D.F. Hakala | D.J. Wierschke

Matrixing for VideoDisc

Strict attention to process control and microcontaminant control are required to manufacture copper and nickel metal parts of sufficient quality to meet VideoDisc needs.

Abstract: *The initial master copy is recorded on a plated copper substrate produced in the Matrix Department. After recording, nickel electroforming is used to replicate this copy to make press tooling in a fan-out process. The processing steps required to do this are decribed, along with material and process control requirements.*

The prime responsibility of the VideoDisc Matrix Department at Rockville Road, Indianapolis, Indiana, is to convert the recorded copper substrate received from mastering to some large number of stampers. Stampers are the electroformed nickel parts that are clamped to the press mold to provide the actual molding surface itself. In addition, the Matrix Department produces the plated copper material that is used by mastering as the recording medium.

Electroforming is a modification of more conventional plating techniques in which the detail of the surface being plated upon is replicated in the surface of the plate. A passive layer on the parent part permits ready separation of the plated daughter part. This is different from most plating operations where adhesion of the plate to the substrate is usually important.

Economical production of the stampers requires the use of a fan-out process that reuses parent parts several times so that, as the original recording is replicated to the master, mother, and finally stamper level, the "family" grows rapidly in size. Fan-out refers to the number of times each parent part can be reused. An overview of the metal-part process flow is given in Fig. 1.

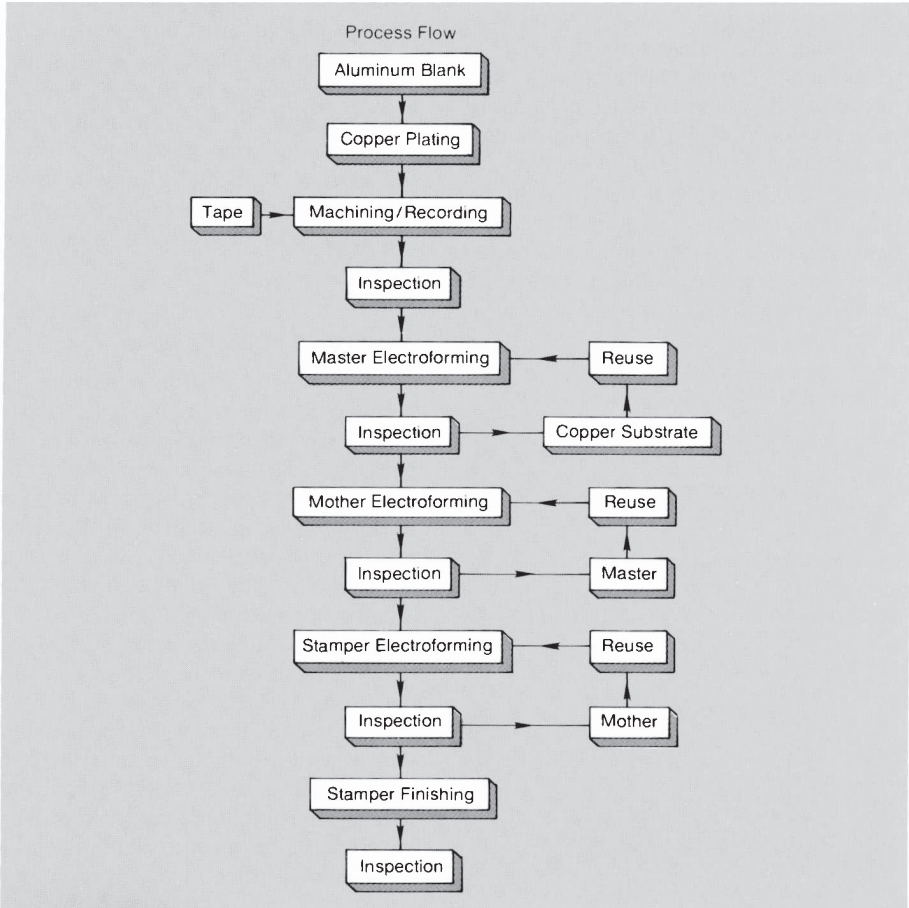

Fig. 1. *VideoDisc metal parts manufacture process flow.*

Final manuscript received September 12, 1983.
Reprint RE-29-2-8

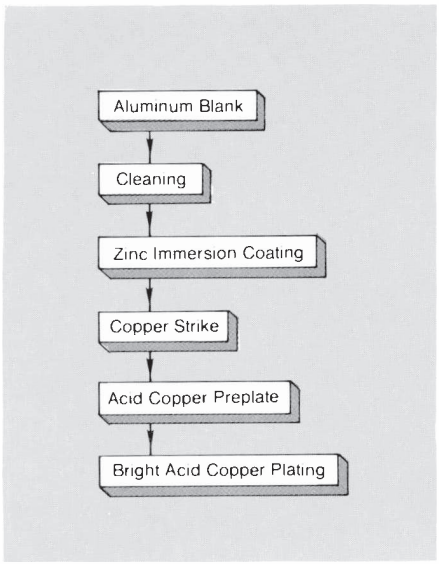

Fig. 2. *Copper plating sequence.*

Manufacturing process

Copper preplate

The VideoDisc matrix department first becomes involved in the process of manufacture of the VideoDisc when an aluminum blank (14.5 inch diameter, 0.5 inch thick) is electroplated with a layer of extremely fine-grained copper that is 1/15,000 of an inch thick. This is done through a series of cleaning and plating steps that begin when the blank is received from the mastering area (Fig. 2). Initially, the blank is rinsed and cleaned with a pad to remove any debris left from the leveling machining operation. It is soaked in an alkaline cleaner with ultrasonic agitation, rinsed, and dipped in a second cleaning solution. This is followed by another rinse, a dip in 50-percent nitric acid, a rinse and drying. The blank is dipped in the zincate immersion-coating solution, rinsed, and again dried.

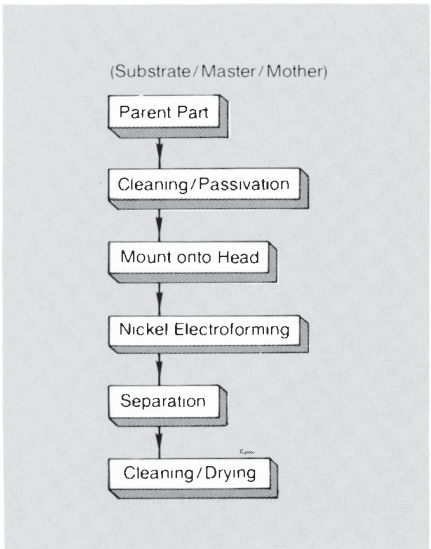

Fig. 4. *Nickel electroforming sequence.*

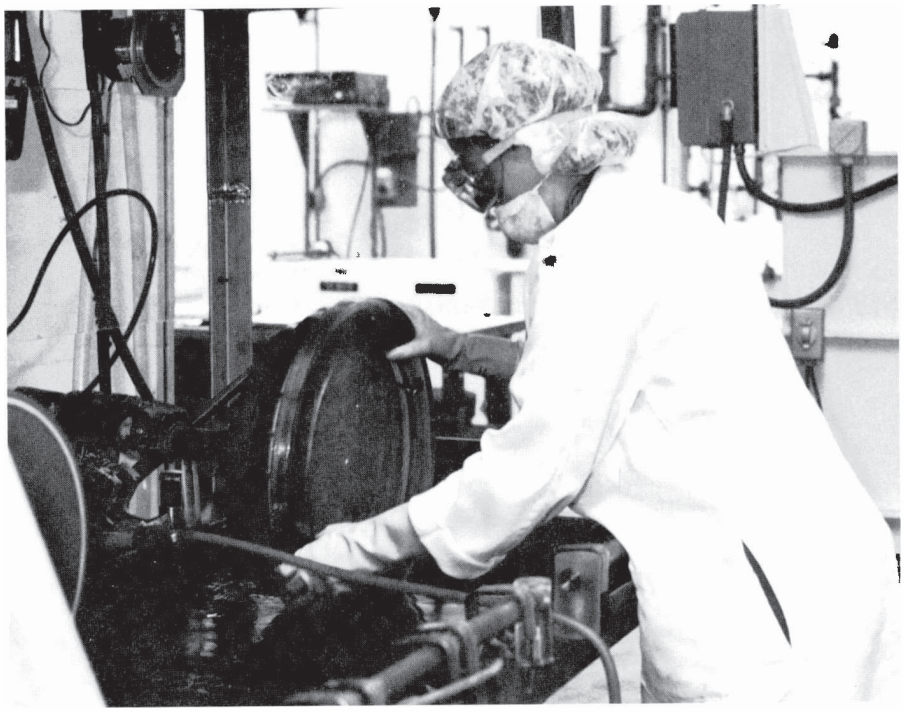

Fig. 3. *Bright acid copper plating bath. The operator loads a preplated aluminum blank onto the plating head for plating of bright copper deposit. The deposit is used as machining medium for VideoDisc mastering.*

The zincated blank is preplated in a copper pyrophosphate bath at a low current density using live entry. Upon completion of this step the blank is rinsed, inspected, and given a second preplate in an acid copper bath, after which it is rinsed, inspected, dried, and put in storage until needed.

Bright acid copper plating

As the mastering department requires copper substrates for recording, the preplated blanks are taken from storage and prepared for bright acid copper plating. The bath is an acid copper sulfate with a proprietary organic addition agent that refines grain size. The preparation consists of cleaning the blank with an abrasive pad under running water, dipping it in a heated alkaline cleaner solution, rinsing it, and dipping it in a 10-percent sulfuric acid solution. After rinsing, the blank is mounted into an especially designed plating case, which in turn is mounted on the plating tank, and the blank is given a final rinse with 5-percent sulfuric acid before being lowered into the plating solution with live entry (Fig. 3). After a plating cycle of four hours, the blank is removed from the tank and the plating case, and then rinsed, dried, and inspected. Accepted substrates will be sent to mastering for machining.

Nickel electroforming

The nickel electroforming steps are similar for masters, mothers, and stampers (Fig. 4). Details are given below.

Electroforming of the master

Once the substrate has been recorded, it is returned to the matrix department for fan out to stampers for use in disc pressing. First, a careful inspection of the recorded surface of the substrate is performed for any defect known to cause a problem in playback of the disc. The inspection is done with a high-intensity light and an optical microscope in a Class-100 clean room. When the substrate has passed inspection, the preparation for electroforming of the first stage of the fan begins when the substrate is placed under running deionized water, and the outside edge is roughened to create a mechanical bond to the electroformed master.

The substrate is then soaked in a solution of alkaline cleaner and potassium dichromate to clean and passivate the copper. After this, the substrate is rinsed in deionized water and mounted in a case that, in turn, is mounted on the plating tank. After the protective shield has been removed

Fig. 5. *Nickel plating bath. The parent part is loaded onto the nickel plating tank for deposition of an electroformed daughter part. The daughter will be the reverse image of the parent.*

Fig. 6. *Inspection station. The parts are inspected for defects using a grazing incidence light inspection, which highlights microscopic defects.*

from the front of the electroforming case, it is lowered into the nickel plating solution (a typical sulfamate nickel bath) and rotation is started (Fig. 5).

After a preplate at low current density, the current density is raised for the remainder of the plating cycle. Upon completion of plating, the substrate is removed from the tank as well as from the electroforming case, rinsed well, and dried completely. At this point, the substrate/master composite is moved to a room where the nickel master is removed from the substrate. Each of the parts is placed in a container and sent to the first face-inspection station where both parts are inspected. Any part that has a defect that is known to cause a problem in playback of the disc is rejected at this time. The entire operation occurs in clean rooms, with Class-100 environments used where the part face is exposed.

Electroforming of mothers and stampers

The production of mothers from masters and stampers from mothers to complete the fan out is identical in all respects except for length of plating time and the current density. In both of these fan-out steps, the parent part is nickel and is prepared for electroforming in the same manner. It is rinsed with deionized water, soaked in an alkaline cleaner with ultrasonics, rinsed, and finally dipped in 10-percent sulfamic acid to neutralize any remaining alkaline cleaner and to activate the surface.

Following another rinse in deionized water, the part is dipped in a potassium dichromate solution to passivate the surface, rinsed, and mounted on another especially designed electroforming case. The case is lowered into solution, rotation is started, and the rectifier is turned on. The current density is initially low and later raised for electroforming both mothers and stampers.

At the completion of the electroforming cycle, the composites are removed from the solution, rinsed with deionized water, and removed from the electroforming case. The composite is rinsed again and taken to the separation room where the two parts are dried, separated, and placed in clean containers before being sent to the first face inspection. Both parts are checked at inspection for defects (Fig. 6).

Finishing operation

After a stamper has been accepted at the first face-inspection station, it goes through a series of finishing operations to prepare it for mounting in the press mold. These operations consist of applying a protective coating to the recorded surface, grinding and polishing the back surface to remove even the smallest nodule, punching a hole exactly in the center of the recording, and coining the inside and outside edges to fit the press mold (Figs. 7-10). After these operations are complete, the stamper is cleaned and re-inspected to assure that no damage has occurred during the finishing operations. Upon acceptance, the stamper is stored in individual containers until needed for disc production.

Quality and process control

The microscopic groove and signal-element geometries of the VideoDisc must be replicated faithfully in the electroforming operations. Small defects on the face of a metal part will result in a corresponding defect in the disc. Building the quality into the parts requires use of extensive fluid filtration of plating baths, cleaning solution, and rinse water. Clean rooms—rated at the appropriate class—and work stations are employed at the various points of the operation. Bath chemistries are carefully controlled by process-control technicians.

The parts themselves are inspected to conform to stringent criteria. Microscopic defects on the face and back of the part are examined by a low-angle bright-light inspection as well as an optical microscopic inspection. Diffracted light from the groove structure is easily perturbed by surface inperfections and observed easily by a visual inspection. Physical measurements on concentricity and thickness are also conducted.

Fig. 7. *Coating application. The stampers that must be handled through finishing operations have the front face protected by application of a protective plastic film.*

Fig. 8. *Stamper backfinishing. The stamper backs are ground and polished to a smooth surface in an automatic finishing machine.*

Fig. 9. *Centering operation. The stamper concentricity is established by a centerhole punch using a video camera focused on a "recorded-in" centering ring.*

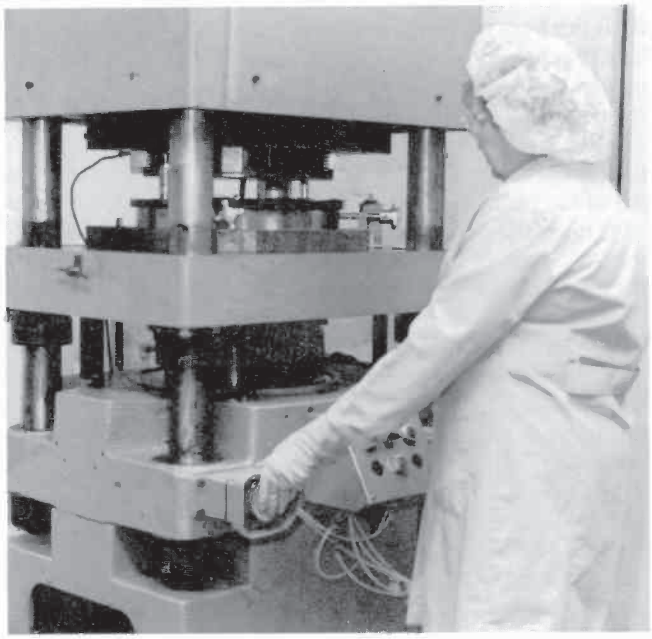

Fig. 10. *Coining die. The mechanical profile of the inner and outer edges of the stamper is formed in a coining operation. The forming allows a match between the stamper and the press-mold geometries.*

Material requirements

The bath chemistry control and process control is required to maintain the material properties of both the copper and nickel plates. The copper for machining requires a plate that is so fine grained that it is almost amorphous. Moreover, it must be resistant to recrystallization, and it must be in a narrow hardness range.

The nickel must be produced with low internal stress to prevent distortion, it must be ductile for long service life on the mold, and it must be reasonably fine grained and hard at the recorded surface. These requirements are sometimes contradictory and an optimum compromise condition is determined.

Summary

The disc quality is only as good as the quality of the stamper from which it is pressed. The microscopic geometries associated with a VideoDisc place far greater demands on the electroforming process than normally encountered. Contaminant control has to be approached as if the part were a large semiconductor circuit wafer rather than a modified audio stamper. Mechanical properties are crucial to long service life in the press operation..

Donald J. Wierschke joined RCA "SelectaVision" VideoDisc Operations in 1980 as a Member of the Engineering Staff assigned to the Matrix Department. He came to RCA with 11 years of experience in precision nickel electroforming in the field of optics. Since then, he has been transferred to Development Engineering with primary responsibilities in the area of nickel electroforming.

Contact him at:
Disc Operations
VideoDisc Division
Indianapolis, Ind.
TACNET: 426-3319

David F. Hakala joined RCA Picture Tube Division, as a process development engineer, after receiving his Ph.D. in physical chemistry from R.P.I. in 1976. After serving as group leader of the Analytical Laboratory for two years, he joined VideoDisc Operations as Staff Scientist working on material problems and subsequently was Manager of Production Engineering for disc manufacturing. Currently, he is Manager of Process and Materials Development Engineering. He holds one patent and is the author of several publications.

Contact him at:
Disc Operations
VideoDisc Division
Indianapolis, Ind.
TACNET: 426-3433