DIVERGING PHASE 2

Way to make the LED not feelable for the skin:

1. **Change LED**
    a. **Use a thinner LED chip (from LTV):** The thickness of the LED chip may be causing it to protrude and touch the skin. Using a thinner LED chip may help alleviate this issue.

b. **Use a softer, more flexible LED material:** Another solution could be to use a softer, more flexible LED material that will mold to the contours of the arm and not poke or prod the skin. Soft, flexible LEDs are becoming increasingly available on the market, so this may be a viable option.

c. **Use chip on board (COB) LEDs:** COB LEDs are a type of LED where multiple LED chips are mounted directly onto a substrate and covered with a layer of phosphor. This creates a uniform and diffuse light source that is more comfortable and less glaring than individual LED chips. COB LEDs also have a smaller amount of welding points, which lowers the rate of failure.

   https://www.digikey.com/en/articles/the-basics-of-chip-on-board-cob-leds

2. **Place Deeper**

   a. **Embed the LED chips deeper into the sleeve:** Easiest solution could be to embed the LED bulbs deeper into the sleeve's layers. This will require redesigning the layers to make sure that the LED bulbs are flush with the surface of the sleeve's interior.

   b. **Create a recessed area for each LED chip:** One possible solution is to redesign the sleeve to create a recessed area for the LED chips. By creating a slightly sunken area in the sleeve, the LED chips will be flush with the surface of the sleeve and will not protrude out, making them non-feelable.

3. **Add layer:**

   a. **Apply a coating on the LED chip:** Applying a thin layer of a soft and flexible material such as silicone or rubber over the LED chip can help to reduce the discomfort caused by the protrusion. This layer can be customized to blend in with the color of the sleeve or made to be more visually appealing.

   b. **Add a layer of padding:** Another solution is to add a thin layer of padding between the LED chips and the skin. This can be done by adding an extra layer of fabric or foam in between the sort fabric and LED chip layer to provide cushioning for the skin.

4. **Modify the sort fabric layer to create a cushioning effect:** The sort fabric layer could be redesigned to have a slight cushioning effect, which would

help to alleviate any discomfort caused by the LED bulbs. This could be achieved by using a slightly thicker or softer fabric or by adding a thin layer of padding between the sort fabric layer and the LED bulb layer.

5. **Design the sleeve to have an adjustable fit:** If the sleeve is too tight, it will put pressure on the LED bulbs, causing them to protrude and poke into the skin. Designing the sleeve to have an adjustable fit will ensure that the sleeve can be worn comfortably and securely without the LED bulbs causing discomfort.

How to make the fabric wires thinner:

1. **Rotary cutter:** A rotary cutter is a tool that has a circular blade that can cut through multiple layers of fabric with precision and ease.

How to Cut Fabric (with Pictures) - wikiHow

2. **Thread-pulling technique:** This involves finding a thread along the edge of your fabric, about 1 inch (2.5 cm) from where you want to cut, and pulling it out. This will create a thin line on your fabric that you can use as a guide for cutting. You can repeat this step for the other side of your fabric wire, and then use scissors or a knife to cut along the lines. This technique works best for woven fabrics, like cottons and linens.

   How to Work With Conductive Fabric : 19 Steps (with Pictures) - Instructables

3. **Use a hot knife:** A hot knife is a tool that heats up to melt the fabric as it cuts through it, creating a clean and precise cut. This tool is often used for cutting synthetic fabrics, and is available in different sizes.

Manufacturing:

1. Laser cutting: Use a laser cutter to cut the conductive fabric wires. Laser cutting produces precise cuts and allows for smaller widths than traditional scissor cutting.
2. CNC cutting: Another option is to use a CNC (Computer Numerical Control) machine to cut the conductive fabric wires. This method allows for precise cuts and can achieve smaller widths than scissor cutting.
3. Rotary cutting: using a rotary cutter, which is a cutting tool with a circular blade that rolls over the fabric to cut it. This method can produce straighter cuts than scissors and can achieve smaller widths than 6mm.
4. Heat cutting: Heat cutting involves using a heated blade to cut the conductive fabric wires. This method seals the edges of the fabric as it cuts, preventing fraying and creating a clean edge. It can achieve widths as small as 1mm.
5. Ultrasonic cutting: Ultrasonic cutting uses high-frequency sound waves to cut through materials. This method can produce precise cuts and can achieve widths as small as 1mm.

Cutting Conductive Fabric

Scissors and Blades

Some materials will be easier to cut than others, ones can feel very soft and can not be discerned from regular fabric. Others feel stiff and are heavily coated with bonding agents and metal. Scissors may become dull quicker if they are being used to cut conductive fabric frequently. There are some knits, that are created with very thin metal wire. For these, "fabric only" scissors that are owned or that can be found in a sewing studio should probably not be used. The thin wires may create tiny notches in the blades, along with dulling them quickly.

Pros

- most accessible
- quick and more collaborative (everyone can use a pair at once) when prototyping

Cons

- scissors may dull quicker
- slower process than other options
- harder to create and duplicate intricate designs
- thin wires may create tiny notches in the blades

CNC Cutting

There are large CNC cutters found in labs and some that can be bought for the home. A favorite of mine is the Silhouette Cameo, which is a table top CNC cutter that can cut fabric up to 12 inches wide and 10 feet long. Silhouette has software that can trace an image, e.g. one created in Illustrator or Photoshop, then cut it. **Check out my** CNC Conductive Fabric Circuit **'ible for more details**.

There are **large flatbed CNC cutters** can be found in some prototyping and production labs, they are an expensive piece of machinery that is usually contained in the garment business. If you have access to one, you are lucky! They can cut up to 60 inch wide fabric and whole rolls containing yards of fabric.

In larger and collaborative labs, what can be more commonly found are **vinyl cutters** and **printer/cutter combinations**. I do not have personal experience with these, but you can purchase canvas and fabric materials to cut on some these machines, so they can probably be loaded with custom material with the proper load settings and perhaps additional backing.

Pros

- can make intricate and measurement specific designs
- one design can be reproduced quickly
- cuts materials that laser cutters can not, such as iron-on fabric
- no scorch marks! Which a laser cutter will produce

Cons

- not as accessible and can be expensive, the table top ones are worth the investment if you do a lot of soft circuits!

Laser Cutting

This method comes with a safety warning. Only cut material that is approved by the laser cutter's manufacturer and read the Safety Data Sheet (SDS) of whatever material is in question. Some materials can release poisonous gases and can combust when hit with a laser. Reflective materials can also damage the lens of the laser cutter, which conductive fabric contains. Find out the fiber content (e.g. nylon, polyester, etc.) and the percentage of metal and which ones are present in the fabric you want to laser, the SDS should contain this. If no one has tested it before on the laser you are about to use, email the laser's manufacturer and ask if it will be appropriate.

Pros

- can make intricate and measurement specific designs
- one design can be reproduced quickly
- if the fabric contains a little polyester or another synthetic fiber that melts, the edges will melt slightly as it's being cut and will not fray when handled

Cons

- heat can produce scorch marks on the fabric, use a mask when possible to prevent from happening
- hot-melt (iron-on) adhesives can produce toxic gases and get messy under the heat of the laser, so iron-on fabrics are not doable

How to make conductive fabric by ourselves

1. **Use conductive thread:** One way to make your own conductive stretchable fabric is to use conductive thread. You can use a regular fabric that has some stretch to it and sew it with conductive thread in a zigzag pattern. This will create a stretchable circuit that can be used in your LED sport sleeve. Keep in mind that conductive thread can be expensive, so you will need to budget accordingly.

2. **Use conductive paint:** Another way to make your own conductive stretchable fabric is to use conductive paint. You can apply conductive paint onto a regular stretchable fabric using a brush or roller. Once it dries, it will create a conductive surface that can be used as a circuit in your LED sport sleeve. Keep in mind that conductive paint can be messy and time-consuming to work with.
3. **Use conductive fabric tape:** Conductive fabric tape is a type of adhesive tape that has conductive properties. You can use this tape to create a circuit on a regular stretchable fabric by cutting the tape into strips and sticking it onto the fabric in a zigzag pattern. This will create a stretchable circuit that can be used in your LED sport sleeve. Keep in mind that conductive fabric tape can also be expensive.
4. **Use conductive glue:** Conductive glue is a type of adhesive that has conductive properties. You can use this glue to create a circuit on a regular stretchable fabric by applying the glue onto the fabric in a zigzag pattern. Once it dries, it will create a stretchable circuit that can be used in your LED sport sleeve. Keep in mind that conductive glue can be messy and time-consuming to work with.
5. **Use commercial knitted cloth and polydopamine (PDA):** PDA is a polymer that can adhere to various surfaces and form a thin layer of coating. You can dip a piece of knitted cloth into a solution of dopamine and water, and then heat it in an oven for a few minutes. This will create a PDA layer on the surface of the cloth that can conduct electricity. You can also add some silver nanowires (AgNWs) to the solution to enhance the conductivity and durability of the fabric.
6. **Use spandex fabric and carbon nanotubes (CNTs):** CNTs are cylindrical molecules of carbon that have excellent electrical and mechanical properties. You can mix some CNTs with ethanol and water to make a dispersion, and then spray it onto a piece of spandex fabric using an airbrush or a spray bottle. Let the fabric dry completely, and then test its conductivity with a multimeter or a LED. You can repeat the process until you get the desired level of conductivity.