Low Cost Very Large Diamond Turned Metal Mirror

Contract No. NNX09CF40P (SBIR 2008-1) (MSFC)

Mirror Technology SBIR/STTR Workshop

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OUTLINE

- **CONCEPT AND GOALS**
- **MIRROR MFG. PROCESS**
- **PROGRESS TO DATE**
- **SUMMARY**

Concept and Goals

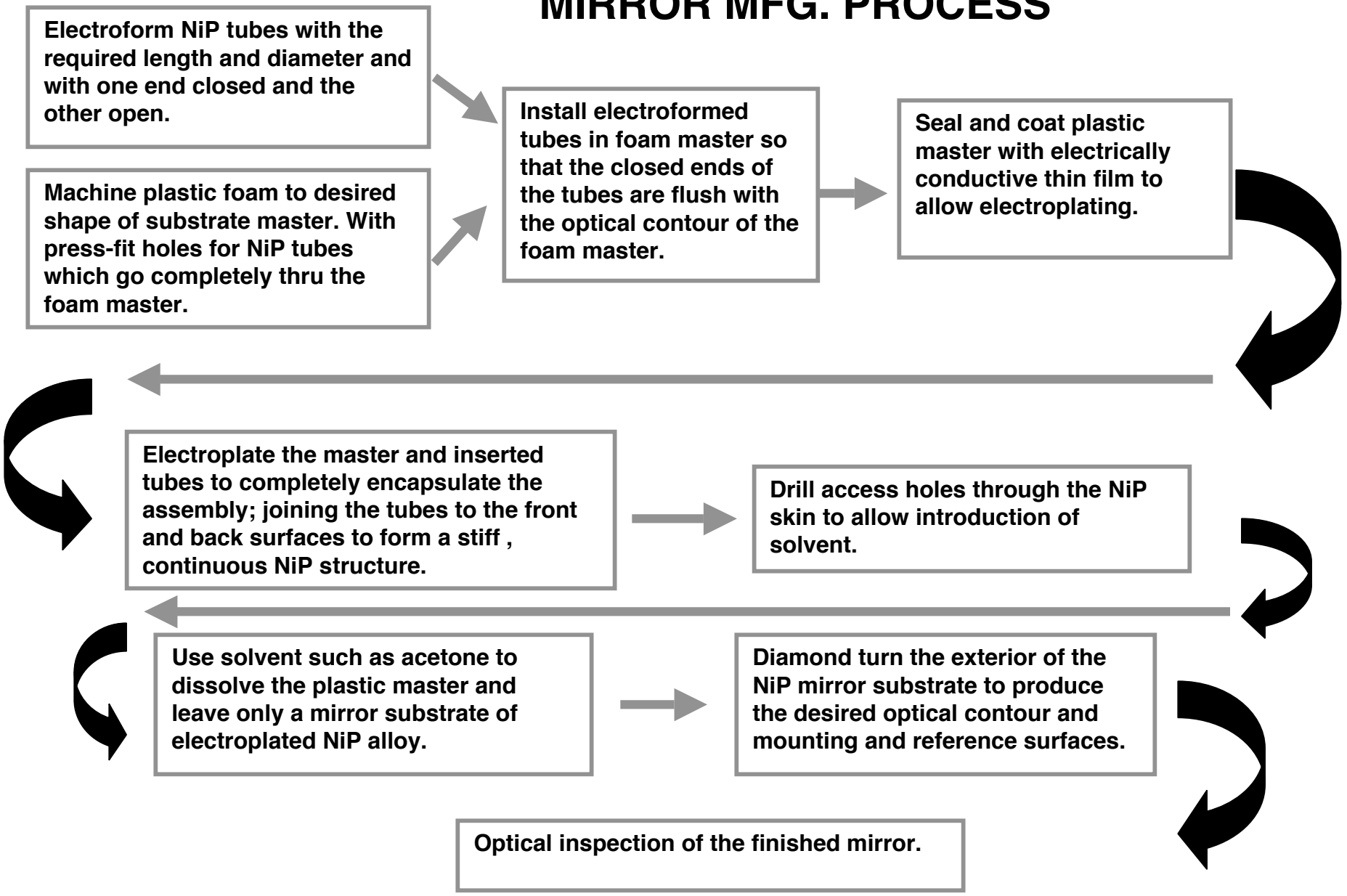
--- Develop and demonstrate a process for producing a light weight, stiff mirror substrate by electroplating a NiP alloy over a plastic foam mandrel which will be removed with solvent after plating.

--- Demonstration of diamond turning as a method of producing a high quality optical surface on the electroplated NiP substrate by producing a 300 mm (12 inch) diameter flat test mirror.

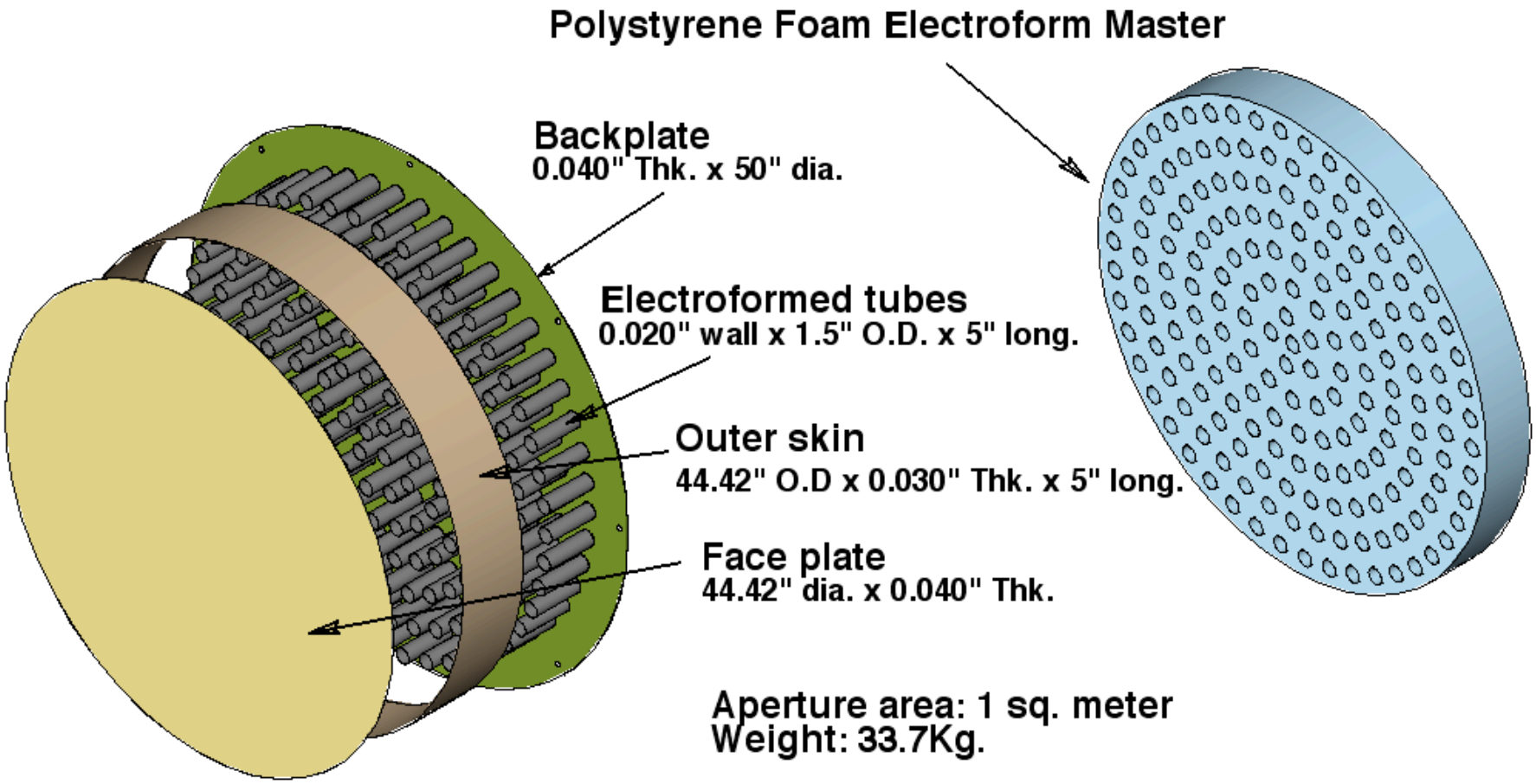
--- Optical inspection of the finished mirrors to evaluate mechanical stability and stiffness and the extent of mirror internal structure print through on the finished optical surface as a function of faceplate thickness.

--- Optical and dimensional inspection and characterization of the finished mirror for overall optical figure accuracy and surface smoothness achieved by diamond turning.

MIRROR MFG. PROCESS



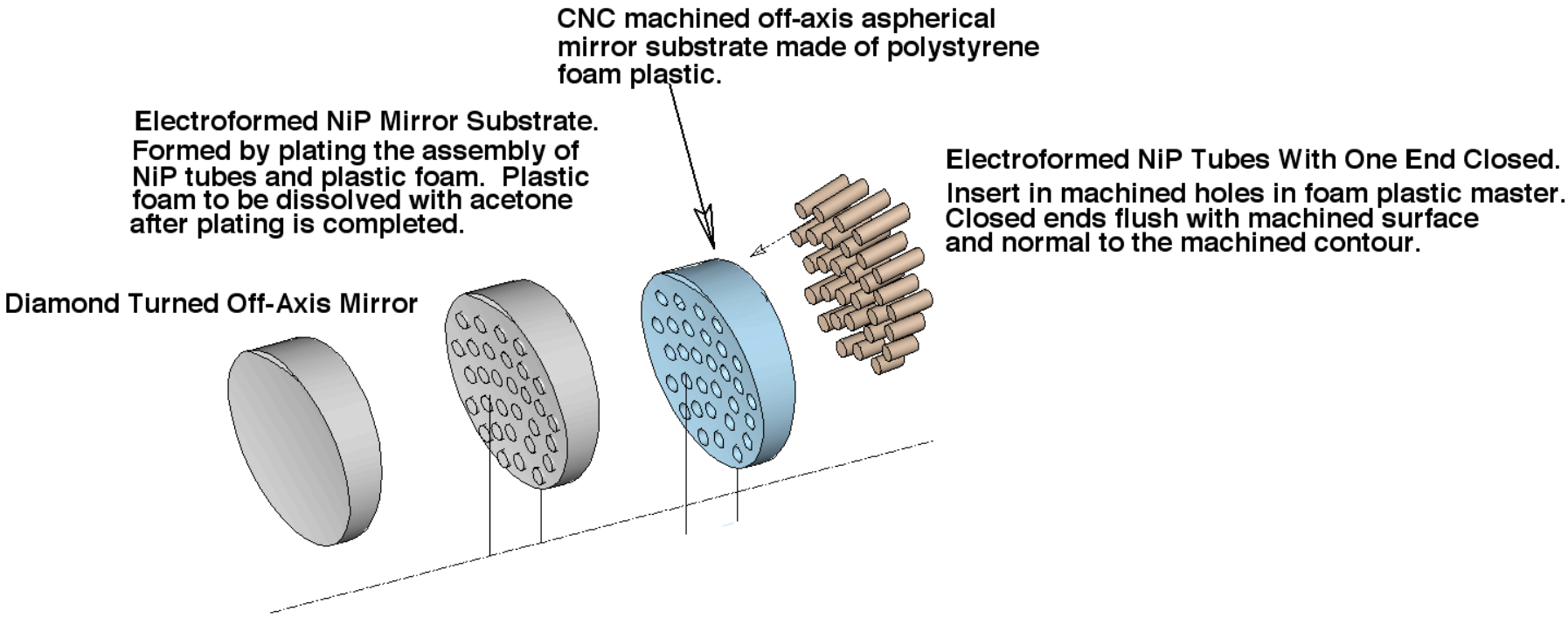
Weight of 1 Sq. Meter Mirror



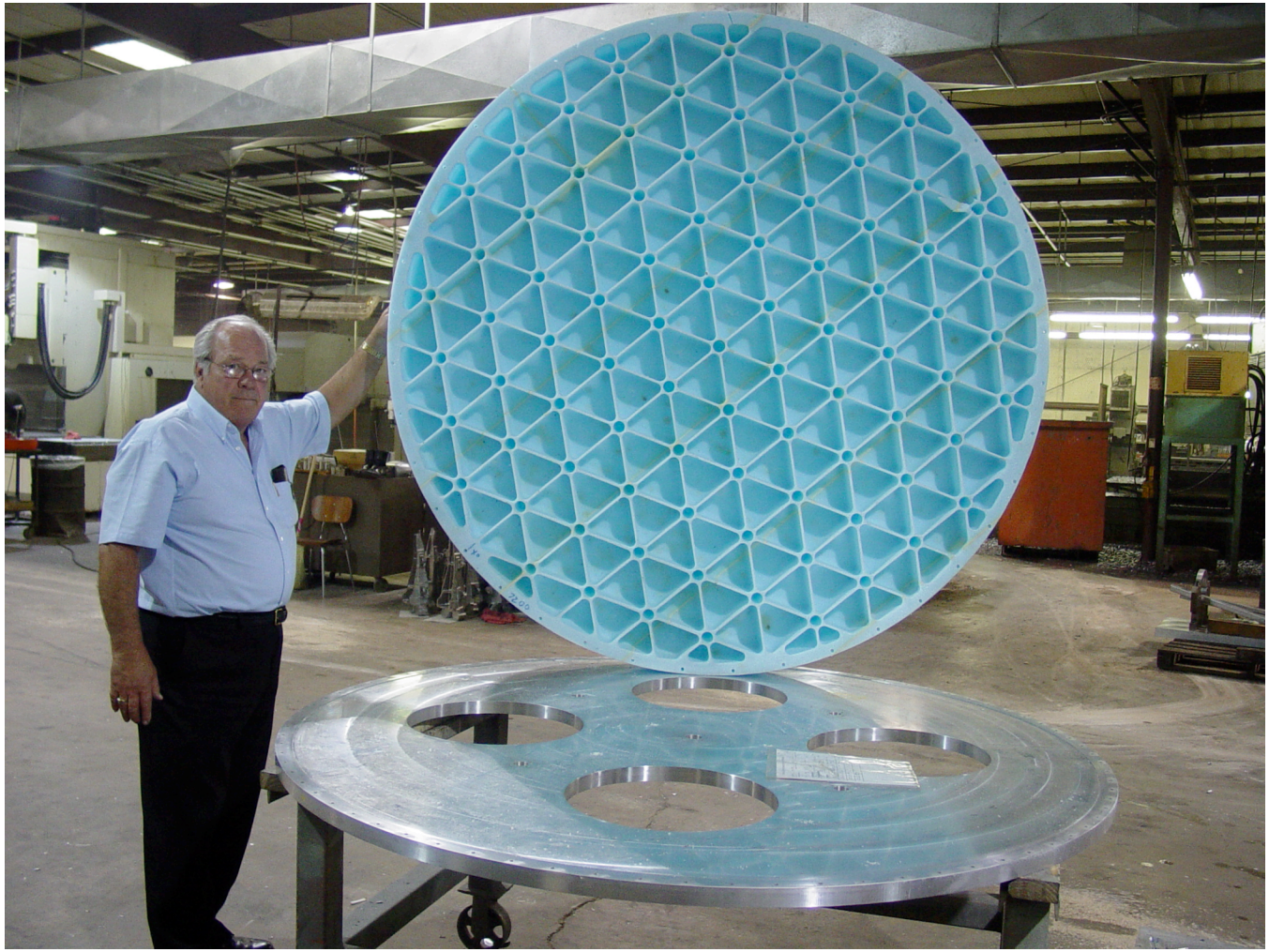
Aperture area: 1 sq. meter
Weight: 33.7Kg.

After diamond turning mirror surface and back plate.
Weight: 27 Kg.

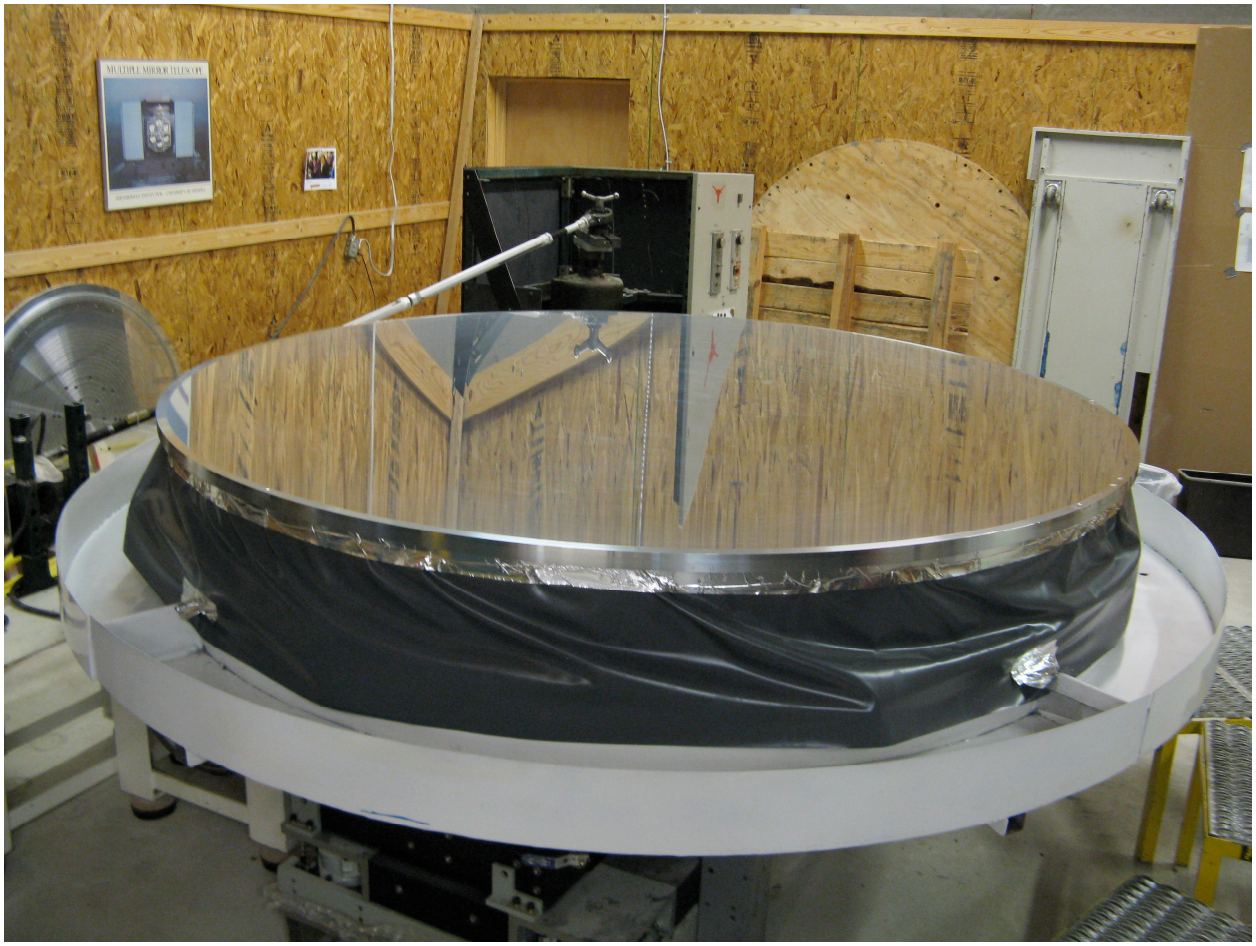
Off-Axis Aspheric Mirror



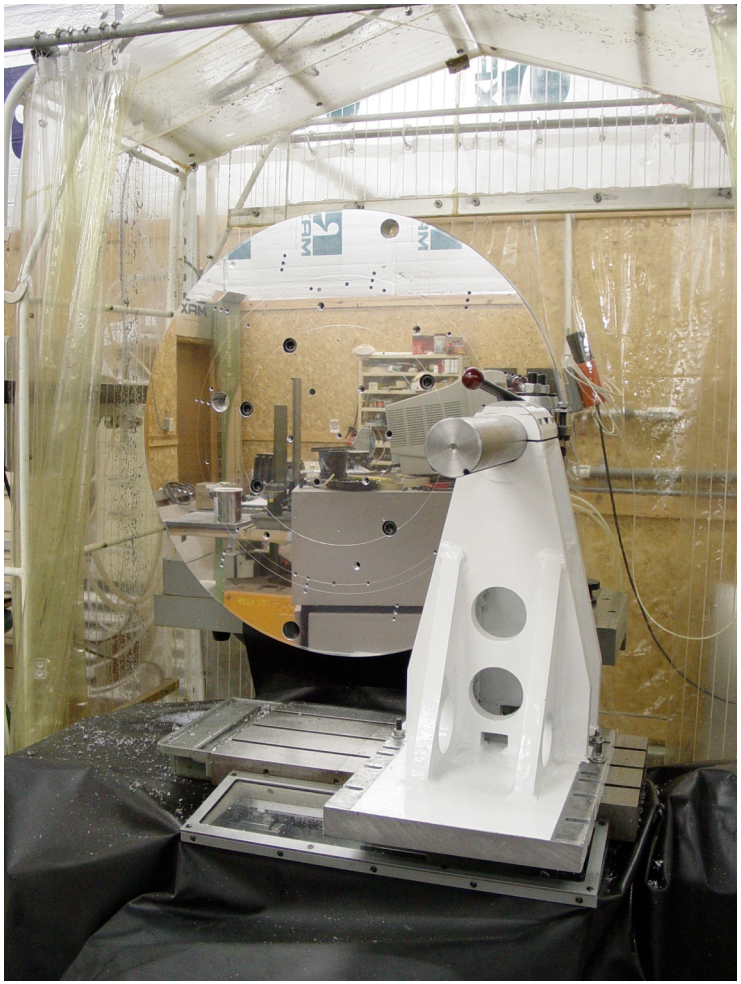
1.8 Meter Diameter Foam Plastic Mirror Substrate



2.4 Meter Aluminum Mirror



Large Part Diamond Turning Experience



Technology

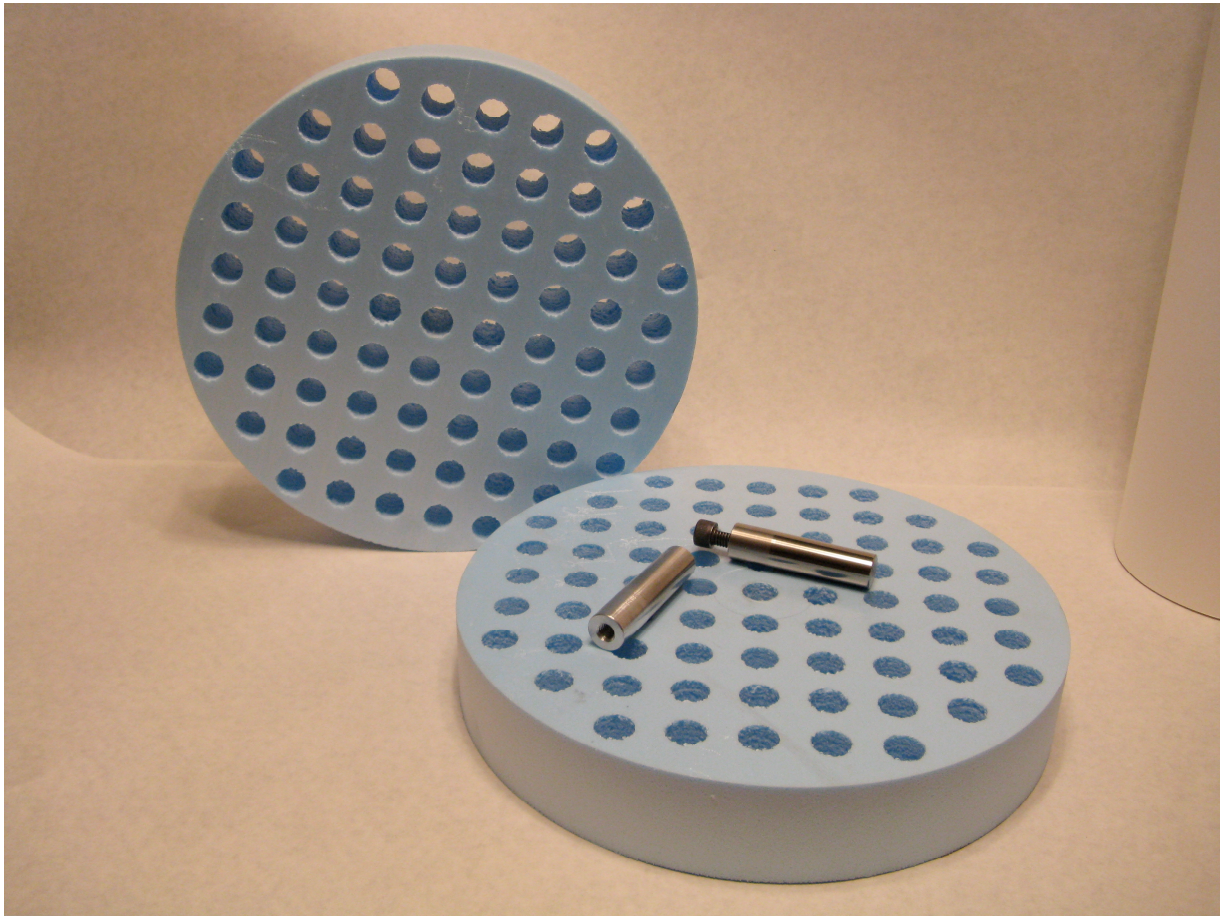
- A very important enabling process for plating high phosphorus nickel alloys using an electrolytic process has been developed at the University of Alabama at Huntsville and at Marshall Space Flight Center. This plating process has been demonstrated to be capable of producing very low stress deposits of very high quality that allow excellent surfaces to be diamond turned on the NiP deposit. The electrolytic NiP plating process is not limited in plating thickness. Thick wall, structurally robust mirror substrates can be built up with this electroplating process.

Comparison of Nickel Phosphorus Deposition to Other Processes

Parameter	Nickel	Electroless Nickel	NiP & NiCoP (Electrolytic)
Plating Temp °C	38 – 50	82 – 90	40 – 50
Control Method	Soluble Anode	Chemical Replenish	Soluble Anode
Yield (0.2%) (MPa)	500	See UTS	See UTS
MicroYield (MPa)	70	500 +	830 +
UTS Max (MPa)	800	850	1800 – 2150
Specific Gravity	8.9	7.8 – 8.0	7.8 – 8.0
Stress Control (Real Time)	Yes	No	Yes
Hardness (Rockwell C)	22 – 24	48 – 52	48 – 52
Diamond Machining	No	Yes	Yes
Thick Deposits	Yes	No	Yes

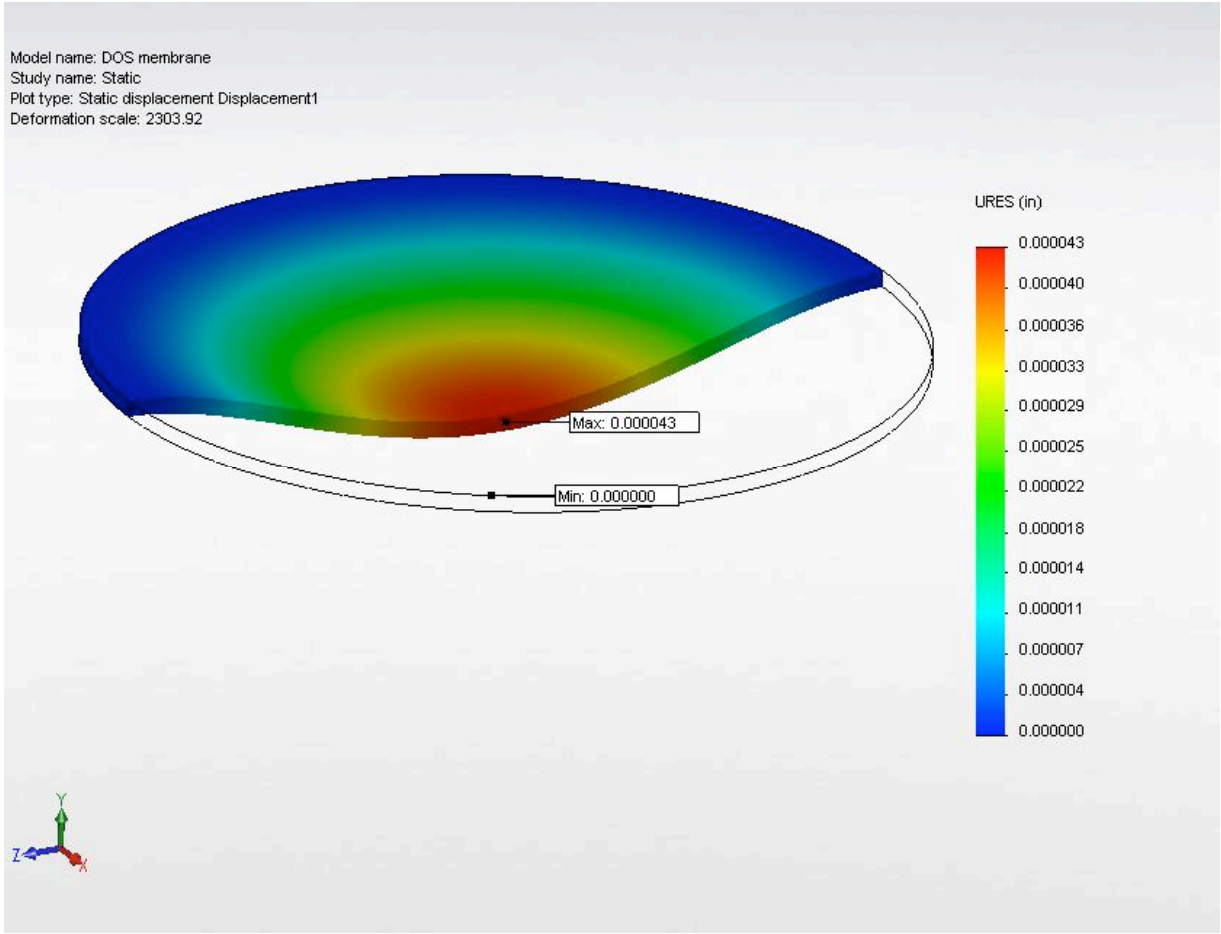
Electroforming Technology Developed by UAH and MSFC for X-Ray Telescope Fabrication

0.3 Meter PLASTIC FOAM MIRROR FORM

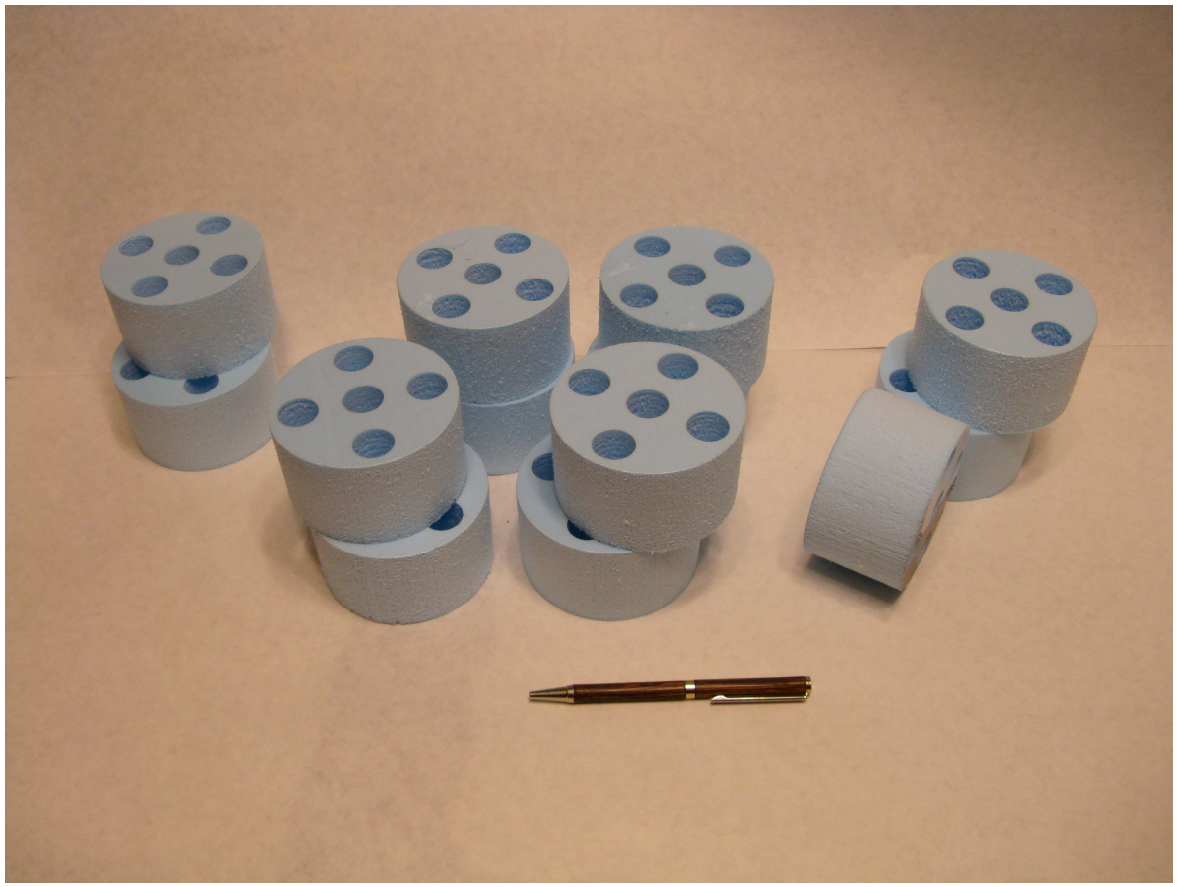


MIRROR DESIGN

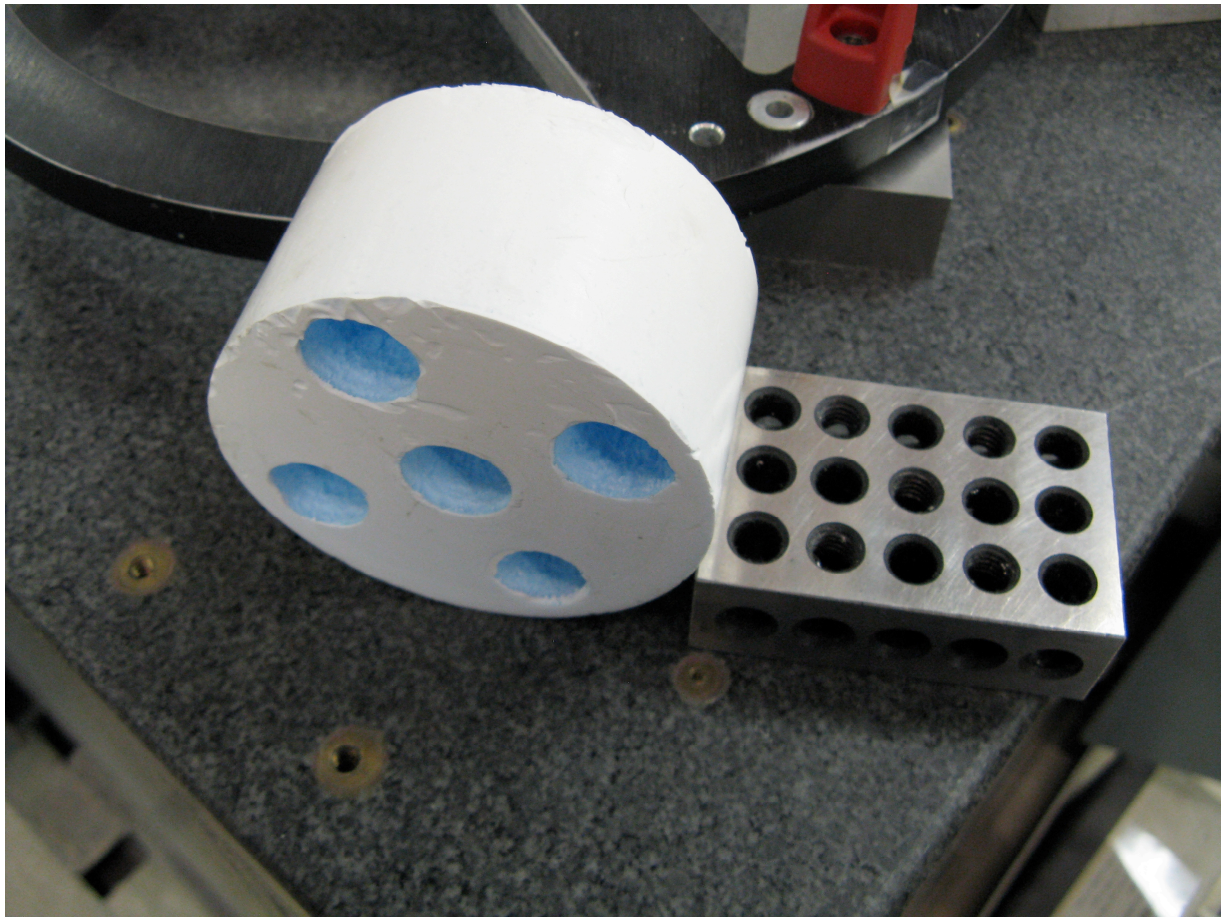
Plating thicknesses and diameter and spacing of tubes optimized for best performance.



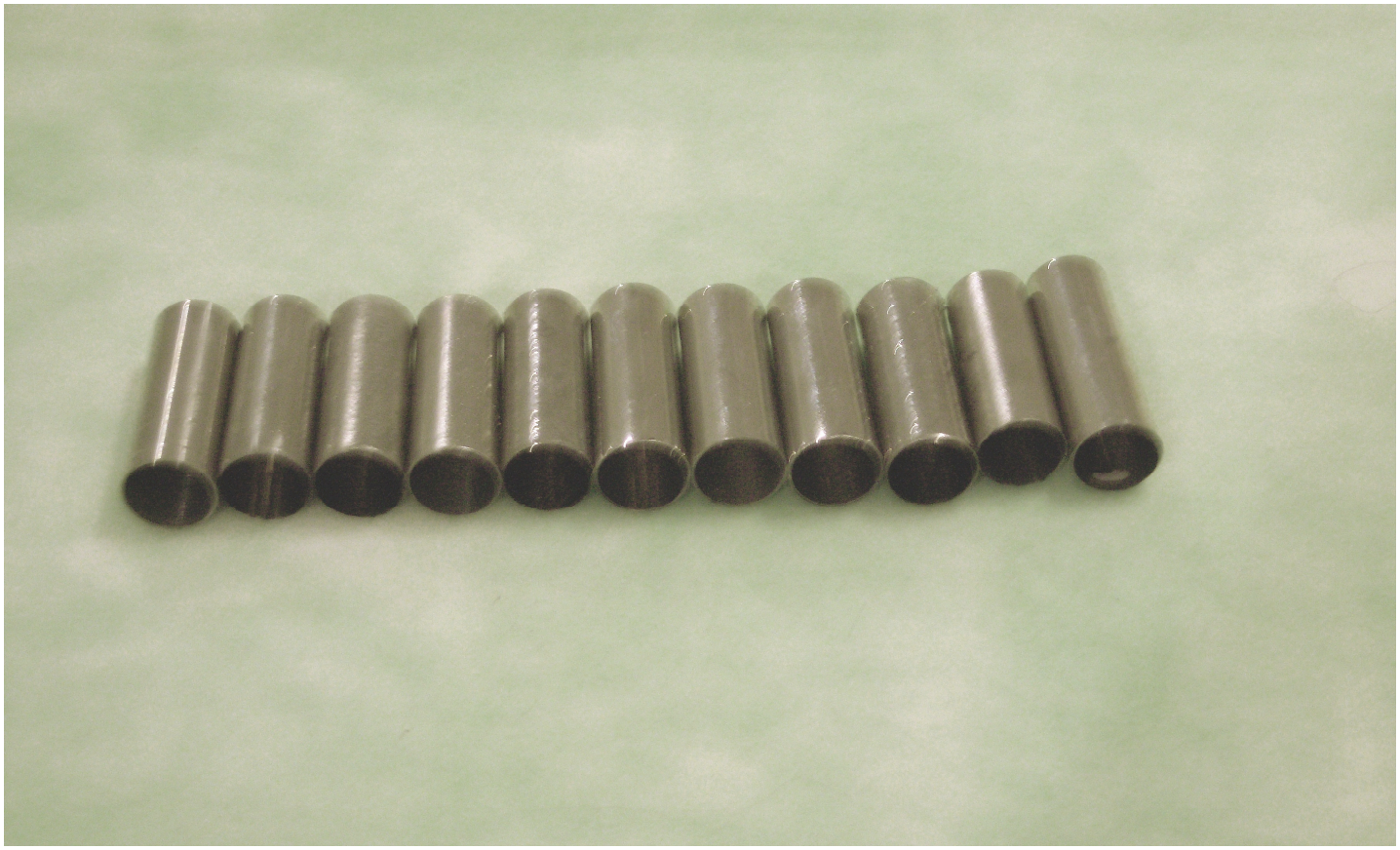
100mm DIAMETER FOAM MASTER FORMS



MIRROR FORM COATED WITH ELECTRICALLY CONDUCTIVE MATERIAL FOR PLATING



Electroformed NiP Tubes

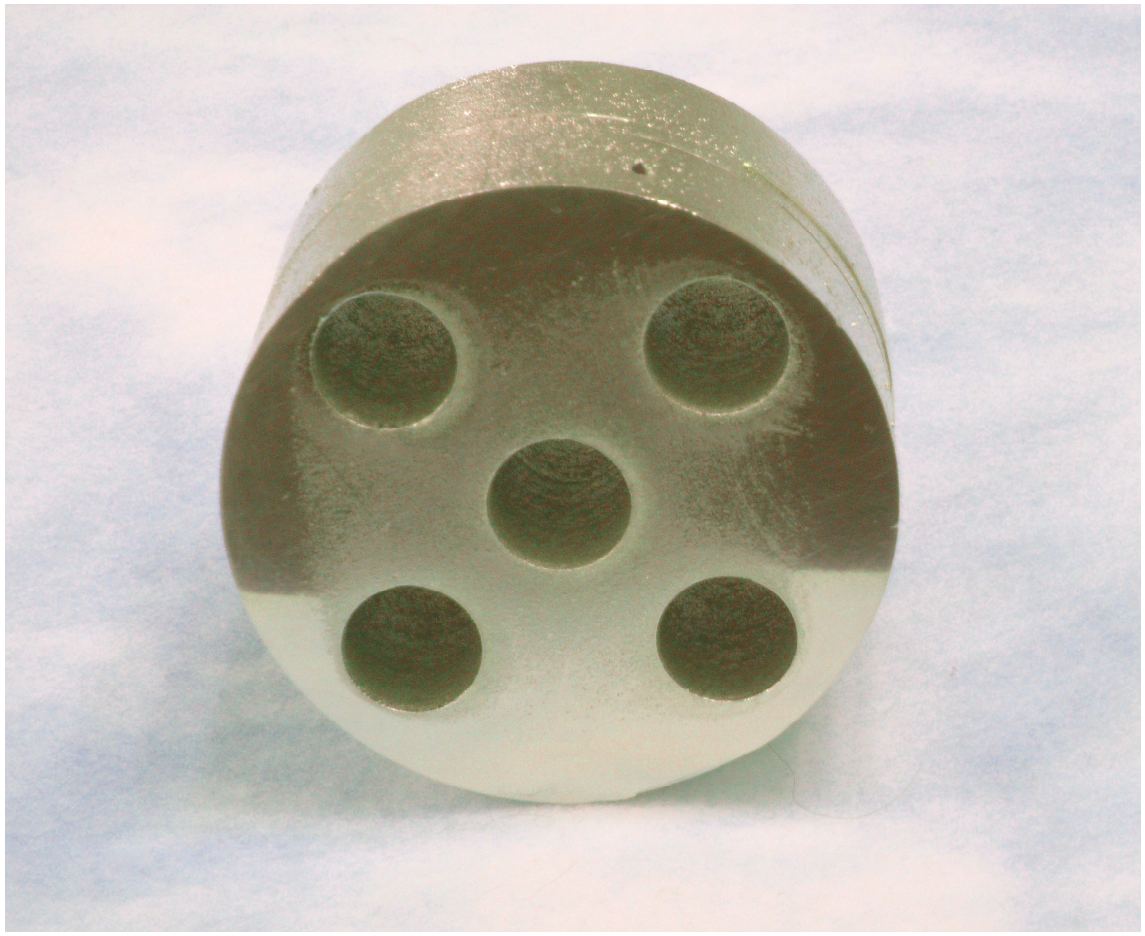


ELECTROFORMED TUBES

NiP TEST FORM AFTER PLASTIC FOAM DISSOLVED

Plated Mirror Assembly

Plated Foam Mirror Form



SUMMARY

- **Low Cost Mirror *SUBSTRATE* by Electroplating of NiP.**
- **Diamond Turning of NiP Electroformed Substrate.**
- **Low Cost Very Flexible Manf. Process for Large Mirrors.**
- **Low Areal Density, Very stiff metal mirror.**
- **Only one material means low thermal distortion.**