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Paper: *Robert E. Parks, "Fabrication of infrared optics", Optical Engineering 33(3), 685—691 (March 1994).*

1. Introduction

This paper discusses the similarities and differences between the fabrication of the more familiar glass optics used in the visible and the fabrication of optics used in the IR. The selection, testing, fabrication of IR materials are discussed.

2. Similarities and Differences Between Visible and IR Materials

Table 1. Properties of some typical IR Materials

Crystalline alkali halides	Water soluble, available in single-crystal or polycrystalline form, very dielectric, high CTE and low thermal conductivities.
Alkaline earth fluorides	Hard and brittle, water insoluble, available in single-crystal or polycrystalline form, very dielectric, high CTE and low thermal conductivities.
Chalcogenide	High indices of refraction, easier to grind and polish
Cesium iodide	Transparent up to 80 microns, good consistency, soft, not easy to polish.

Table 1 lists the property of some typical IR materials. Generally, all these IR materials can be treated very similarly to optical glasses during the initial steps of manufacture, the cutting of the blank from a boule, generating to a flat or specific radius, and loose abrasive grinding to a dimension and finish suitable for polishing. Even in polishing, the same types of tooling are used as for glass and the same sorts of strokes are used during polishing to control the radius.

3. Selection and Testing of IR Materials Before Polishing

Difficulties on testing the IR materials include:

1. Many IR materials do not transmit in the visible. So it is hard to measure the quality of the raw material until it has been installed into a finished optical system.
2. Most suppliers of IR materials are subsidiaries of companies whose main business has nothing to do with optical applications. Thus, many materials is produced not on the basis of its optical properties.

However, for optical glass the manufactures have already do a very good job in inspecting and certifying the glass so that we do not have these problems.

4. Polishing IR materials

The difference between polishing IR materials and glass is mainly in the chemistry of the polishing process. Glass is always polished with a polishing compound of high cerium oxide content. The cerium oxide can dissolve the outer layer of glass. So that after the polishing lap has passed, the silica-rich polishing slurry can redeposit a silica layer on the glass. This silica layer will provide a fine surface and cover up small defects.

As for IR materials, the cerium oxide no longer works due to chemical reasons. A common choice for IR materials polishing would be fine-grade aluminum oxide. The choice of aluminum oxide can start with Linde C, whose particle size is 3 microns. But smother surfaces can be obtained by using Linde B or a mixture of Linde A and Linde B, whose particle sizes are 1 microns and 0.3 microns respectively.

Table 2 lists some typical problems in the IR fabricating process and their solutions.

Table 2. Typical problems in IR fabricating and corresponding solutions

Problems	Solutions
Linde materials tend to roll around on the lap instead of cutting	Beeswax is applied to the pitch surface
The contact or friction between work and lap is too great	Add someome detergent or glycerine to the water slurry of alumina
Sleeks or scratches during polishing	Polish the bevels before polishing the face in question
Polishing with water-soluble crystals	Wear latex surgical gloves at all times to avoid moisture from the skin damaging the surface

5. Polishing of Large Quantities IR optics

The previous part is about working on one or two pieces at a time. When it comes to a large market with relatively small IR optics. The polishing can be done with diamond and synthetic polishing pads rather than aluminan oxide.

Although the diamond polishing may not yield the best surface for a particular IR material, it can always yield the most uniformly predictable and fastest polish on IR matericals.

6. Fabrication of Aspheres in IR Materials

The common method of making aspheres in IR materials is single-point diamond turning (SPDT). SPDT is a method of producing an optically finished surface in suitable materials on a very precise, numerically controlled lathe with a cutting tool made of a single-crystal diamond polished to a fine cutting edge. Very luckily, most of IR materials can be diamond turned quite successfully.

7. Conclusions

In this paper we have showed the mainly difference between the fabrication of IR optical elements and most visible-light optical elements. The main things that differs is the polishing step due to the unique chemical properties of IR materials. The discussion will be helpful on relative field and can be applied to IR applications, such as thermal imaging and remote sensing.