GLARE REDUCTION SYSTEM – SMART WINDSCREEN

Project report submitted to the

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BY

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DECLARATION

I hereby declare that this project report entitled **"GLARE REDUCTION SYSTEM – SMART WINDSCREEN"** is based on the original work carried out by me under the supervision of Dr.Lini Devassy of the Department of Physics, Bharata Mata College, Thrikkakkara

PLACE: THRIKKAKARA

DATE: April 26, 2023

ACKNOWLEDGEMENT

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PREFACE

Driving at night can be a challenging task for even the most experienced drivers. One of the most significant difficulties faced during night driving is dealing with bright headlamps from other vehicles on the road. These bright lights can cause temporary blindness, making it difficult for drivers to maintain their focus on the road ahead. When drivers are temporarily blinded, they may fail to notice important road signs or obstacles, such as pedestrians or animals.

The intense light from bright headlamps can also cause eye fatigue, making it harder for drivers to stay alert and attentive to their surroundings. Drivers who are experiencing eye fatigue may have slower reaction times or become easily distracted, putting themselves and others on the road at risk. In addition, bright headlamps can make it challenging to judge distances, making it harder to estimate braking distances and reaction times. Bright headlights can also cause discomfort or pain for drivers with certain eye conditions, such as photophobia or astigmatism.

When drivers are exposed to the glare from high beams for a prolonged period, they may experience a phenomenon known as "night blindness." Night blindness is a temporary condition where drivers are unable to see clearly, even in well-lit conditions. When driving on winding roads, bright headlights from oncoming traffic can be particularly disorienting, making it harder to stay on course and avoid potential hazards. The glare from bright headlights can also create shadows, making it difficult to see objects on the side of the road. This can be especially dangerous in areas where pedestrians or cyclists may be present. In some cases, the brightness of headlights can even cause temporary vision impairment, making it difficult to see clearly for a short period after the lights have passed. This can be especially hazardous when driving at high speeds, as drivers may not be able to react quickly to changes in the road ahead.

This highlights the necessity for developing systems to combat this issue. Tackling the troubles due to bright headlamps will improve the overall safety and comfort of driving at night.

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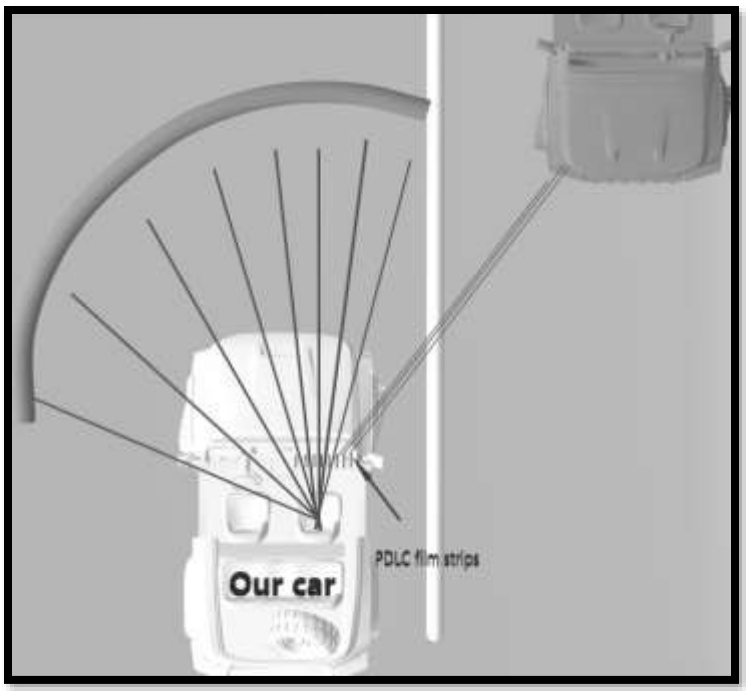
Abstract

This project aims to reduce the temporary blinding of vision while driving at night due to the bright headlamps of the oncoming traffic. It attempts to block only the bright light from the eyes of the driver without affecting his vision of the road ahead of him. It uses PDLC film strips that can toggle from opaque to transparent upon the conduction of electricity. These strips are arranged perpendicularly on the windscreen of the cars.



Introduction

While driving at night, often we become temporarily blinded when oncoming drivers do not dim their headlamps. Some drivers forget to dim their lamps while a few others consider it unimportant. This results in accidents and health issues and causes great annoyance to the affected drivers who experience a sudden loss of vision of the road ahead. This problem is especially prevalent in countries like India where roads do not have sufficient medians to obstruct the bright light from the opposite lane. Currently, there are no real solutions to this problem. Though filmed windscreen and eyewear are used, they, in addition to reducing the piercing bright light, also reduce the overall light that enters through the windscreen or eyewear, thus posing a danger. This is where Smart Windscreen finds its application.

The smart windscreen effectively blocks the light coming from the oncoming traffic without reducing the driver's visibility. This is done by limiting the angle through which light is allowed to pass through the windscreen.

Here, very small strips of PDLC film, which can switch from opaque to transparent when electricity is passed through, are mounted perpendicularly on the windshield.

PDLC films

Polymer Dispersed Liquid Crystal (PDLC) films are innovative materials used in a variety of applications, including privacy glass, smart windows, and advertising displays. PDLC films work by utilizing the properties of liquid crystals to control the transparency of the film. When an electric field is applied to the film, the liquid crystal molecules align and change the orientation of the crystal structure, allowing light to pass through.

The PDLC film is made up of a polymer matrix and liquid crystal droplets dispersed throughout. The liquid crystal droplets are typically in the range of 1-10 microns in diameter and are distributed evenly throughout the polymer matrix. The polymer matrix can be made from a variety of materials, including acrylics, epoxies, and polyesters, depending on the application requirements.

In its natural state, the PDLC film is opaque, with the liquid crystal droplets randomly oriented within the polymer matrix. However, PDLC film can be electrically switched from a light-scattering or opaque "off state" to a non-scattering or transparent "on state". When a low voltage is applied (the **ON** state), the molecules align in a formed manner, allowing light to pass straight through, and making the glass transparent. As electricity is turned **OFF**, the LC molecules scatter randomly again, breaking the passage of light and turning the glass opaque. After passing through the film, the intensity of light reduces by 35%. PDLC films are coated with a thin layer of electrically conductive Indium Tin Oxide.

The speed at which the PDLC film transitions from opaque to transparent and vice versa is determined by the properties of the liquid crystal molecules and the applied voltage. When a voltage is applied, the electric field aligns the liquid crystal molecules, which requires energy. The time it takes for the liquid crystal molecules to reorient themselves and return to their original state when the voltage is removed is known as the relaxation time. The relaxation time is determined by the viscosity of the liquid crystal and the strength of the electric field applied. Further working of the polymer is beyond the scope of this project.

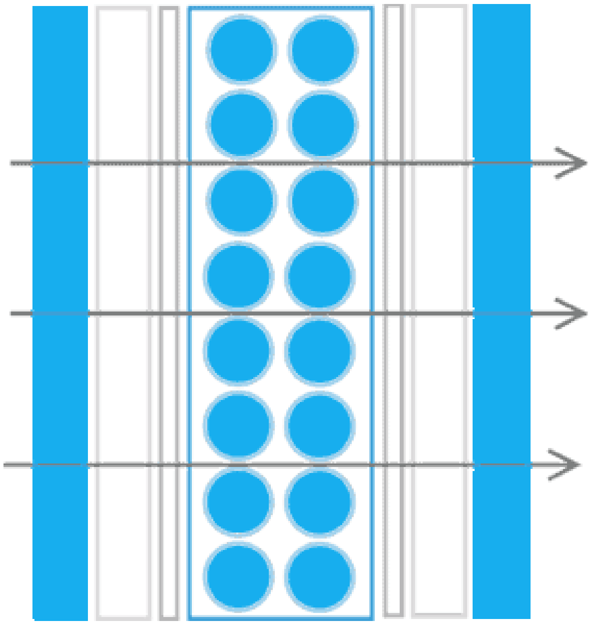


Figure 1: ON State

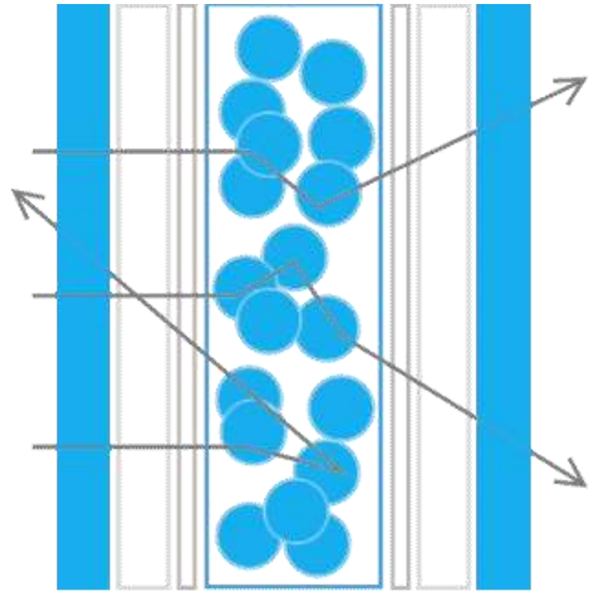


Figure 2: OFF State

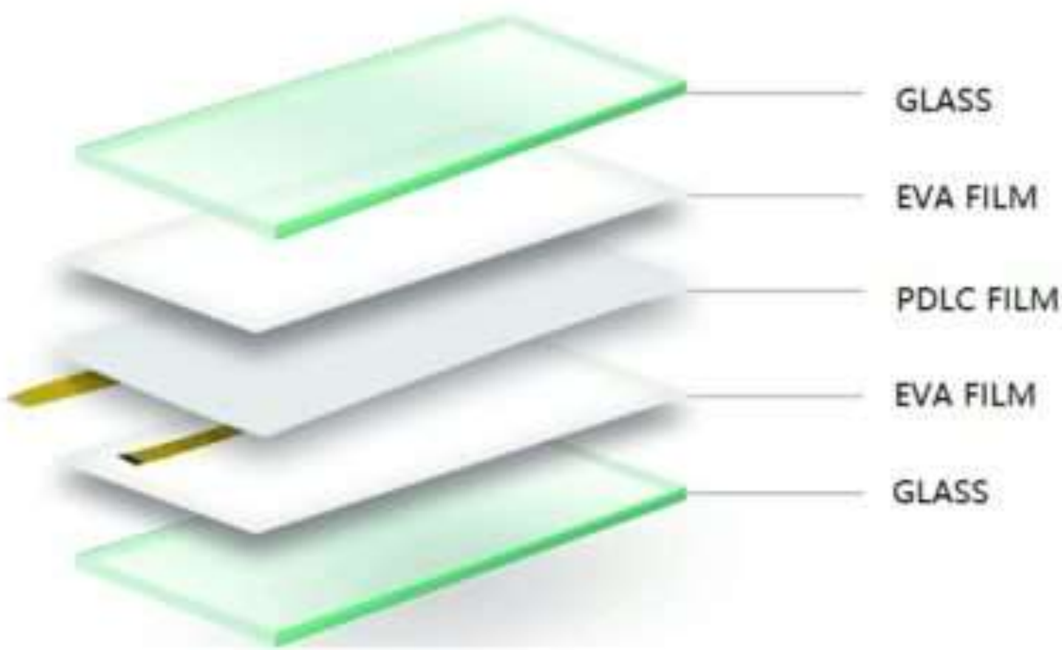
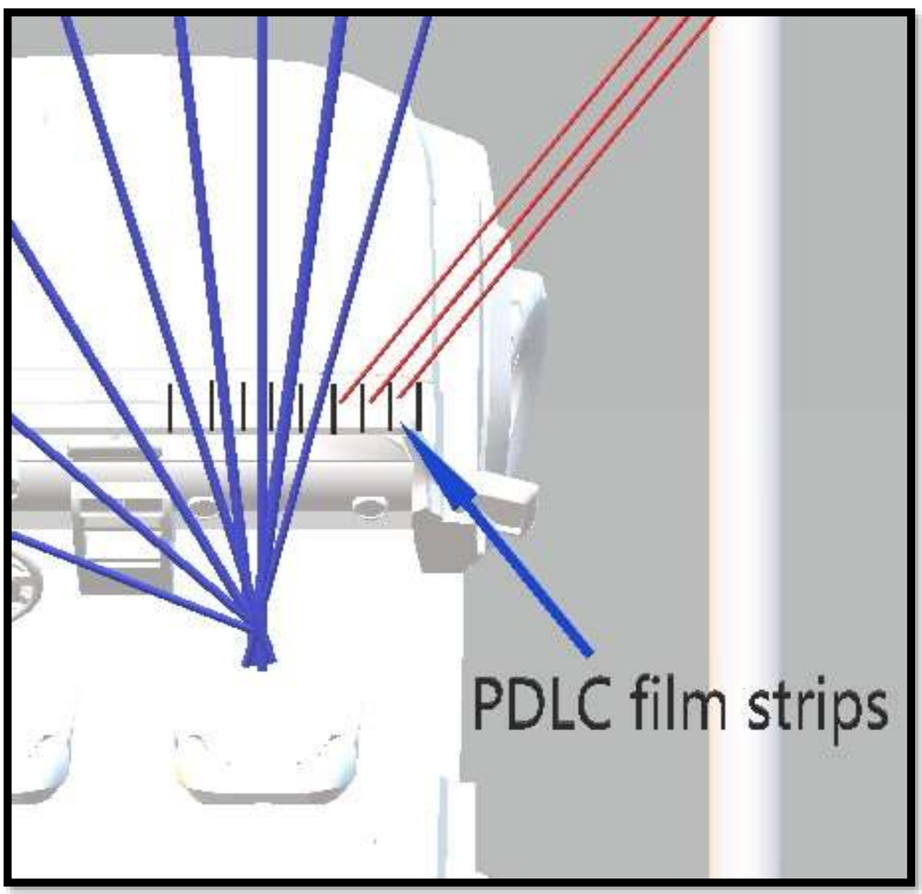
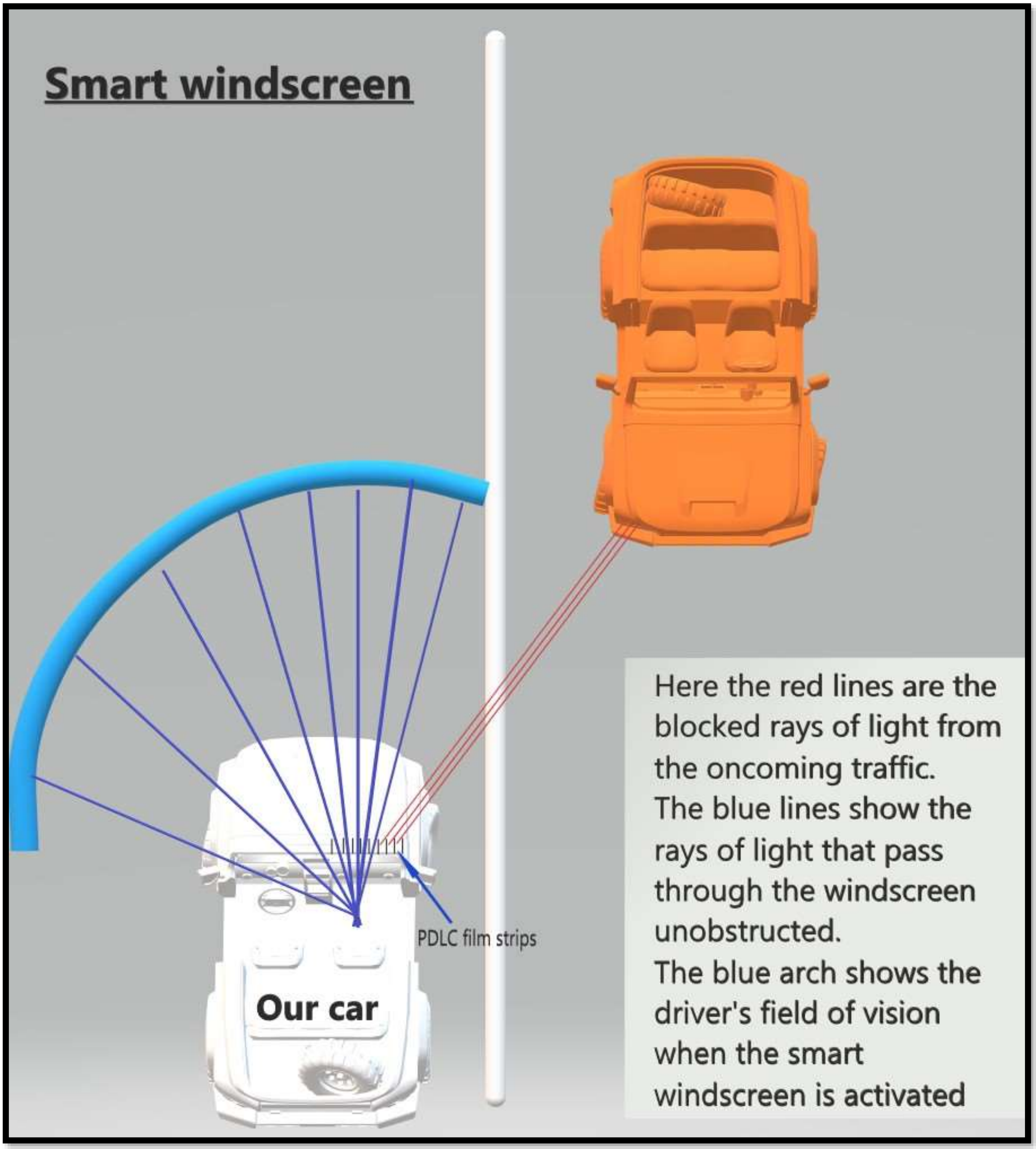


Figure 3: Smart glass layers

Working of Smart Windscreen

Strips of PDLC film are mounted perpendicularly on the windscreen (as shown in the figure below). The system can be controlled manually or automatically. In manual mode, they can be toggled on/off by a push switch (*that remains on as long as the user pushes it*) near the steering wheel. Usually, the strips will remain turned on and transparent. When the bright lights bother the driver, he can easily turn off the strips, effectively reducing the intensity of the light from the oncoming traffic without affecting his vision of the road in front of him. The bright light from the vehicle will be reduced by around 35%. After the vehicle passes through, he can just as easily turn on the strips again by releasing the lever and thus make the whole windscreen transparent. The limiting angle depends on the width of the films and the spacing between them. The figure below shows a highly magnified view of the strips on the windscreen.




Smart windscreen
PDLC film strips
Our car
Here the red lines are the blocked rays of light from the oncoming traffic.
The blue lines show the rays of light that pass through the windscreen unobstructed.
The blue arch shows the driver's field of vision when the smart windscreen is activated

Construction

Ideal dimensions

To limit light from the right side to an angle of 10 degrees, the strips will have to be 2 mm wide with 0.35 mm of spacing between them. They will run from the top of the windscreen to the middle (so that the middle line of the road is always visible, whether the strips are on or off). The strips will have a thickness of a few micrometers.

The limiting angle to the driver's right, when the strip is opaque, should be around 5 - 10 degrees. The angle can be varied by; i)increasing the width of the strips, ii)decreasing the spacing between them, iii) tilting the strips by a constant angle to the left, iv) or a combination of all three.

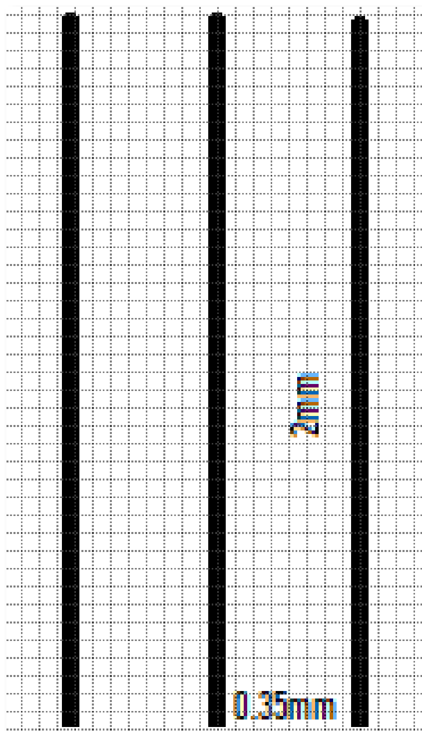


Figure 4:DImensions

Prototype

As proof of concept, a small working model was designed. For this, we bought two square feet of PDLC film. After testing the whole film, several 15cm × 3cm strips were cut out and tested separately. The specifications of the film are provided below.

Table 1: Film specifications

Specifications	Value
Thickness	0.4mm
Operating voltage	110v
Light transmittance (ON mode)	84%
Light transmittance (OFF mode)	4%
Haze	4%
Response time	<10ms
Power consumption	$5W/m^2/hr$

Materials used

The materials used for creating the prototype are listed below;

- Two square feet of PDLC film sheet
- Copper adhesive tape
- Connecting wires
- 220 – 110 Voltage converter
- Multimeter
- Scissors, Cutting blade
- Wire stripper
- Mini clips
- Box frame
- Water container

Methodology

The PDLC film was obtained from EdgeGlaze manufacturers, Bangalore. The film was connected to a 220 – 110 volt converter and tested on arrival. The product worked fine, turning transparent when the voltage was turned on. Then the product was cut into strips of 15cm × 3 cm using a cutting blade. Care was taken to ensure that the product did not bend or deform while altering as bends would break the connection between the two conducting layers of the film. Next, the protection layers were removed as they would reduce vision when bright light was pointed at the film, adding to the glare.

Figure 6: Sheet of PDLC film

Figure 5: Strips of PDLC film

The film contains five layers primarily; the Polymer dispersed crystal sandwiched between two layers of conducting ITO film and a layer of protective film on both sides.

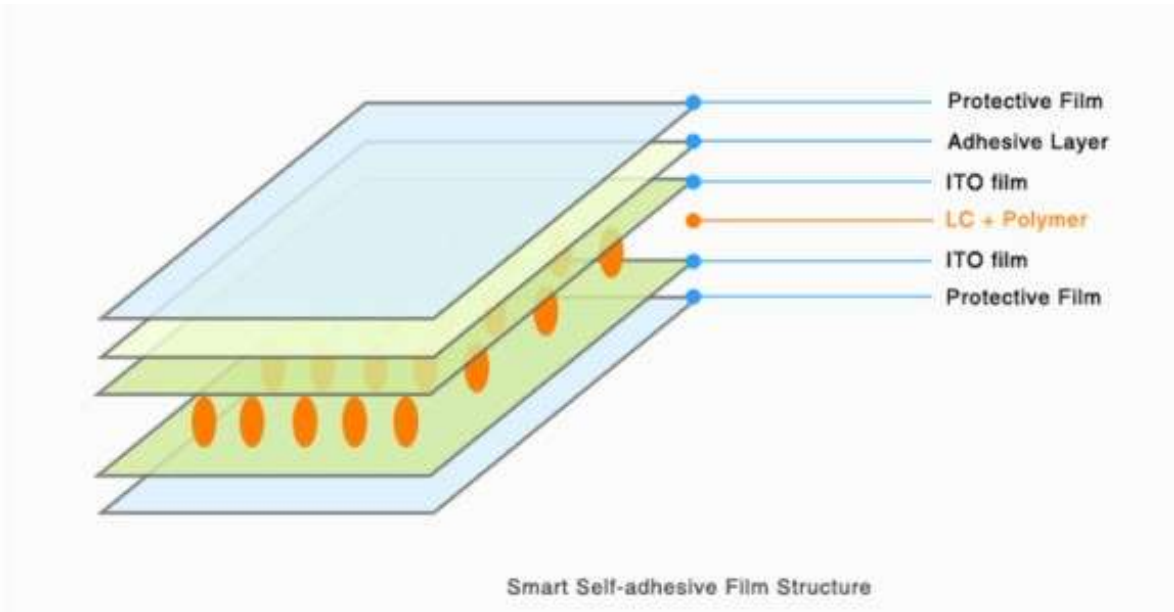


Figure 7: Layers of PDLC film

Once the protective layers were peeled off, we proceeded to make the connections. The positive terminal must be connected to the inside of one of the ITO films and the negative to the inside of the other. For this, the film was carefully opened up and opposite layers were sliced off at the top and bottom of the film. Connecting wires were connected to the sliced area and wrapped with adhesive copper film to ensure uniform connection. We designed it such that all positive terminals would come at the top of the film and all negative ones at the bottom. However, it was found that ensuring uniform connection across the width of the film was nearly impossible with our limited resources. To tackle this, all positive terminals were immersed in a container containing water to ensure uniform conductivity. The negative terminals were connected using connection wires. Mini clips were used to secure the wires in place and more importantly, to provide enough pressure on the film to ensure conduction.

Next, a frame was required to place the strips vertically. For this, a paper box was used. The dimensions of the strips were marked on the box and wedges were cut into the box along the marks made. For the prototype, we decided to go for a zero-angle tilt for the film strips, which made the construction simpler at the cost of effectiveness. The spacing between the strips was 1.5cm resulting in an effective blocking of rays incident at an angle greater than 23 degrees. The strips were inserted into the wedges in the frame.

Figure 8: Frame

Working model

A working model was developed according to the methodology given above. An image of the working model is provided below.

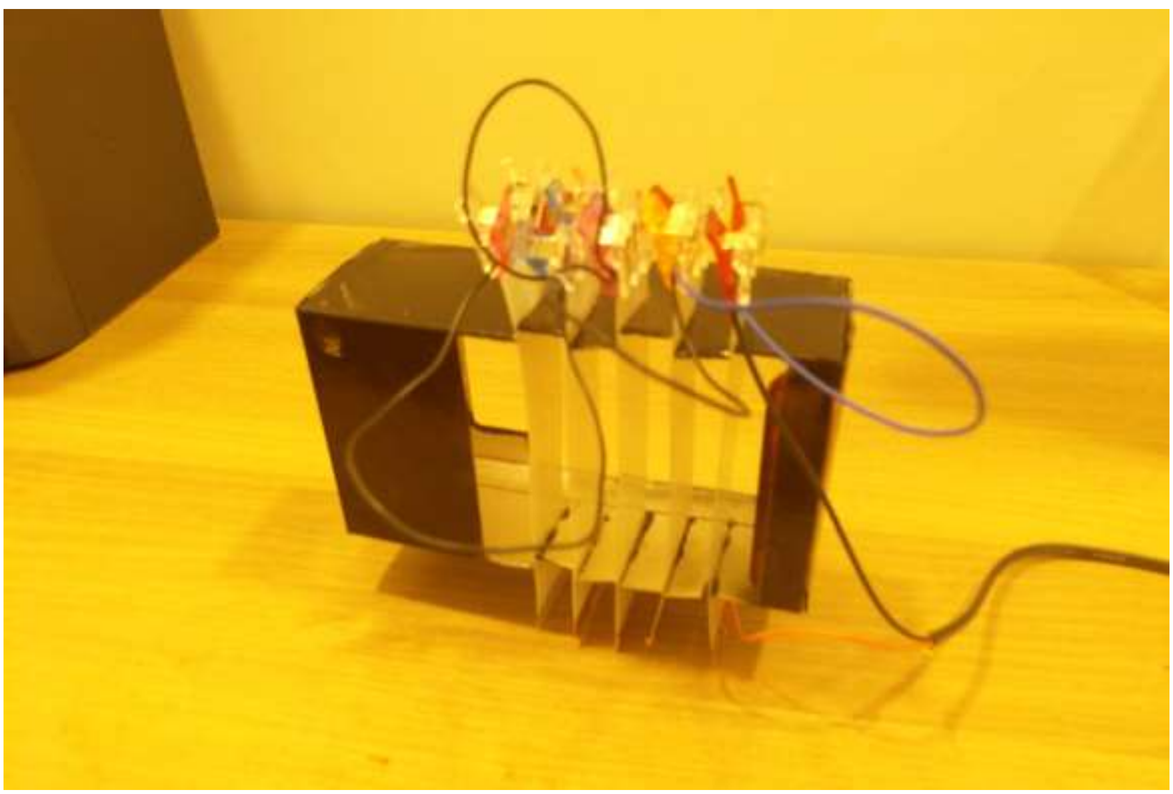


Figure 9:Working model

Limitations

Though Smart Windscreens would be a blessing to every night driver, it comes with its limitations.

- Firstly, the small size. The strips used in this technology must be millimeters wide and the distance between the strips must be in micrometers. This was difficult to construct with our limited resources.
- The light transmittance when the film is powered on must be increased to close to 100%. Reduction in light transmittance will drastically affect driving safety. Though films with higher light transmittance were available in the market, they were too costly to afford.
- The technology is not fail-safe, i.e., if the power supply to the windscreen fails, the windscreen will be semi-opaque, negatively affecting driver safety. Installation of auxiliary power sources would add to the cost. This could be rectified if materials that turn transparent when the supply is removed were deployed. Though such technology exists presently, they perform poorly in other factors such as transparency and switching speed
- When the car is off, the windshield will be opaque on the driving side, which could be an aesthetic compromise

Alternative technologies

There exist a few alternate technologies to Polymer Dispersed Liquid Crystals. Though they offer better performance on some factors, they fail to work well enough in certain others.

- **Suspended Particle Devices** (SPDs) are a type of smart glass technology that can switch from transparent to opaque when an electric current is applied. SPDs consist of a thin layer of particles suspended in a liquid or gel, sandwiched between two layers of conductive material. When a voltage is applied across the conductive layers, the particles align themselves to form a dark layer that blocks light and makes the glass opaque. When the voltage is removed, the particles return to their random orientation, allowing light to pass through the glass and making it transparent again.
- **Electrochromic glass** is a type of smart glass that can change its color or opacity in response to an electrical voltage. It consists of a thin layer of electrochromic material sandwiched between two conductive layers, with a transparent substrate on one side and a reflective coating on the other. When an electrical voltage is applied, ions from the electrochromic layer migrate to the adjacent conductive layer, causing a change in the color or opacity of the glass.

Conclusion

Bright headlamps from the oncoming traffic are a curse for every night driver, especially in India where most semi-urban roads do not have sufficient lighting or medians to block light from the other side of traffic. Hence, the market for this technology is huge as every night driver experiences this problem. Thus, the potential customers would amount to 111 million four-wheeler owners in India. Bringing out such a product would require some initial investment in research and development but if done, this will be a blessing to every night driver who has experienced this pain. The approximate cost of one square foot of PDLC film in the market today is 1500rs (retail cost). But considerable sums will be required for product development. Fabrication and equipment usage charges would be the areas that require more expenditure. Our model is a prototype to illustrate how it would work in the real world.

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