsion layers onto glass to high levels of quality and reproducibility. The original process of pouring molten emulsion from a teapot onto cold glass was replaced by automated coating machinery[3]. The technical issues involved in ensuring a satisfactory level of adhesion between glass and the coated layers in particular was the subject of considerable work. The issue of the non uniform thickness of emulsion coating towards the edge was also dealt with, in some cases by cutting away significant areas from the edge of the plate but in others by considered and judicious adjustments to the coating conditions.

In an era when silver halide products themselves are threatened by digital technology photographic glass plate products are very much a rarity. However, this does not mean that their use is consigned to history, as illustrated schematically in Figure 1, a traditional Product Life Cycle diagram. Whilst the use of photographic glass plate products has fallen, it has not (as yet) fallen to zero. There remains a persistent "tail" to the distribution that consists of scientific, technical and artistic applications.

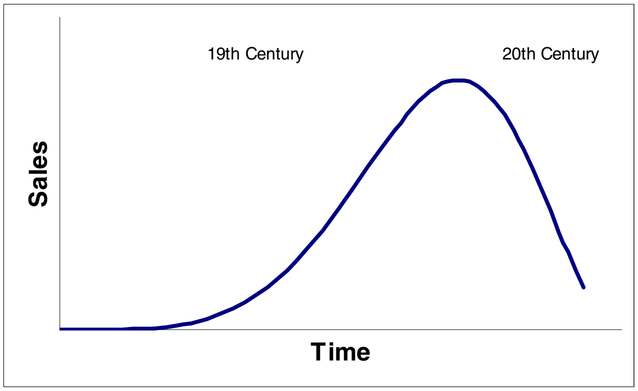

Figure 1 Product life cycle diagram of photographic glass plates

Glass plates now

Whilst the present use of photographic glass plates can be considered as divided into Scientific, Artistic and Technical applications there is often no clear boundary between these. A good example is their use in holography which spans all 3 of these. Glass works particularly well for holography as it fulfils specific needs in terms of rigidity, scatter, light transmission and birefringence. However, there are a number of other specific applications that are more common.

Scientific applications

Photographic glass plates have been used in scientific applications since the earliest days of photography. As an example, they have been used since 1867 in the study of radiation and particle physics[5]. Whilst there have been many types of specialist photographic plates produced for scientific applications only a few products currently survive.

They are still used in vacuum applications such as far UV spectroscopy and spark source mass spectroscopy[6]. The key attributes here are the fact that glass contains no small, labile molecules that could leach out to spoil the vacuum and that glass can be manufactured thin enough to be curved to the image plane. This latter attribute was also important in the history of astrophotography[7].

Glass coated with photographic nuclear emulsions[5] continues to be used for diverse applications such as autoradiography[8], particle physics[9] and X-ray topography[1] where the dimensional stability of glass allows for precise location of detail.

Reproducing historical photographic processes

There is presently historical interest in the use of photographic glass plate products. As we pass through the centenaries of a number of historical photographic milestones there has been renewed interest in reproducing these original techniques. Processes such as the Autochrome and Orotone have recently enlivened the interest in glass plate products.

The Autochrome process was the first practical system for colour photography. It was somewhat unusual in that it was an additive colour process using RGB dyed starch grains[10]. Patented in 1904 it was produced on glass until the 1930s so has recently passed through the centennial. However, much of the subject matter recorded on this medium, such as the pictorial records of 1914-18 wartime France are now approaching centennial events that refresh interest in the medium.

Another example is the Goldtone process used by Curtis[4]. This has recently been resurrected using photographic glass plates using modern methods[11].

The ability to reproduce these processes is important from a number of perspectives. There is historical and artistic interest in reproducing these technologies, particularly around the centennial anniversaries. Also, reproduction of the technology using modern methods provides a useful perspective for the preservation and restoration of the original imagery. However, perhaps of more importance for future glass plate applications is that it refreshes our technical capabilities and reminds us of knowledge that was once common and is in danger of being lost as photographic glass plate production becomes confined to a smaller experience base. A pertinent example of this is knowledge of coated layer adhesion and the factors that govern this for some materials on glass.

Technical applications – Digital Fabrication

Once again there is a long history of the use of photographic glass plates in technical applications. For example, the rigidity of the glass substrate lends itself to precision work making photomasks for semiconductor fabrication. Most of these applications are now consigned to history.

However, there is one area where the use of glass plates in imaging applications is growing. This is the field of Digital Fabrication. The ability of printing processes such as ink jet to generate 3 dimensional structures by overlaying many layers of printing “ink” looks likely to become an enabling technology that will unlock many other applications. One early example is the ability to build up Braille characters by this method[12].

Whilst these applications do not use the silver halide coated glass plates of the past they are still pertinent to consider here. The key attributes listed earlier in this paper that made glass attractive for photographic use are still of value in these applications. Also, the knowledge and technical capabilities developed from years of glass plate technology are applicable to some of the emerging applications.

Over the last few years we have seen the appearance of flatbed inkjet printers that are capable of printing onto rigid media. Whilst these devices are capable of printing onto glass plates this has mainly been restricted to creative applications. Process development systems designed for Fabrication are now appearing, capable of printing onto glass substrates[13]. In addition advances in print head design are giving access to different jettable fluids[14]. The key enabling technologies are now coming into place for rapid advancement in this field.

Much of Digital Fabrication technology is still in the R&D phase and the same key attributes listed earlier in this paper that made glass attractive for photographic use are still of value at this time. Prints on glass substrates are being used to develop processes for fabrication in hybrid printing systems[15] and electronic memory devices[16]. Glass has also found use as a test bed for materials development of metallic inks for the fabrication of conductors in printed electronics[17].

In addition to these development activities some early applications already exist. As an example, fabrication techniques using glass substrates have been shown to be effective in catalyst screening[18].

Glass plates into the future

Some small scale demand for photographic glass plates looks set to continue into the future for applications such as reproductions, holography and scientific work. However, it remains to be seen if this will be sufficient to keep production machines in use, maintain a supply of people skilled in the art and retain the small number of manufacturers remaining in this field. Without new applications commercial pressures may cause all this to disappear.

The R&D use of glass plates in Digital Fabrication seems set to continue but the more lucrative and high volume sales await production scale applications. Glass plates are currently the substrate of choice for flat panel display fabrication as it can withstand the temperature conditions of the process and has the requisite dimensional stability[19]. Whilst much effort in display technology and printed electronics will go into work on flexible substrates market research[20] indicates that $183 million of glass substrates will be consumed by the printable electronics industry in 2013. However, as the majority of this seems set to be in the form of standard, uncoated glass types we cannot rely on printed electronics to save the capabilities needed to produce photographic glass plates.

There are some applications coming along that require the same sorts of technologies that are used in photographic glass plate coating. What remains to be seen is if these are sufficient to ensure the commercial viability of glass plate coating into the future.

Coated glass into the future

There is still the potential for photographic applications to develop sufficient volumes to save the commercial viability of glass plate coating. A consortium of holographers in Europe has secured European Community funding to investigate the production of materials for full colour holography[21]. This project is to include glass plate coating.

One promising area that Digital Fabrication will undoubtedly move into is the manufacture of optical devices. Some early work has shown that microlens arrays can be produced by depositing polymer droplets onto a substrate[22]. An interesting extension of this is the manufacture of microlenses by ink jetting drops of solvent onto a polymer substrate and allowing the wetting and subsequent evaporation of the drop to deform the surface[23]. Anyone who has experienced drying marks on photographic film will recognise this phenomenon. Swellable layers coated by traditional coating methods may find application in optical device fabrication.

Biochemical applications may also play a part in the future. Traditional gelatin coatings may prove to be an interesting medium for biochemical processes dispensed by these new Fabrication technologies. Biomedical applications that use silver sensitised systems have also appeared[24]. The ability to coat controlled swellable layers containing suspensions of inorganic salts to high uniformity may yet prove to be of value to these emerging technologies too.

Conclusions

Unless further applications appear the capability to produce photographic glass plates will disappear because of a lack of commercial viability. Whilst this would be unfortunate for conservators and historians interested in our photographic heritage we are at risk of losing knowledge, capability and experience that may prove to be of value to future applications.

There is some hope for the future viability of this process. A resurgence of interest in some photographic glass plate applications and new Digital Fabrication technologies may arrive in time to save this capability.

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Alan received his BSc in chemistry followed by a PhD in instrumentation from Manchester University in 1982 and began work as an Image Physicist with ILFORD Imaging. After a number of technical support and Sales & Marketing roles his final role was Technical Services Manager at the head office in the UK, covering both traditional silver image and emerging ink jet technologies. In 2004 he left to become an independent consultant on optics and non-impact printing. He is a member of the IS&T and the Institute of Physics.