Chapter 1
Introduction

1.1 Safety

Before cleaning optics, first read the relevant safety data sheet (SDS)—formerly known as material safety data sheet (MSDS)—to communicate the dangers of hazardous chemical products; this important document explains the requirements for the safe use, storage, and disposal of the cleaning and optical materials. Wear personal protective equipment (PPE) as required while working with solvents, materials, or other chemicals. Containers should be labeled with the type of solvent or chemical stored within.

> Read, review, and follow your company's policies for safely handling toxic materials, solvents, chemicals, and other cleaning materials.

In the United States, the Occupational Safety and Health Administration (OSHA) offers guidelines on the safe use of chemicals called the Hazard Communication Standard (HCS or HazCom). Chemical information is readily available on the web. Manufacturers, chemical suppliers, and chemical science and engineering organizations have detailed information on their use and can offer updated safety requirements, similar to SDSs. Internationally, the United Nations Committee of Experts under the United Nations Economic Commission for Europe (UNECE) has written new guidelines on the classification and labeling of chemicals. The new program is called the

Globally Harmonized System (GHS). OSHA has modified their HCS program to conform to the GHS program; see the OSHA or GHS websites for more details and the new labeling requirements.

Staging and pickup areas should be positioned away from the workstation. There should be minimal movement in and around the workstation, as bumping the workstation during the cleaning process can cause the optic to move or roll off of the table. To prevent tipping, the optic should always lay flat or be mounted. Avoid leaning over the optic. Keep the upper pockets of your clothing free of pens, pencils, and other objects to prevent them from falling onto the optic. Keep the optic covered while moving it around the shop. Use caution—assume that an optic is located under any tissue. Label the tissue if necessary to prevent damage, but use marking methods that do not bleed through the tissue and come in contact with the surface of the optic.

> Follow your company's policy on ergonomic procedures when setting up your workstation. The station should be comfortable and accessible, and the table should be set at the proper height.

Lighting and other electrical equipment should be used with caution, especially near water sources. All cords and wires located on the workstation should be secured to prevent accidents. Keep the area organized. Storage for cleaning materials should be close by. Drawers can be used for daily or weekly supplies, whereas storage cabinets should be used for extra supplies. Place the cabinet in a cool, dark, dry room away from high-traffic areas such as hallways.

1.2 Optical Materials: Glass, Coatings, Plastic, and IR

Glass is a wonderful material that, among other things,

- shields people against many types of radiation,
- covers filaments in light bulbs and lamps,
- keeps people cool in summer and warm in winter as windows,
- converts sunlight into electricity or generates hot water when used in solar panels,

- provides surfaces to cook with, eat on, and store food,
- protects artwork from the environment and can be used as an artistic medium, and
- makes television, computer, and smartphone screens possible.

The glass types discussed in this book refer to optical glass used for lenses, mirrors, prisms, and windows. Optical glass is used in telescopes, microscopes, and precision windows.

> Glass for buildings and vehicles is typically called soda lime, plate (polished glass), or float glass. It is manufactured in higher volumes than optical glass. Vehicle glass is made of a laminate of glass and plastic. Safety glass is toughened to crumble into small pieces when broken.

Optical glass is divided into groups. For example, crown and flint glasses are used for refractive optics. Chemical elements and compounds, including rare-earth materials, are added to the batch or melt of glass to change its optical characteristics and performance. Over time, improvements in the production of these glasses have reduced the environmentally hazardous materials used while still maintaining the same optical properties. This process has caused a reduction in the availability of certain types of glasses over the years and has put limits on optical designs, as the original glasses are no longer requested.

> Optical glass is manufactured in many countries. The major producers are in the United States, Japan, Germany, England, France, Eastern Europe, India, and China.

Refractive glass materials can be used for reflective optics, such as prisms, laser windows, small mirrors, and catadioptric optics. Depending on its formulation, refractive glass reacts more or less strongly to environmental conditions such as climate, alkalines, acids, heat, cold, and water (moisture).

The cleaning and handling of soft glasses requires extra care. The optical coatings on soft glasses are typically much harder than the glass itself; they are easily damaged, which can be an issue when cleaning.

The majority of reflective optics use materials with a low coefficient of thermal expansion (CTE). These include borosilicate, fused quartz, fused silica, and ceramic glass. Reflective glass materials are harder than refractive glass and can withstand some light mishandling without damage. However, the reflective metal coatings placed on the surface are very thin (nanometers in thickness), soft, and easily damaged. Dielectric coatings are slightly more robust.

Plastic materials used in optics include polycarbonate, acrylic, and polypropylene. They are considered very soft and require special care when handling and choosing the right cleaning solvent. Hard coatings can be applied to plastic to reduce the risk of damage.

Infrared (IR) transmission optics are used in defense, commercial, and scientific industries. Applications include ordnance (fire) control, unmanned aerial vehicles (UAVs), night vision, marine, security, automotive, firefighting, and thermography systems. IR optics use many different types of semiconductor and crystal materials: silicon, germanium, zinc sulfide, zinc selenide, calcium fluoride, magnesium fluoride, and sapphire, to name a few.

> Silicon, germanium, and sapphire are examples of unique IR materials. Try common glass cleaning methods with these.

Extra caution is required when cleaning, handling, and mounting all IR materials. The materials and coatings are easily damaged due to their softness, brittleness, water solubility, and poor thermal properties. It is important to understand the physical properties of the IR materials. Check with your IR material supplier or fabricator for additional methods on cleaning and handling; refer to the relevant SDS or GHS for all handling requirements.

Most IR materials are made using a crystal growing process. The common processes are Bridgman–Stockbarger, Czochralski, Kyropulos, or Verneuil. As an example, the Czochralski process starts with a seed of the material attached to a rod. The rod is dipped into a crucible of molten material, slowly rotated, and then removed. When the material is exhausted, the process is complete. The process yields a large cylindrical shape called an ingot or boules. Just like glass materials, the ingot is tested, cut, and processed to the customer's requirements.

1.3 When to Clean

Cleaning is required when a surface has a type of contamination that can damage the optical surface or interfere with the system performance.[1,2] Before cleaning the optic, an evaluation of the degree and type of contamination must be made; this will determine whether cleaning is necessary and what method should be used. Some types of contamination, such as dust or fibers, can be tolerated on optical surfaces without any appreciable degradation in performance.

Access to an optical surface may be difficult. Knowing when the surface(s) needs cleaning will prevent unnecessary and time-consuming disassembly of a system. Inspection of the optic with proper lighting techniques will help identify the degree and type of contamination. In some optical systems, the contamination will be visible to the eye, as on an objective, focused beam on a surface, imaging surface, or eyepiece.

Before cleaning an expensive optic, it is prudent to practice on a surplus optic, such as an achromat, first-surface mirror, or coated prism. The methods described here are generally not harmful to most optical surfaces. However, it is possible to cause damage to some types of glasses and optical coatings.

> Know what you are cleaning and review the process. Experiment on a practice piece until you have mastered the cleaning methods.