Project Deliverable

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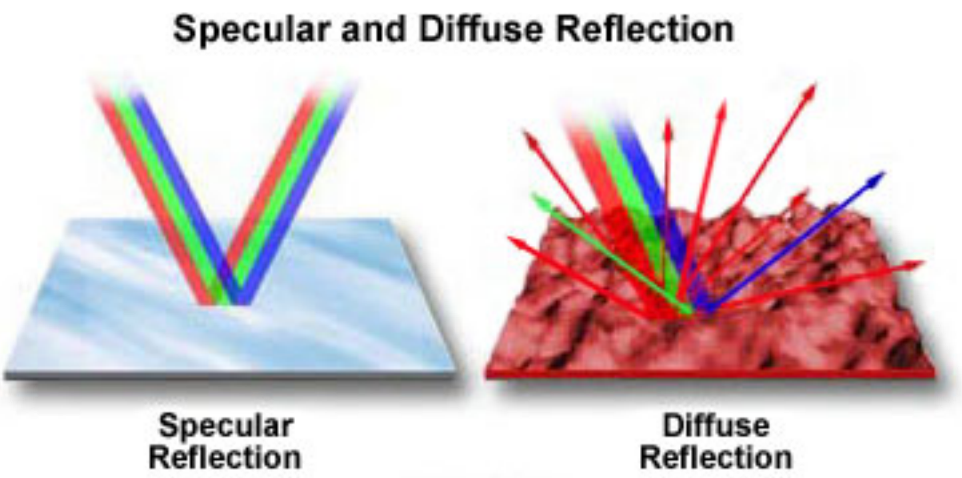
1 Introduction

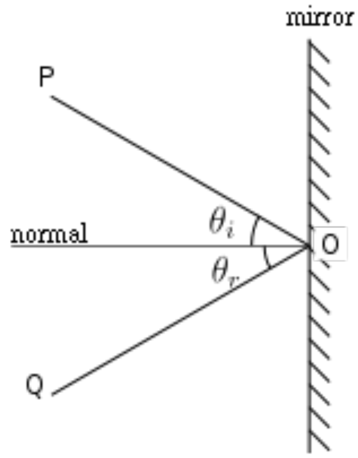
Most concentrators depend on a reflective surface to concentrate the rays of the sun to a smaller area. The surfaces are either polished aluminum or silver or aluminum on either the front or back surface of glass or plastic. When silver or aluminum is deposited on the back surface of a protective transparent material, it is calleda *back*-surfaced or second surfaced mirror.

The quality of a reflective surface is measured by its reflectance and specularity. *Reflectance* is the percentage of incident light that is reflected from the surface. Specularity is a measure of the ability of a surface to reflect light without dispersing it at angles other than the incident angle.

An ideal surface reflects all incident light rays at an angle equal and opposite to the angle of incidence.



2 Specular reflection model



Specular reflection is the mirror-like reflection of light (or of other kinds of wave) from a surface, in which light from a single incoming direction (a ray) is reflected into a single outgoing direction. Such behavior is described by the law of reflection, which states that the direction of incoming light (the incident ray), and the direction of outgoing light reflected (the reflected ray) make the same angle with respect to the surface normal, thus the angle of incidence equals the angle of reflection (**θ**_i = **θ**_r in the figure), and that the incident, normal, and reflected directions are coplanar. This behavior was first discovered through careful observation and measurement by Hero of Alexandria (AD c. 10–70).

Specular reflection is distinct from diffuse reflection, where incoming light is reflected in a broad range of directions. An example of the distinction between specular and diffuse reflection would be glossy and matte paints. Matte paints have almost exclusively diffuse reflection, while glossy paints have both specular and diffuse reflection. A surface built from a non-absorbing powder, such as plaster, can be a nearly perfect diffuser, whereas polished metallic objects can specularly reflect light very efficiently. The reflecting material of mirrors is usually aluminum or silver.

The reflectivity of a surface is the ratio of reflected power to incident power. The reflectivity is a material characteristic, depends on the wavelength, and is related to the refractive index of the material through Fresnel's equations. In absorbing materials, like metals, it is related to the electronic absorption spectrum through the imaginary component of the complex refractive index. Measurements of specular reflection are performed with normal or varying incidence reflectometers using a scanning variable-wavelength light source. Lower quality measurements using a glossmeter quantify the glossy appearance of a surface in gloss units.

The image in a flat mirror has these features:

It is the same distance behind the mirror as the object is in front.

It is the same size as the object.

It is the right way up (erect).

It appears to be laterally inverted, in other words left and right reversed.

It is virtual, meaning that the image appears to be behind the mirror, and cannot be projected onto a screen.

3 Types of material

Most reflective surface are metals. Under laboratory condition, polished silver has the highest reflectance of any metal surface for the solar spectrum. Aluminium reflect most of the solar spectrum but not have the hight reflectance of silver.

Silvered-glass mirror are made by silver painting the surface of a glass, this technique has been used for numerous domestic application such bathroom mirrors. These mirrors are difficult to bend into a concentration shape and have a low transmittance because common glass contains iron; the resulting mirror does not have high reflectance because the incident light must pass twice through the thick, low-transmittance glass.

To increase performances for solar application of silvered-glass mirror, thin-glass have been developed. Glass used are iron-free and do not absorb strongly in the solar spectrum. The mirrors can have a 95% of reflectance.

A variety of plastic films with an evaporative deposited aluminium coating have been used for many years, althought the optical and mechanical properties of most plastic degrade after logn exposure to ultraviolet rays. New products promise slows degradation and high reflectance with high specularity.

Polished aluminium sheet are available in large size and are relativity inexpensive with good specular reflectance (> 85 %). Another disadvantage is their poor weatherability.

4 Tested reflective materials

Were examined five different types of reflective materials :

- **Classic mirror with a thickness of 4 mm**

  Tempered glass with classic silver surface

- **Polished aluminium sheet ALANOD**

  Sheet with thickness of 0.8 mm glued on a pre-curved surface

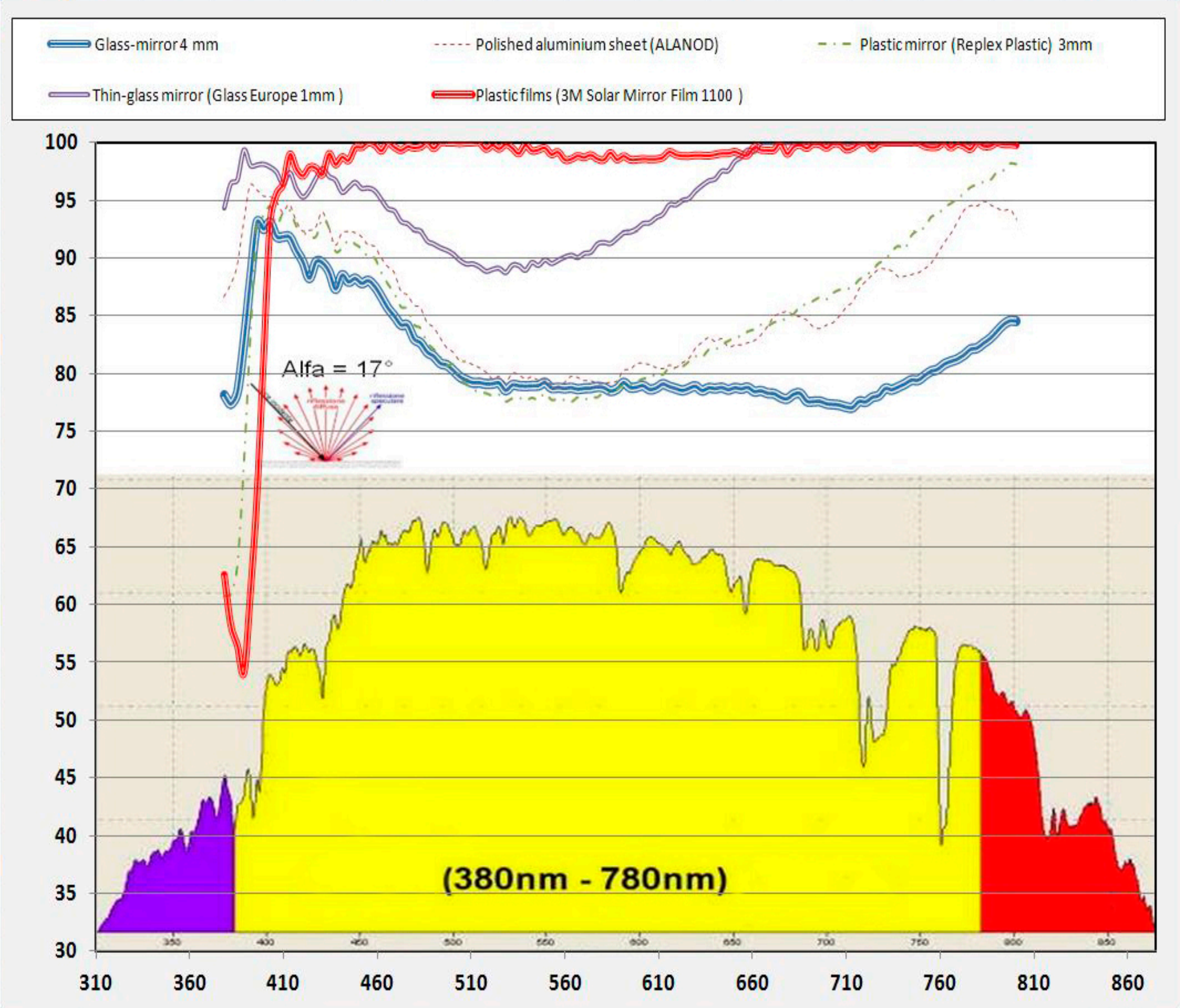
- **Plastic mirror with a thickness of 3 mm**
- **Plastic film 3M SOLAR MIRROR FILM 1100**

  Adhesive film applied to pre-curved surface

- **Thin glass mirror**

  1 mm of glass with classic silver surface and applied to pre-curved surface

Below a chart which related tests on five samples :



5 Results

In terms of the specular reflectance 3M solar film 1100 would be the best choice, but there are problems in the mechanical application of the same on a surface with parabolic curvature and problems of a fast degradation at the edges.

3M solar film after six month

Currently we are testing in collaboration with ENEA a thin-glass mirror with 0.5 mm of thickness, which should offer performances close to the 3M solar film 1100, better life-cycle and better applicability.

6 Reference

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