SkyLight Glass

Keep It Glassy ™

Group #13

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Project Narrative

One of the leading causes of high energy usage in houses is energy inefficient windows. Letting uncontrolled sunlight through heats the house causing the homeowner's air conditioning unit to expend more energy to keep the house cool. To keep houses cooler and more energy efficient, the direct sunlight needs to be blocked off.

Most windows use blinds and curtains to prevent unwanted sunlight. Blinds and curtains collect dust, are difficult to open, and often break. Additionally the blinds themselves heat up and since they are inside the house warm the surrounding area. A better method is to create a barrier that prevents most direct sunlight from entering the house while still allowing indirect sunlight to enter through windows that are not in contact with direct sunlight. Rooms with Smart Film have measurably lower temperatures compared to rooms that use traditional means of blocking out sunlight.

Blocking out the light creates another problem: the lighting in the house is obstructed. When the window becomes opaque, the light level within the room needs to adjust to compensate for the loss of natural light. This can be achieved through artificial lighting. Natural light in the room also affects the development of melatonin which helps regulate sleep cycles. To ensure the homeowner’s quality of sleep is not impacted by the artificial lighting in the room, certain hues in the light must be removed. Considerations must also be made for homeowners that sleep during the day, allowing them to adjust light levels according to their sleep habits.

Multiple products already exist that use Smart Film technology in order to provide energy savings to homes and businesses as well as added privacy. Many of these products react to time of day instead of direct light impingement resulting in the entire building having reduced natural light levels. There are also films that may be applied to preexisting windows that rely upon solar energy to transition from transparent to translucent states. There are two types of Smart Film material: active and passive. Active Smart Film responds to user-provided stimuli (such as electric current) while passive Smart Film relies upon environmental stimuli (such as heat and UV radiation).

Many of the aforementioned products often do not offer the ability to adjust light levels in the room the window is attached to in response to reduced light levels entering through the windows. As the windows darken, internal light sources are required for homeowners to compensate for the lack of natural light. The homeowner must do this manually because existing products surveyed do not tie the window’s transmissivity to interior lighting levels. The hue of the interior lights is also not tied to time of day resulting in light levels that are not conducive to melatonin production that aids in regulating sleep cycles.

Most Smart Film products have low power draw but also do not have to provide illumination of the interior room as described above. Any prototype that incorporated both of these features would have to be designed to operate on low power levels to maintain the cost savings from the reduced energy bills.

Project Goals and Objectives

The objective of this project is to develop a prototype window and lighting system that adjusts based on sunlight intensity and time of day to modify the transmissivity of the window. The prototype shall also adjust light levels and hues within the room the window resides in. To accomplish this, a smart window will be developed which adjusts light levels according to the environment and user inputs.

The smart window will be easy to set up and use. While a marketed product based on this technology would fit in a standard sized residential window, the prototype will be smaller scale for demonstration and cost purposes. The window will block most visible light when activated and will function within the normal range of temperatures for Central Florida. The LEDs shall automatically adjust their hues based on time of day to incorporate a range varying from warm to cool color temperatures. On top of adjusting their hue, the LEDs shall be able to illuminate a small bedroom. All light features of the prototype system may be manually adjusted by the user.

The goal of this project is to develop a prototype smart window that may be implemented throughout a homeowner’s entire house that can detect and adjust window opacity based on light levels in order to increase energy efficiency of cooling systems inside the house to save money. The concept is that windows that are receiving direct sunlight will respond by turning translucent, blocking most heat and UV radiation that would pass through normally while other windows in the house that are not receiving direct sunlight will remain open to help increase natural light levels.

A software interface will be developed that allows the user to override the passive response to sunlight in order to keep a window open or closed and modify the hue of the LEDs as well as their intensity. In instances where the user does not have access to the software interface, a manual keypad will be integrated with the prototype.

Requirements

Identified requirements for SkyLight Glass are identified in Table 1.

Marketing Requirements	Engineering Requirements	Justification
6, 7	Window dimensions: The window shall fit a frame of dimensions 12 inches wide and 12 inches tall.	Based on size needed for a demonstration prototype.
4	Visible light transmission: When active, system shall block at least 70% of visible light.	Based on existing smart window technology and material which can block at least this much.
2, 7	LED illumination: LEDs shall be capable of illuminating a 10 foot by 10 foot room.	Based on the size of a small bedroom; shall be in accordance with OSHA (Occupational Safety and Health Administration) standards for illumination.
3, 5, 7	LED hue: LED color temperature shall be capable of varying color temperature between 3000 Kelvin (reddish orange light) and 5000 Kelvin (blueish white).	In order for a human to produce melatonin for sleep, omitting blue hues from lights is beneficial. Range given is from lights with minimal blue components to light that is more similar to natural light.
1, 3, 5	System control: The window transmissivity, LED intensity, and LED hue shall be controllable by the user to match preferences within specifications listed.	Based on the need of the user to adjust light levels according to an individual's needs.
Marketing Requirements 1. The LEDs must be dimmable. 2. The LED at full power must be able to illuminate a small room. 3. The LED hue range (color temperature) should range from warm to cool colors. 4. The window must be able to block most light from outside. 5. System controls must be easy to use. 6. The system should be easy to install. 7. The system should have low cost.		

Table 1. Requirements

Engineering-Marketing Trade Off

Table 2 indicates the marketing requirements (y-axis) and how they relate to the engineering requirements (x-axis) and details the relative importance of each to help facilitate trade-offs and design.

Legend

→Marketing (Customer) Requirements

→Engineering Requirements

→Correlation Matrix

↑ = Positive correlation ↑↑ = Strong positive correlation

\+ = Positive polarity - = Negative Polarity

↓ = Negative correlation ↓↓ = Strong negative correlation

		Tinting Efficiency	Cost	Installation time	Dimensions	Power Consumption	Luminous Flux
		+	-	-	-	-	+
Lighting Illumination (LEDs)	+		↑			↑	↑↑
Effective Tinting Material	+	↑↑	↑			↓	
Dimming (LEDs)	+		↓			↑	↑↑
Hue Range	+		↑			↑	↑
System Control	+	↑	↑				
Installation Ease	+		↓	↓↓	↓		
Cost (Yearly)	-		↑↑	↑	↑↑	↑↑	
Targets for Engineering Requirements		≥ 70%	< $1000	< 1 day	12 x 12 Inches	≅ 20 - 50 W (avg.)	≅ 1000-2000 lumens

Table 2. House of Quality

Some of the polarities are negative. For example, the cost has a negative polarity indicating that, as cost of the item goes down, the desirability of the product goes up. For tinting, as the ability of the glass to block light goes up, the desirability of the product increases.

Block Diagram of System and Work Distribution

As part of the initial design process, the team identified the major components of the final product. Each component was assigned to a team member based on that team member's proficiency as indicated in Figure 1.

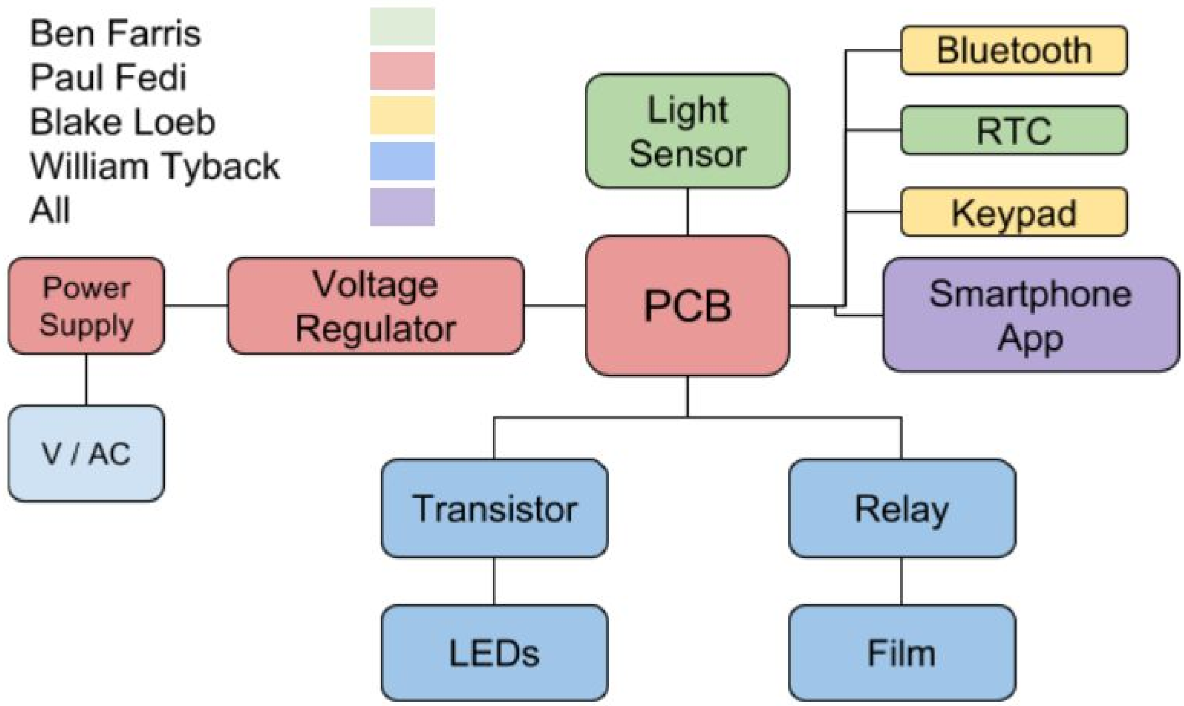

Fig 1. Block Diagram

Concept drawings of the final product are included in Figures 2 and 3. Figure 2 provides a concept drawing of the overall system from the outside and the lights as seen from inside the house. Figure 3 illustrates the control application for the window that will be provided to the user. The drawings are concept only and do not necessarily reflect the final product's design.

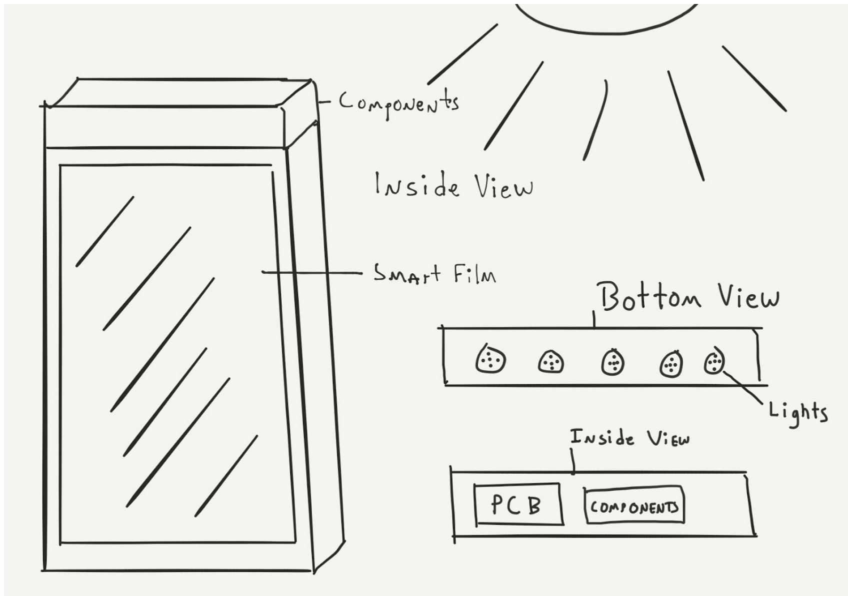

Fig 2. Concept Window

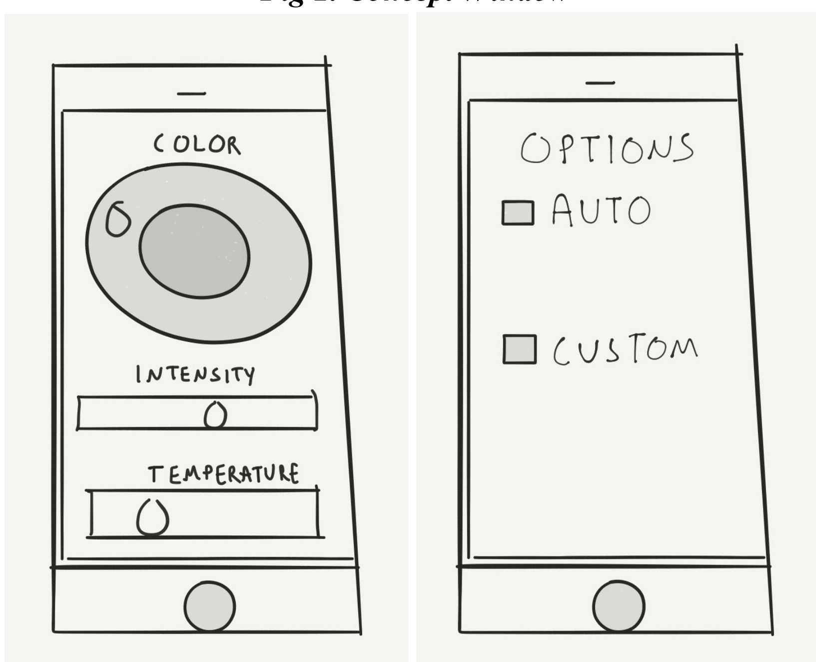

Fig 3. User Interface Concept

Table 3 is a breakdown of the expected materials to develop the SkyLight Glass system and their estimated prices. As the team enters the detailed design phase, price estimates will be updated and incorporated into the budget.

Item	Price	Quantity	Total
Window Film	$75	1	$75
Color Temperature LED Strip	$50	1	$50
Microcontroller Chip	$1	1	$1
Voltage Regulator for LED	$1.5	1	$1.5
Relay for controlling film	$30	1	$30
Voltage Regulator for Chip	$1.5	1	$1.5
Power Supply	$0	1	$0
Lux sensor	$6	1	$6
Bluetooth Module	$10	1	$10
Keypad	$5	1	$5
RTC unit	$20	1	$20
Polycarbonate “window”	$10	1	
Wood for window frame	$5	1	
PCB related costs	$100	1	
TOTAL			$315

Table 3. Estimated Budget

The SkyLight Glass project will take place over a period of seven months (January to July 2017). Project milestones and initial schedule to meet the goals within the period of performance are detailed in Table 4.

Class	Topic	Item	Deadline	People
Senior Design 1	Tangibles	Form Group	Jan 12	Group 13
Senior Design 1	Tangibles	Initial Document	Feb 3	Group 13
Senior Design 1	Tangibles	Update Initial Document	Feb 17	Group 13
Senior Design 1	Tangibles	Table of Contents	Mar 24	Group 13
Senior Design 1	Tangibles	Final Document	Apr 27	Group 13
Senior Design 1	Research/Design	Power Supply/Control	TBD	Blake
Senior Design 1	Research/Design	Wireless Communications	TBD	Ben
Senior Design 1	Research/Design	Smart Film and LEDs	TBD	Paul
Senior Design 1	Research/Design	Chips and ICs	TBD	William
Senior Design 1	Construction	Order Parts	Apr 27	Group 13
Senior Design 2	Construction	Prototype Film/LEDs	TBD	Blake
Senior Design 2	Construction	Prototype PhotoSensor/RTC	TBD	William
Senior Design 2	Construction	Prototype Bluetooth/Keypad	TBD	Ben
Senior Design 2	Construction	PCB design & manufacture	TBD	Paul
Senior Design 2	Construction	Final Manufacture	TBD	Group 13
Senior Design 2	Construction	Final Presentation	TBD	Group 13

Table 4. Project Milestones