# Cross linked Polystyrene used in Radar

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*Abstract*

**Radar is the most useful instrument used in Aircraft. Radar consists of different elements & parts. Among them radar lens is unique, special and important element of the system. Innumerous development took place in this element design construction & material, this paper discuss about cross linked polystyrene used as material for radar lens.**

**What is Cross linked Polystyrene?[1]**

It is a thermoset, rigid and translucent plastic produced by cross linking polystyrene with divinylbenzene.

**CHARACTERISTICS [1,2]**

**Outstanding Dielectric properties**.

Dielectric constant of 2.53 together with extreme low dissipation factor.

**High voltage insulators.**

Ability to withstand high voltage is important for producing gap switch houses, capacitors and other components. It is proven superior over acrylic.

**Radiation Resistance**

Superior to most plastics. Little change in dielectric loss over a wide range of exposures up to 1000M Rads. Has superior resistance to mechanical deterioration by ionizing radiation.

**Rigidity and dimensional stability**

Exhibits no permanent deformation or plastic flow under loads of 10 to 2000 PSI at temperatures of 20 to $125^0$ C. In addition, all castings are stress-free, not requiring any stress relieving prior to, during or after machining.

**Self extinguishing**

Burn rate of less than 1" per minute.

**Optical**

Transmission approximately equals to acrylic - (87% visible light, 1" thick). Refraction index 1.59 @ 589 nanometers, 1.604 @ 486 nanometers and 1.585 @ 656 nanometers. Used in combination with acrylic lens for color correction.

**Sound transmitting**

Excellent acoustic impedance close to water. Velocity 93x10"/second.

**Out Gassing**

Negligible. Residual monomer greatly reduced.

**Water Absorption**

Less than .05 percent. It has been immersed in boiling water for 1000 hours without change in dielectric constant.

**Machinability**

Handles well in all machining operations. Tool configuration is similar to those used on acrylic. Because of high resistance to cold flow and freedom from stress, it is easily machined or laser beam cut to very close tolerances and accuracy of .0001 can be obtained in grinding. Rexolite will not craze, providing sharp tools are used and excessive heat is not generated in polishing.

**Chemical resistance**

Alkalis, alcohols, aliphatic hydrocarbons and mineral acids have no effect. Aromatic and hydrocarbons cause swelling and should be avoided.

**Light weight**

Specific gravity of 1.05. Approximately 15 percent lighter than acrylic.

**Environmentally friendly**

Non hazardous contains no ingredients harmful to the environment.

**Applications:[2]**

- Valuable for microwave lens,
- microwave circuitry,
- antennae,
- coaxial cable connectors,
- sound transducers,
- TV satellite dishes and sonar lens.
- Other uses include non-destructive material testing devices, surveillance equipment, radar windows, radomes and missile guidance system housings.
- One interesting application is for radar lens which are used for mapping the earth's surface from fast high-flying aircraft.

**Grades Available:[2]**

**1422:** Thermoset cross-linked styrene copolymer.

- Combination of good physical and excellent electrical properties
- Low loss and stable dielectric constant makes this material suitable for use in microwave lens as well as for precision components.

**2200:** Thermoset cross-linked styrene copolymer with glass mat reinforcement to provide greater temperature stability and strength.

- Highly suited for missile and other applications where extreme cold, thermal shock and mechanical stress are encountered.
- Used principally for printed circuit boards.

**PROPERTIES TABLE**

| Property | Description | Grade 1422 | Grade 2200 |
|---|---|---|---|
| **ELECTRICAL** | | | |
| | Dielectric constant at 1MHz - 500GHz | 2.53 | 2.62 |
| | Typical dissipation factor at: 1MHz | .00012 | .0004 |
| | Typical dissipation factor at: 10MHz | .00025 | .0005 |
| | Typical dissipation factor at: 10GHz | .00066 | .0014 |
| | Volume resistivity (Ohm-cm) | > 10~16 | 5 x 10~13 |
| | Surface resistivity (Ohm) | > 10~14 | 5 x 10~12 |
| | Dielectric strength - step by step (volts/Mil) | 500 | 500 |
| **PHYSICAL** | | | |
| | Specific gravity | 1.05 | 1.11 |
| | Tensile strength (psi) | 9000 | 9500 |
| | Flexural strength (psi) | 11500 | 10500 |
| | Impact strength - Room temperature to -75° C (Ft lb./In. of notch) | 0.3 | 0.75 |
| | Coefficient thermal expansion (1° C) | 7.0 x 10~5 | 5.7 x 10~5 |
| | Thermal conductivity - Col/Sec/cm° C/cm | 3.5 x 10~4 | 5.0 x 10~4 |
| | Recommended operating temperature range | -60° to +100° C | -75° to +100° C |
| | Acoustic impedance - Velocity of sound | 93 x 10~3/sec | |

| Property | Description | Grade 1422 | Grade 2200 |
|---|---|---|---|
| **CHEMICAL** | | | |
| | Water absorption | .05 Max | .10 Max |
| | Alkalis (Sodium/Potassium Hydroxide) | No effect | No effect |
| | Alkalis (Sodium/Potassium Hydroxide) | No effect | No effect |
| | Alcohols (Methanol/Isopropanol) | No effect | No effect |
| | Aliphatic Hydrocarbons (Pentane, Cyclohexane, n-Heptane, n-Hexane | No effect | No effect |
| | Aromatic Hydrocarbons (Benzene, toluene, xylene, styrene) | Swells | Swells |
| | Mineral Acids (Hydrochloric, Sulfuric, Nitric) | No effect | No effect |
| | Chlorinated Hydrocarbons (Carbon Tetrachloride, Chloroform) | Swells | Swells |
| **OPTICAL** | | | |
| | Visible light 1" thick | 87% | |
| | Refractive index 589 | 1.59 | |
| | Refractive index 486 | 1.604 | |
| | Refractive index 656 | 1.585 | |

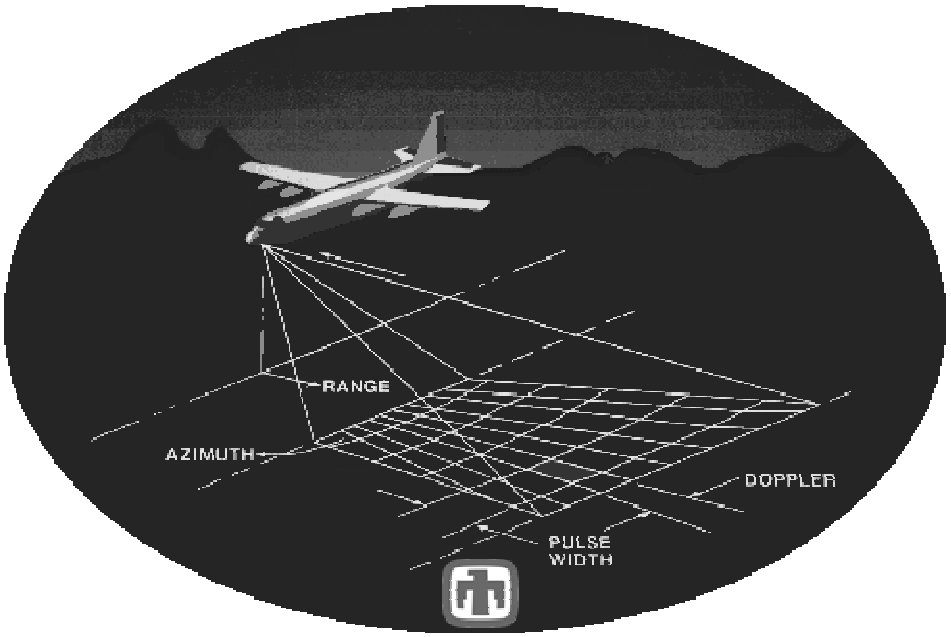
**Application in Radar :[4]**

**RADAR** is a system that uses radio waves to detect, determine the direction and distance and/or speed of objects such as aircraft, ships, terrain or rain and map them.

- Speed detection is measured by the amount of Doppler Effect frequency shift of the reflected signal.
- A transmitter emits radio waves, which are reflected by the target, and detected by a receiver, typically in the same location as the transmitter.
- Although the radio signal returned is usually very weak, radio signals can easily be amplified, so radar can detect objects at ranges where other emission, such as sound or visible light, would be too weak to detect.
- Radar is used in many contents, including meteorological detection of precipitation, air traffic control, police detection of speeding traffic, and by the military

**How does Radar work?[5]**

Consider an airborne RADAR imaging perpendicular to the aircraft velocity as shown in the figure below. Typically, RADAR produce a two-dimensional (2-D) image. One dimension in the image is called range (or cross track) and is a measure of the "line-of-sight" distance from the radar to the target. Range is determined by precisely measuring the time from transmission of a pulse to receiving the echo from a target and, in the simplest RADAR, range resolution is determined by the transmitted pulse width, i.e. narrow pulses yield fine range resolution.

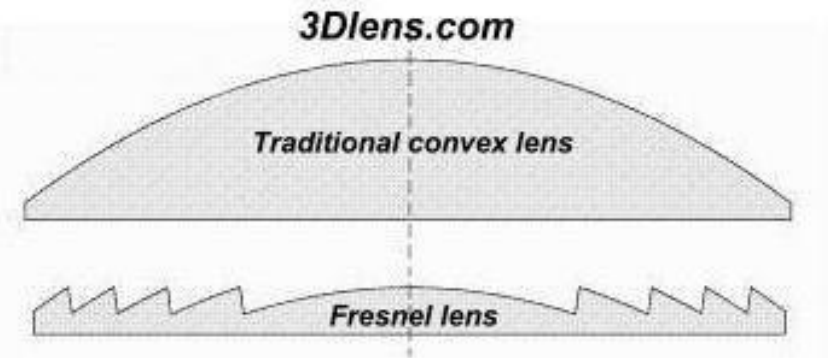



**Why used in Lens of radar?[5]**

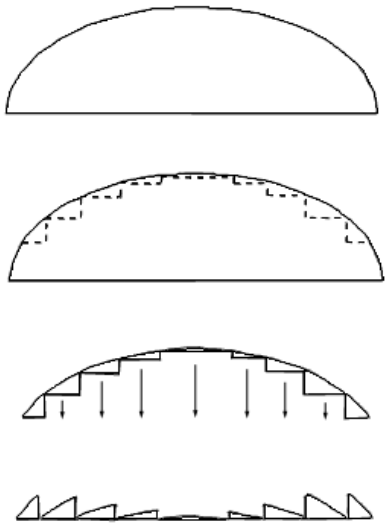
- Lens Antennas can be made of dielectric material. Focal lengths in radar antennas tend to be quite short by optical standards, ordinary lens would be impractically thick.
- Comparing with glass it has also high heat resistance.
- For this reason lens known as Fresnel lens consisting crosslinked Polystyrene.

**Construction :[6]**

- They are thin, flat optical lens which consist of series of small narrow concentric grooves on the surface of light weight plastic sheet to reduce thickness, weight and cost.
- Each groove is at slightly different angle than next and with same focal length to focus light towards central focal point.
- Each groove can be considered as an individual small lens to bend parallel from light waves and focus the light.
- The lens comprises a cross-linked polymer polystyrene material. The first surface of the lens is convex in shape and the second surface of the lens is planar.



Below is a schematic cut-away diagram showing how a Fresnel lens is made.



**Advantages**:
Can be design and manufacture in large size with light weight due to less than 4 mm thickness so cost will be lower. Reduced lens thickness results saving material cost. Reduced weight results saving mounting and assembly cost.

**References:**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5. Radar – Principal, Technology, Application- Byron Edde
6. www.3dlens.com