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# Pattern Changing Clothing

April 17

# 2013



**Author – Yong hwan Kwon**  
Degree – Master of Fine Arts  
Program – Industrial Design  
Rochester Institute of Technology  
College of Imaging Arts & Sciences

Pattern Changing Clothing by yong hwan Kwon

## **Approvals**

**Stan Rickel**, Chief Advisor & Committee Member

Associate Professor, Graduate Program Chair, Industrial Design

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**Marla K Schweppe**, Associate Advisor & Committee Member

Professor, Computer Graphic Design

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

**W. Michelle Harris**, Associate Advisor & Committee Member

Associate Professor, Interactive Game & Media

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

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## **Abstract**

People's styles and characters are changed by their environment and their relationship throughout their lifetime. However, the garment that we wear has just one look without accessories because once we wear clothing its appearance doesn't change, even though it is an essential medium to express ourselves. This thesis project's main goal is to make a piece of responsive clothing and to provide users the pleasure of creating their own style.

When the clothing is an active medium through interactive communication between a wearer and a garment, it will be a responsive living object for a user. By the use of the developing display technology of E ink, which is thin, rugged, flexible, and segmented, a wearer can change various styles that he/she wants anytime and anyplace. When this E ink clothing displays different pattern, users will be able to make various styles with just one garment. In addition, Pattern Changing Clothing will help wearers enjoy expressing their individuality through the activity of changing or creating styles and patterns as individual customization.

## 01 Introduction

Fashion is something we deal with every day; we are all faced with it every morning. Most people are not entirely comfortable with fashion trends and most wearers are not active customers but passive followers in that they merely buy and wear mass produced clothing. However, fashion is one of the most expressive and creative ways of showing one's personality to others. As an industrial designer, I would like to design a functional garment that can play a role as a fashionable wear as well as a wearable computer.

"Fashion is a big deal. The global apparel accessories and luxury goods market generated total revenues of \$1,334.1 billion in 2008."<sup>1</sup> Also, by collaborating with various areas, the fashion industry has been broadening the scope of the field and it increasingly affects our life-styles enormously. Now is the time for innovating enhanced clothes. We can wear them not only for protecting our body but we can also find delight in wearing them.

For this thesis project, general topic is fashioning technology. Developing customizable wear as a product will be the focus. Designing custom clothing is so important in that a piece of clothing hardly changes itself. There are a lot of wearable computer concepts already but current futuristic fashion is emphasizing more electronic functions than basic functions of clothes such as aesthetics. At this point, we should think what new technologies customers want on a piece of clothing. We can design fabulous clothing not as digital wear, but as innovative clothing. The following research will concentrate more on finding ways of changing clothing's look, the change in trends for last 100 years, and fashioning technology.

What follows is the brief description of this thesis project

**Target:** The main target audience is for women in their 20s who are sensitive to trends in the year of 2060. Making clothing according to trends won't be easy for them. One of my design goals is for young women to be able to easily make their own fashion look. In doing so, I can make people feel closer to fashion as well as improve the interaction between wearers and clothing.

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<sup>1</sup> MarketLine, Consumer Goods: Global Industry Guide, March 2009, Datamonitor.



**Problem:** The irrational consumption of clothing is caused by customers' feeling that they don't like old-fashioned clothing anymore. For this reason, people buy more and more clothing. Mass production, which uses lots of natural resources, is related to this kind of consumer behavior. In addition, clothing from mass production isn't helpful to people to express their individuality since there are many similar clothes out there. Current clothing consists of the aspects of visuals and materials that exist when it is produced. It doesn't offer anything other than those things, such as the sense of sight and a tactile sense.

**Solution:** If a new and smart piece of clothing can be changed visually every day by users and it offers unusual visual aspects, consumers will be interested in the clothing. The interest in the clothing is able to satisfy them with the garment. Furthermore, by wearing it continuously, the product's life cycle can be increased.

Problem	solution
Irrational consumption of clothing	Providing continuous interaction between clothing and wearers to make wearers feel excitement of owning a new piece of clothing. Various styles can be displayed with a single piece of clothing.
Waste of natural resources/ Harm to nature	The garment can give users satisfaction for the long-term : New interest in a piece of clothing may extend product life cycle.
De-individuation	Designing an innovative product that can encourage a wearer to create his/ her own styles
Fewer responses between people and clothing	New and exciting interaction between users and clothes : Constant interaction between clothing and wearers by creating new fashion from one digital garment
The problem of Mass Customization	Individual customization offset disadvantages of mass customization

Table 1. Brief Summary – Problems and Solutions

## **02 Design Background**

In order to better understand what products might be fashionable in the future, I needed to know the general background of textile, fashion, and fashionable technology. Especially, since, I am not a fashion major, this research was necessary and helpful to develop concepts and ideas for this collaboration, which takes the form of fashion plus product design.

### **The History of Textile Technology**

The textile industry has been developing since human beings made clothes to protect their bodies. The trade of textiles from the Silk Road brought prosperity to much of the world. Industrial Revolution in the 18<sup>th</sup> century made mass production possible. After the revolution, women's advanced social status and increased recreation led to technological development in the textile industry. The appearance of functional fibers such as polyamide (nylon), polyester, and microfiber made the next generation of textiles possible.

Through studying technological innovation of textiles in the past, I was able to find the needs of textile technologies for each generation. In the 21<sup>st</sup> century, people are looking for new clothes with original textiles such as fiber optics fabric, light emitting fabric, and heat-reactive jackets. In addition, many fashion designers try to combine their fashion designs with wearable technology. An example is shirts that light up with LED ads or textiles with embedded temperature sensors. Athletic gear that changes color to show the intensity of an athlete's workout represents how to use recent technology in fashion industry. Wearable technology has enough potential to change the environment of the fashion industry.

A special material or textile is possibly able to change the style of a piece of clothing as well as its functionality but the variation of the look is limited to a few styles. Also, the development in textile is more focused on enhanced functionality than the style of clothing. Therefore, I shifted my focus to style, not to technological advancement in textiles.

## **The History of Modern Fashion**

In order to create an innovative garment, observing fashion trends by years is advantageous to consider colors, textures, and styles in the future. Specifically, if designers want to anticipate trends in the future, studying famous fashion designers' works chronologically is very useful.

Clothing more recently has been focused on a variety of patterns and colors and designers have emphasized individuality in clothing by adopting exquisite styles. Coco Chanel always emphasized the personality in women's clothing. She is quoted as saying, "I don't do fashion, I am fashion" and "In order to be irreplaceable one must always be different." This statement indicates that each wearer must be active in order to create their own styles and not to be fashion followers.

## **Fashionable technology**

Recently, the fashion industry has been looking for creative ways to go further in the future. Fashionable technology is increasingly developing innovations in fashion. From the beginning of this thesis, it was acknowledged that a wearable is a big picture means to develop a product. However, fashionable technology is not common sense to ordinary people, including me and most industrial designers. Therefore, it is necessary to study the meaning of fashionable technology and what has been done so far. From this study, I am looking both for inspirations for a new garment and innovative technologies in clothing. The following is the definition of fashionable technology:

"Fashionable technology refers to the intersection of design, fashion, science and technology... Fashionable wearables are 'designed' garments accessories or jewelry that combines aesthetics and style with functional technology. As designers of fashionable wearables, we view end users as fashionable beings who are attentive to style and powerful potential of wearable technologies. Our design philosophy is based on the notion that garments are the immediate interface to the environment and thus are a constant transmitter and receiver of emotions, experiences, and meaning."<sup>2</sup>

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<sup>2</sup> Sabine Seymour, *Fashionable Technology: The Intersection of Design, Fashion, Science, and Technology* {New York: Springer, 2008}, p.12.

Current clothing is always in an analogue state. That is why a wearer hardly expects changes in a garment physically or visually. However, advanced wearable technologies make clothing responsive anytime and anywhere. Fashionable technology can be an extensive medium to express personal emotions, experiences, and visual preferences.

Clothing played a critical role as the one of the most essential elements of human living. When fashion meets technology, the role of a garment can be more than merely covering or protecting a body but if a garment looks like a device, not clothing, most people would not be attracted to it. The wearable can be helpful to a user depending on what technologies can be used to create it. Therefore, wearable designers should think about technology as well as style. From this point of view, I am curious about the meaning of fashion in our society and direction of fashionable technology in the future.

According to Sabine Seymour, fashionable wearable is much more than fashion since it provides wearers with interactive interface plus fashion what we understand it as a style, dress, adornment, and clothing. Also, today wearables more pursue both style and comfort as a medium of self-expression than early wearables.<sup>3</sup>

When wearables are more focused merely on technology without fashionable senses, they will be exactly the same as early wearable computers. As Seymour mentions, if fashionable technology will concentrate on both technology and style, it can be an innovative medium of self-expression. The important thing is that the clothing is a supportive medium that does not outshine the wearers, and technology can give life to the clothing.

From the book, *Fashionable Technology* (2008), we know the definition of fashioning technology. The following research will show what kinds of technologies have been incorporated into fashion recently.

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<sup>3</sup> Sabine Seymour, *Fashionable Technology: The Intersection of Design, Fashion, Science, and Technology* {New York: Springer, 2008}, p.12, p.13.

Wearable technology is being used in various fields such as sports and medical care. When fashion meets technology like ubiquitous nature of tech, wearable becomes more than fashion along means of self-expression.<sup>4</sup>

Currently, many celebrities like Katy Perry, Rihanna, and the Black Eyed Peas use fashioning technology as a means of self-expression. Sometimes, they use the LED lights to show symbolic words or to show themselves as fashionable beings. These cases show that fashionable technology is not only a technological invention to improve the functionality of clothing, but also a fashionable piece of clothing. Maggie Orth and Kerri Wallace address the trend of wearable technology and its innovative direction in the future.

Maggie Orth, Founder and CEO of International Fashion Machines, takes the big view. She points out that wearables combine elements of soft and hard materials, traditional and modern technologies, and old and new aesthetics. And she argues that a wearable is “an extension of self.”

When textile designer Kerri Wallace discusses what she sees as a growing trend in the use of technologies in the fashion world, she uses words that evoke change and embedded intelligence. Wallace says that the tipping point occurred with, “the excitement of items and products being intelligent and moving this intelligence away from conventional predominately ‘hard’ products, with the possibility and potential to become ‘soft’, ‘flexible’ and ‘invisible.’” (Wilson, 2008)

If the technology that is applied to clothing is getting supple, more flexible, and even becoming invisible, designers will be able to design an advanced wearable with great style.

In the following cart, I summarize the relationship between fashion and technology. It shows what I believe are the crucial elements in fashionable technology.

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<sup>4</sup> Ashley Laurel Wilson, *Wearing Tech: Where Fashion Meets*, 2008,  
<[http://www.pcworld.com/article/150971/wearing\\_tech\\_where\\_fashion\\_meets\\_technology.html](http://www.pcworld.com/article/150971/wearing_tech_where_fashion_meets_technology.html)>

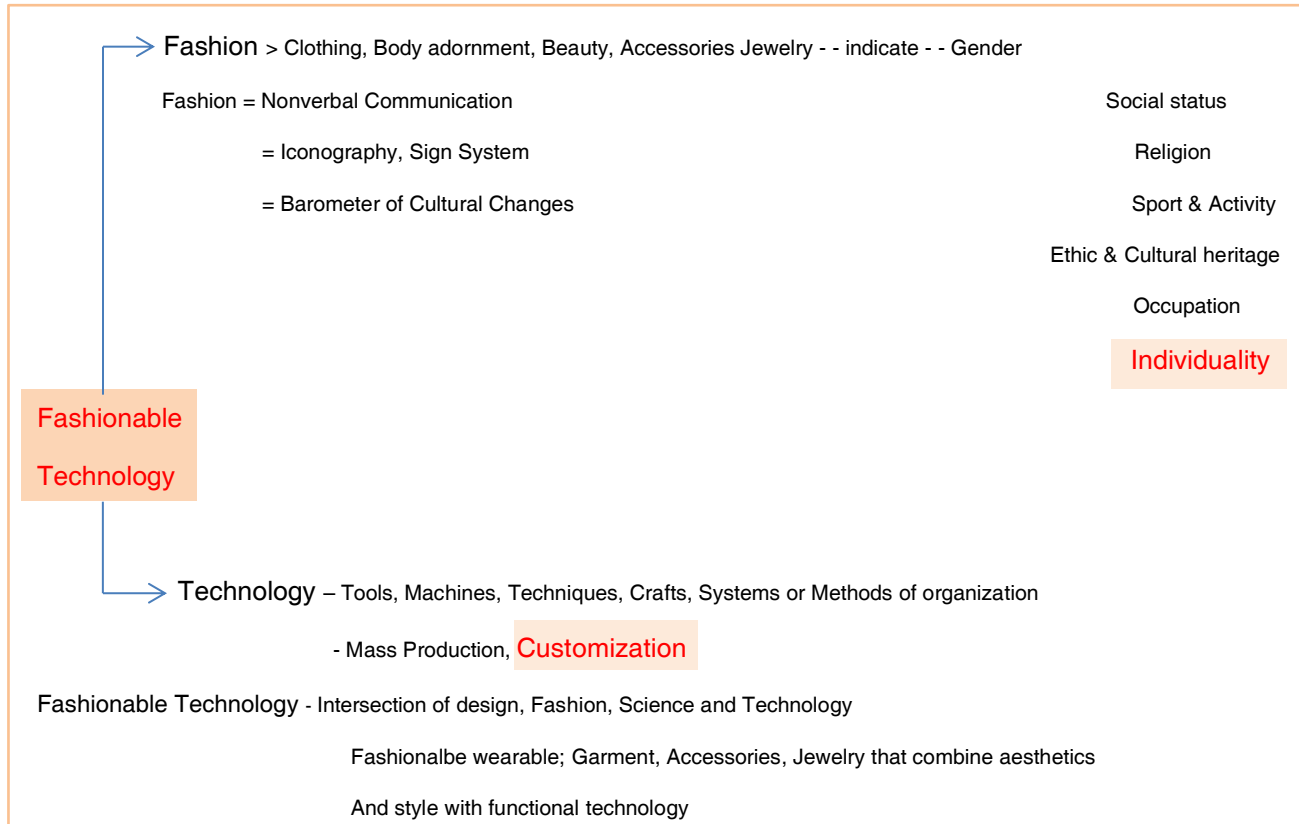


Fig.1. Fashioning Technology is Fashion plus Technology<sup>5</sup>

## Fashioning Technology (Considerations)

### 1) Inputs & Outputs

When we design fashionable wearables, we should consider several factors such as inputs and outputs. Inputs help outputs to be activated. Outputs can be seen, felt, touched, or smelled by inputs. For example, if you wear a LED dress that can be activated by certain codes, the software is Input and the lights of LED are output. The reason of this research is to know what technology is used for innovative clothing, hoping that this research will help to find a right technology on my purpose to make visible changes with a piece of clothing.

<sup>5</sup> Seymour, 2008

Wikipedia, Technology, 2012 <<http://en.wikipedia.org/wiki/Technology>>

“A garment is seen, felt, touched, heard, and smelled. The many output options can stimulate any of our five senses. The variables captured from the input sources are software-based data and consequently allow computation that in turn determines the output. Outputs can stimulate the senses of the wearer or his audience. For example, shape memory alloys change to the silhouette of a fashionable wearable making it a visual interface for an audience and a tactile experience for the wearer.”<sup>6</sup>

The next table shows outputs based on the five senses. As a result of my research, I decided to focus on output’s visual aspects such as LED and E ink.

Senses	Outputs (examples)
<b>Visuals</b>	LEDs, Thermo chromic inks, Photochromic inks EL Wires, <b>E ink (Flexibility)</b>
Sound	Speakers, Buzzers
Touch	Motors/ Actuators Shape memory alloys, Conductive yarns, Conductive fabrics
Smell/ Taste	Scent capsules

Table. 2. Considerations 01 – Outputs toward Five Sense

#### 1) Other Considerations – Software, Energy, Materials, and Communication

For designing a fashionable wearable, there are four other considerations: software, energy, materials, and communication. Every condition systematically works with wearables. For instance, if a designer makes LED shirts, you need to have a power source to turn on the lights. And when you want to blink LED for a second, you need to consider software like Arduino. For users of LED shirt, a switch button and a power button are necessary to communicate between a user and a piece of clothing. Also, a user is able to use a wireless remote-controller, which is built in with a Bluetooth as a means of communication.

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<sup>6</sup> Seymour, 2008

Lastly, the choice of fabrics or materials is a matter of conveying electricity. The main technical considerations for the creation of fashionable wearables are:

- (1) Software – Arduino, **Photoshop**, Html Editor, Flash
- (2) Energy – Batteries(EP Implantable Battery)  
**Solar Panels**  
**Alternative Energy** (Organic Photovoltaic, Carbon Nanotube Springs, Hydrogen Battery)  
Human Body Itself (Nano Technology, Human Body Temperature)
- (3) Materials – **Electronic Textiles**  
Carbon Nanotubes  
Nano Technology (Microfibers)  
Live Organisms (Spider Silk, Human Skin Cells, Transgenic Goats)
- (4) Communication (for immediate Feedback) - Ubiquitous Computing  
UMTS (Universal Mobile Telecommunications System)  
GPRS (General Packet Radio Service)  
GMS (Global System for Mobile Communications)  
WIFI  
Bluetooth  
IR (Infrared)  
GPS  
Cell Triangulation  
PAN (Personal Area Network): Transferring the data  
using body's own  
electrical conductivity  
**NFC (Near Field Communication)**  
RFID

Considerations 02 - Other Considerations<sup>7</sup>

### Various Types of Batteries

In order to design activated wearables, we need a power source. Power sources like batteries are developing rapidly these days. They look thinner and lighter than the things we invented in the past. The following sentences will show what batteries I can possibly use as a power source for a wearable.

#### 1) Organic Battery

Organic batteries could be lightweight and could be molded into any shape. They have the potential to store more energy than conventional batteries and could be safer and cheaper to produce.<sup>8</sup>

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<sup>7</sup> Seymour, 2008, p. 19, 20.



Organic batteries and solar panels are more flexible and thinner than typical types of batteries. I expect that their innovative characteristics will help designers or technicians to make wearables without heavy weight and to design interactive clothing.

## 2) Nanotechnology Battery (Nano Battery)

According to *ScienceDaily* (Mar.22.2009), Researchers at the Maryland NanoCenter at the University of Maryland have developed new systems for storing electrical energy derived from alternative sources. Traditional ways of harvesting energy derived from renewable energy sources are not effective way to get enough power. However, nanotech batteries' power is ten times stronger than the current systems for storing electrical energy from renewable resources.<sup>9</sup>

This battery is tinier and thinner than a normal battery. More importantly, this battery is a powerful renewable resource using physical laws of nature by its own structural compositions, identical nanostructures.

Thin film nanotechnology by Front-Edge Technology shows that it can be used as a power source to turn on one Led. If we develop a smaller Nano battery with more powerful energy, it might be used for a power on any sort of displayers including E ink Surf.

## 3) Human body temperature (Body as a source of energy)

“Vladimir Leonov and Ruud Vullers of the Inter university Microelectronics Centre in Belgium have built up on past work and devised an ambitious “energy harvester”- a device that essentially turns humans into big walking batteries. The research could lead to iPods and cell phones that never lose their charge.”<sup>10</sup>

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<sup>8</sup> Lee Clippard, Electron Switch Between Molecules Points Way To New High-Powered Organic Batteries, 2010, <<http://web5.cns.utexas.edu/news/2010/09/electron-switch>>

<sup>9</sup> ScienceDaily, Nanotech Batteries For A New Energy Future, 2009, <<http://www.sciencedaily.com/releases/2009/03/090320173859.htm>>

<sup>10</sup> Jason Mick, Researchers Move Humans One Step Closer to Being Walking Batteries, 2009 <<http://www.dailytech.com/Researchers+Move+Humans+One+Step+Closer+to+Being+Walking+Batteries/article17222.htm>>

Clothes that we wear are one of the closest materials to our skin. When clothing is an energy harvester itself by human body temperature, there will be a great solution for getting energy to power wearables.

People consider limited natural resources such as oil. Therefore, many researchers and scientists are developing power sources using alternative energies, such as human body temperature. However, the problem is that they are not powerful enough to power products. For this reason, I planned two ways for getting power. One is to use wireless power transmission at home. Another is to use solar energy for constant charge of energy outside the home.

#### Materials

Finding conductive fabric is so important for this project because it can give and take signals from images or sounds by its conductivity. Currently E ink uses thin and flexible film as a displayer. However, when a conductive fabric is more developed, the displayer can be replaced from film to fabric and a sheet of transparent fabric will possibly be used as a displayer. From this point of view, I researched enhanced fabrics with conductivity such as Carbon Nanotube Super Fabric.

#### Carbon Nanotube Super Fabric – Conductive fabric

In Jeffery Winters' 2011 article, "Carbon Nanotube Super Fabric", the author states that it is soft, strong (50 times that of carbon steel), and conductive (potentially conducting greater current densities than copper).

Nanotube super threads as thin as human's hair could conduct and hold electrical charges. Electronic devices could be directly incorporated into fabrics made of them. <sup>11</sup>

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<sup>11</sup>Jeffery Winters, Carbon Nanotube Super-fabric, 2011, <<http://www.asme.org/kb/news---articles/articles/nanotechnology/carbon-nanotube-super-fabric>>

The previous research about materials proves that there is no problem in regard to clothing's conductivity in order to make an interactive wearable. I am able to use conductive threads as well as carbon nanotube super fabric to activate signals on a piece of clothing.

## Futuristic Clothing

A piece of clothing with advanced functionality can be a great example of futuristic fashion. However, a futuristic garment doesn't need to be functional. Aesthetically, if the clothes look brand new through use of unique materials or original textures, etc., we are able to refer to them as futuristic fashion. The following table is instances of futuristic fashion and by doing research of



the examples; I was able to find the current flow of futuristic fashion and was inspired to create fresh concepts by them.

OLED	<b>Lumalive by Philips</b>
<b>Liquid crystal display monitors</b> <a href="http://www.t-shirts.com">http://www.t-shirts.com</a>	
	Self-painting dress for women by Anouk Wipprecht
Light trail by Atton Conrad	<b>Led dress by Hussein Chalayan</b>

Table.3. Futuristic Clothing

## 03 Design Motivations

### 1) Individuality in Fashion

People usually want to express their individuality through clothing but it's difficult to judge personality just what someone is wearing. However, the obvious thing is that what we wear is the one of important standards to know who we are.

Fashion is - An investment of self

An unprecedented aesthetic self-observation

The pleasure of seeing and of being seen

The pleasure of exhibiting oneself to the gaze of others

A vector of Narcissistic individualization

The way of presenting and representing ourselves

This statement shows how fashion has become a medium of self-expression.

“With fashion, human beings begin observing each other endlessly; appreciating each other’s looks, evaluating nuances of cut, color, and pattern in dress. As an apparatus for generating aesthetic and social judgment, fashion has favored the critical gaze of the worldly-wise; it has stimulated more or less agreeable judgments of elegance of others.”<sup>12</sup>

For this reason, fashion became a main medium of communication, bringing unique styles to each individual.

“Yet fashion has not been merely a stage for the appreciation of the spectacle provided by others; it has also unleashed an investment of self, an unprecedented aesthetic self-observation. Fashion goes hand in

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<sup>12</sup> Gilles Lipovtsky, *The Empire of Fashion: Dressing Modern Democracy* {New Jersey, Princeton University Press, 2002}, p.29.

glove with the pleasure of seeing, but also with the pleasure of being seen, of exhibiting oneself to the gaze of others...Fashion makes narcissism a constitutive and permanent structure of fashionable individuals, by encouraging them to pay more attention to the way they present and represent themselves, by inciting them to seek elegance, grace, and originality. The endless variation of fashion and the code of elegance invite individuals to study themselves, to adapt novelties for their own use, to concern themselves with their own dress. Fashion has not only made it possible to display one's membership in a given rank, class, or nation, it has also been a vector of narcissistic individualization, an instrument for enlarging the aesthetic cult of the self, even at heart of an aristocratic age."<sup>13</sup>

According to the book, *The Empire of Fashion*, fashion can be used as a medium in order to express our individuality. Next study is the elements in fashion that can be helpful to show our personality.

Individuality is one of the important factors in fashion. However, mass-produced clothing does not contain personality, so some major clothing companies such as Levi Strauss challenge the custom clothing on/off line. However, custom clothing is limited to a few changes in style. My initial thought was that technology such as LED or E ink will help to show personality through each wearer's clothes by using unique patterns.

#### (1) Individuality in color

Both colors and accessories are crucial elements of style statement. According to varied colors and accessories, fashion style can be set up individually by them. Therefore, I researched the effect of both factors on personality.

"Color is recognized universally as a natural component of beauty...But colors are far more than just beautiful; they are useful. Color can be used to communicate ideas and emotions, to manipulate perception, to create focus, to motivate and influence actions"<sup>14</sup>

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<sup>13</sup> Lipovtsky, p.29.

<sup>14</sup> Linda Holtzschue, *Understanding Color: An Introduction for Designers* {Hoboken, New Jersey: John Wiley & Sons Inc.}, Chapter.1 - The Use of Color.

Nita Leland (*Exploring Color*, 2000) writes “Trust your intuition, your selection of color is highly personal as you reveal your individuality through your color choices.” (Leland, 2000)

Each person has a unique taste toward colors. When people match their favored colors on their clothing, style can be established by oneself.

## (2) Individuality in Jewelry

Stacy LoAlbo describes the meaning of layering accessories on our bodies in her book, *Vintage Fashion Accessories*:

“We choose not to bow down to convention but to make our own regulations and express our individuality through the garments and jewels we layer onto our bodies on a daily basis. The clothes we wear express out statement that says ‘I am unique, with my own set of different rule for styles that I create.’” (LoAblo, 2009, p.10)

“Honoring and enjoying such a piece of jewelry is a way of celebrating your own individuality and value.”<sup>15</sup>

Creating new styles using accessories enables us to improve our creativity as well as individuality since designing every style starts from self-awareness. Decorating something onto our bodies means that we love ourselves and want to show styles to others.

From this point of view, I wonder if we have expressive ways for our own individuality and what design factors are able to have a positive effect on our personality. At first, by doing research, I realized that there are lots of style elements to create unique individuality and I chose five elements among them.

## **Expressive ways of individuality**

Based on the research on individuality in fashion, I studied through which fashion elements people can express their individuality. There are five components to show our personality:

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<sup>15</sup> Shaki Carola Navran, *Jewelry & Gems for Self-Discovery: choosing gemstones that delight the eye & strengthen the soul* {Woodbury: Llewellyn Publications, 2008}, p.178.

(1) Hair style

Hair color, style, or length makes someone look different.

(2) Make-up

Customizing our own face with make-up encourages people to be distinguishable.

(3) Nail Art and Accessories

Both nail art and accessories harmonizes with each individual's artistic sense.

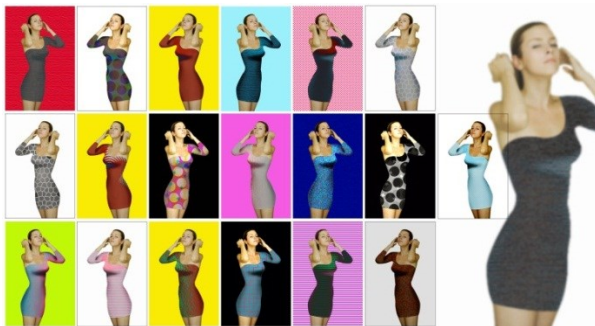
(4) Tattoo and Piercing

A tattoo is a very personal thing. It helps to communicate with others by use of symbolic images. Its meaning is differentiated by each one's intend and favored taste. People usually get tattoo to show symbolic words, cultural or artistic preferences, or symbolic images.

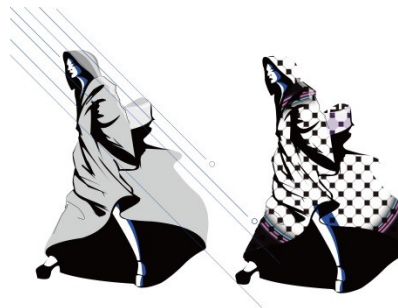
(5) Pattern/ Clothing

Patterns on clothes can give visual identity to an individual because most people have different taste toward colors, symbolic images, and relations between a pattern and clothing. As I recall one girl who loved teddy bears so much, so she would wear various types of clothing with a teddy bear image. Her repetitive pattern of behavior gave her the nick-name, "Little teddy bear". This example shows that a favorite thing can become an individual visual identity.

Moreover, most designers and companies in the fashion industry increasingly use the pattern as their brand identity. For example, Roberto Carvalli (Italian fashion designer), Burberry, and Louis Vuitton are using unique patterns for their distinguishable visual identity.



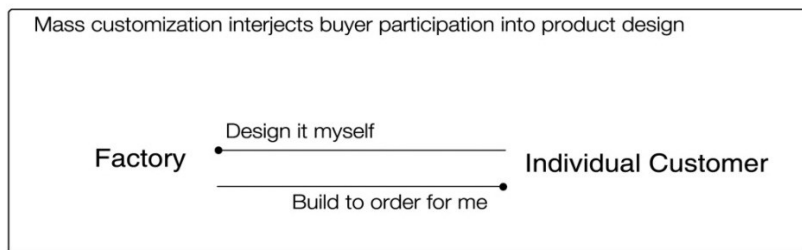
Pattern mania



A pattern makes different style

## 2) Mass Customization

Mass customization is the next big wave after mass production. These days, custom clothing is one of the most popular fields in Mass customization. The problem of current clothing is that it is excessively produced without expressing individuality in clothing. Mass customization of clothing can possibly be the solution for this issue. Thus, I decided to research mass customization, looking for its innovative ways to reduce production of clothing and to prolong its life cycle. I researched the examples of mass customization, regarding from general areas to fashion industry. The next figure displays the process of mass customization and its types.



(Source : Forrester Research.Inc)

Fig.2. Mass Customization injects Buyer Participation into Product Design by Forrester Research.inc

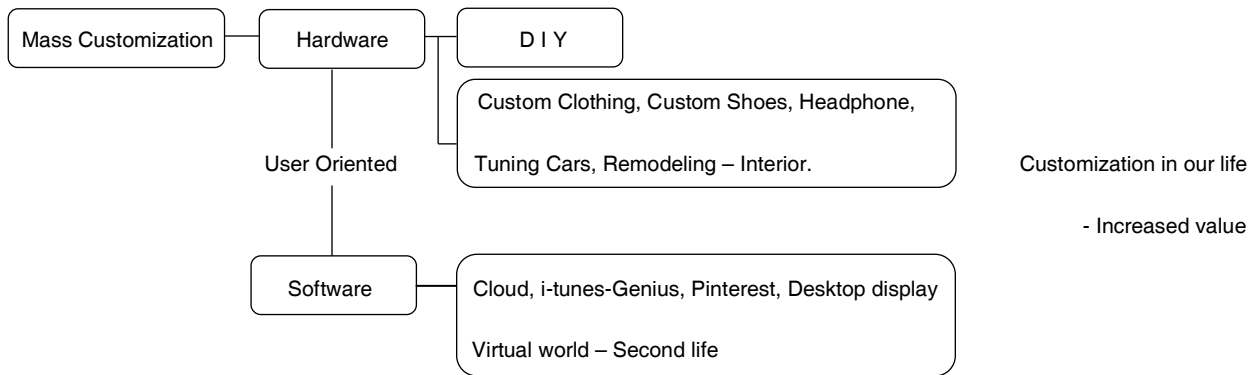


Fig.3. Flow Chart – The Types of Mass Customization

Each customer’s participation on the process of mass customization shapes new and unique products for buyers. Particularly, custom clothing is the biggest part of mass customization among many other items by mass customization. It is rapidly developing. However, most companies which are related to mass customization were not successful in their business. For example, Levi Strauss wasn’t successful to offer customized jeans from 1993 to 2003. But today, many major companies such as Kraft, Hallmark, M&Ms,



Wrigley and the longest-running success, Nike are enjoying their heydays. I started thinking that advanced technology will overcome limit of mass customization, especially, the area of custom clothing.

Mass customization is widely used as a medium of interrelation between products and individuals. The fields of mass customization are varied from a car to a piece of clothing. Specially, more people engage in custom clothing than other areas. Luxury brands' offerings online seem to be limited.

Uche Okonkwo, she urges "online customization" in her book *Luxury Fashion Branding: Trends, Tactics, and Technique*:

Currently, the online customization offerings of luxury brands are limited, mainly because the internet and e-business strategy of the luxury fashion sector is still in the introductory phase. (Okonkwo, 2007, p. 263)

As she writes luxury brands in the fashion industry didn't offer many options toward mass customization. However, when it comes to fashion in general like custom clothing, the situation can be reversed. According to Frank T Filler's research, fashion items are 43.2% of mass customization.

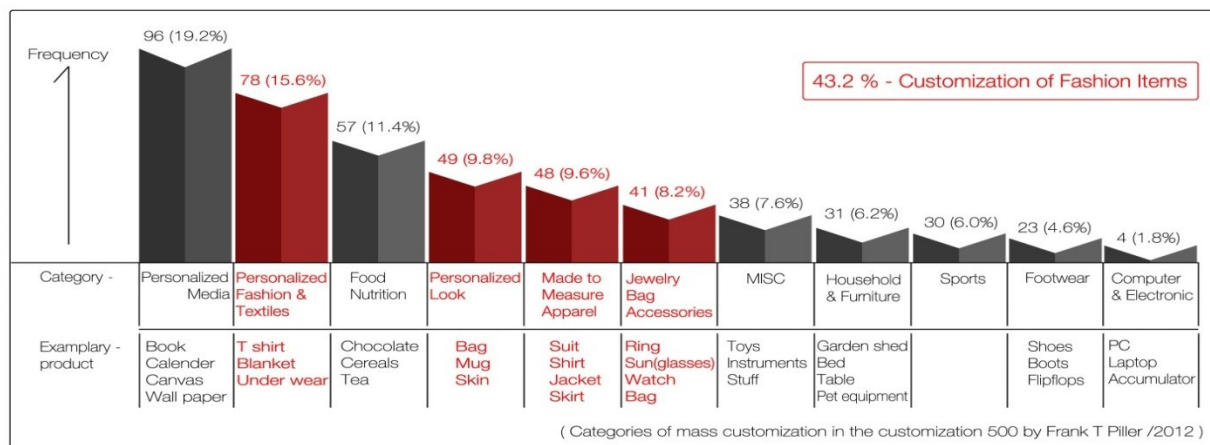


Fig.4. Which are dominating industries with mass customization offerings<sup>16</sup>

<sup>16</sup> Frank T Piller, Categories of mass customization application in the Customization500, 2009 <[http://mass-customization.de/service\\_customization/](http://mass-customization.de/service_customization/)>

An article about mass customization in the *NY Times* shows that; “mass customization retailers grow more than ten times as fast as online sales in general.” (Clair Cain Miller, Dec.22.2009). Currently, many companies such as Zazzle, Blurb, Blue Nile, and Cafepress provide online services for customized products. These companies are helping people quickly to create one-of-a kind product like clothing, books, and jewelry.

## Problems of Current Clothing

### (1) Irrational consumption of clothing

People who are sensitive to trends tend to buy more clothing in order to keep up with the latest trends. This behavior causes not only a waste of energy, but also a waste of time and money since fashion changes so fast.

Current purchasing habits and tendencies are obsessive as well as unproductive. For example, if we don't want to buy more clothing, will we fall behind the trends? According to Teri Agins' book, *The End of Fashion*, "Every few years, when the silhouettes change, women and men have been compelled to go shopping and to rebuild their wardrobes to stay in style." (Agins, 1999, p.7)

When fashion goes out of style, people quit wearing it. This results in wasted clothing, such as with the rise and fall in skirt lengths for women and for men the widening and narrowing of trousers and neckties. If we feel our clothing is an old-fashioned item, what will we do? To that point of view, it is a waste of clothing and people are often not willing to buy second-hand clothing.



When we want to buy clothing, we have to spend a lot of time at many stores. The problem is that we don't have enough time to do that; therefore, most people might experience disappointment with their shopping. In order to stop people's irrational consumption and dissatisfaction, one piece of clothing might create different looks for users. That's why customized clothing is reasonable for customers' contentment.

## **(2) Waste of natural resources, harm to nature**

In order to make myriad items of clothing, we have to use lots of energy causing air pollution and exhaustion of non-renewable resources.

Furthermore, we lead animals such as wolves, coyotes, foxes, minks, and beavers to be endangered, when people buy fur clothing. The FFA (Fur Free Alliance) claims that; “Each year fur industry kills over 50 million animals for fashion.”<sup>17</sup>

Fashion designer Isaac Mizrahi showed chubby new fake fur jackets (2010). Many famous fashion models, organizations such as PETA, and other people who are interested in the protection of animals have joined the campaign of protecting endangered animal like sables. This is because people, especially, women are eager to buy luxurious items. Why do we have to produce clothing excessively despite these disadvantages to humans and animals? Excessive consumption of clothing is harmful to human beings as well as our environment, the earth.

To solve this problem, developing materials or fabrics that are look-alikes for animal furs or skins might help. For instance, when three dimensional digital images, which seem like fake materials, were developed, fur clothing could be replaced with them. For saving energy, we may use solar energy or some renewable resources to generate the visuals onto the garment.

## **(3) De-individuation**

Historically, clothing has been a protection for the human body from physical conditions and climate, as well as protection for health. As Francois Boucher describes the functions of clothing in his book, *20,000 years of fashion: the history of costume and personal:*

The Greeks and Chinese believed that Man first covered his body for some physical reason, particularly to protect himself from the elements, while the Bible, ethnologists and psychologists have invoked psychological reasons: modesty in the case of the ancients,

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<sup>17</sup> Fur Free Alliance, Fur-Bearing Animals, 2012, <<http://www.information.com/index.php/fur-bearing-animals>>

and the idea of taboo, magical influence and the desire to please for the moderns.  
(Boucher, 1987, p.9~10)

Later, costumes reflected social factors such as religious beliefs, magic, aesthetics, and social status. Therefore, fashion before the Industrial Revolution served as a traditional function more than a means of individuality. However, these days, people are looking more for individual unique fashion. For example, one research shows that college students express more individuality in their fashion choices than other people.

According to one survey by Lifestyle monitor, “59% of the younger group say they like to get noticed for their clothes, while only 44% of the older group does, similarly, 79% of the younger respondents feel better they get a second opinion about their outfit compared to 66% of the older ones.” (Lifestyle monitor, 2010)

Most of the younger generations want to express their individuality to be differentiated from others. However, mass produced clothes are not responsive enough of a medium to reflect their true character.

Paula Darnell and jewelry designer notes that “we all have fashion personality that guides our sense of style, classic, trendy, casual, romantic.”<sup>18</sup> These are all fashion personality types and she believes that these kinds affect our life style.

Much clothing is made by mass production. It causes us to lose not only individuality to express our own ideas or view-points onto our clothing, but also creativity since we merely wear and buy clothing which is made not for an individual but for the majority of people. These behaviors are not active but passive, causing us to be a fashion follower like a copycat. Mass produced clothing makes people feel awkward in expressing their original personality through their clothes.

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<sup>18</sup> Paula Darnell, Fashion Personality: What’s your Fashion Personality Type?, 2012,  
< <http://petite.about.com/od/fashionpersonality/tp/fashionpersonalitytypes.htm>>

School uniforms are an extreme example of this problem. Students would like to be free of rules and regulations. They want to keep up with fashions and are against school uniforms. Of course, school uniforms have some benefits, such as instilling students with discipline and helping students concentrate on their work in school. However, there are many negative effects resulting from dress codes.

Sarabeth Asaff writes,

Some experts believe that public education attempts to strip children of their individuality. They believe that public education does not meet the needs of children who do not fall in the norm, and that uniforms attempt to force every student into one mold. They see standard dress as yet another way for public educators to remove student individuality where they should be embracing and celebrating diversity.<sup>19</sup>

Therefore, if students create or design their own clothing, it will help to increase their unique personalities. So, if images on their uniforms can be changeable or movable, they will use the uniform after school. Like a cell phone, a uniform can be “turned on or off” by the design just as a cell phone would. My research is going to find some ways of changing garments visually like Lumalive by Philips; Products include light-emitting shirts, which integrate LED into the fabric. They have also developed jackets and a couch using this technology.

#### Mass- Produced Individuality

Clothing is usually produced by mass production. Therefore, customers find it difficult to discover uniqueness in mass-produced clothes. The article “The way we live now, Mass-Produced individuality” criticizes mass production arguing that it results in mass-produced individuality.

Rob Walker expresses mass-produced individuality in his article, “The way we live now, Mass-Produced Individuality”: “Lately, however, mass production has been cast not so much as the best thing that ever happened to consumers but as an annoyance, even a problem. It stands in the way of our individuality.”

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<sup>19</sup> Sarabeth Asaff, Pros and Cons of School Uniforms, 2012,  
<[http://kids.lovetoknow.com/wiki/Pros\\_and\\_Cons\\_of\\_School\\_Uniforms](http://kids.lovetoknow.com/wiki/Pros_and_Cons_of_School_Uniforms)>

(Walker, 2005, NY Times) And he points out this problem might be solved through more technological innovation like unique and customized items for each individual.

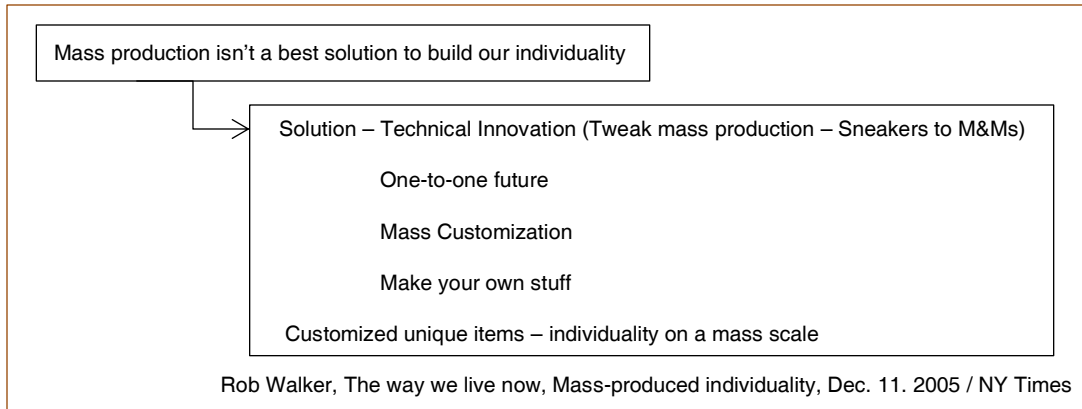


Fig.5. Mass-produced Individuality and the Solutions

#### (4) Fewer responses between people and clothing

There are fewer responses between clothing and wearers. When we wear clothing, there are always several reasons. One of the important reasons is to interact with others. In a word, some people who are especially sensitive to follow trends like women in their 20s want to show their clothing to others in order to show their individuality.

However, current clothing has some limitations of response between an owner and others. For instance, once a person wears clothing, there are fewer ways of showing his or her individuality to others because one piece of clothing has just a few looks. In order for clothing to be communicative with others all the time, the design must be changed by users.

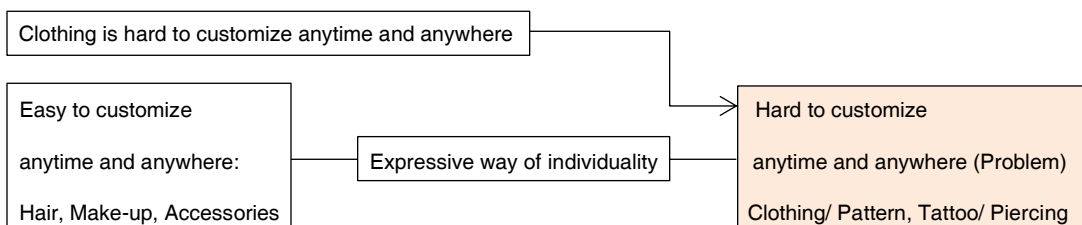


Fig.6. The Problem of Normal Clothing's prompt Customization

Personally, when users create their own clothing like customized clothing, it will be one kind of interaction between users and the garment since it means that they are not merely consumers but also can be

creators of clothing. Customizable clothing enables us to feel more affection toward our own customized clothing.

So I decided to research customized clothing and found there are some customizable services online such as those offered by Nike, Gap, M&M, and Reebok. Contemporary businesses have begun realizing that they have to be more user-oriented. Also, startups and major retailers are utilizing the web to create unique products in all sorts of categories. So, we don't even have to buy in bulk as in the past.

For example, as David Hogue notes,

We can design our own Nike's, put our initials on M&M's, and even design our own Kleenex boxes. So, we can design our own product to represent our personalities. Customization of products is on a new way of giving customers exactly what they want. Soon, we will be able to customize shoes, clothing, etc. on the website without paying premium prices for the privilege. These things can be active interaction between clothes and users because the process of customized clothing reflects a person's own thought. However, problems of current customized clothing are that it creates more choice to get clothing that they want, possibly too much choice, for the customer and it takes time to receive the finished product<sup>20</sup>

In addition, nowadays customization of clothing won't stop producing much clothing even though custom clothing is a unique feature that can give someone a versatile look.

## **(5) The Problem of Mass Customization**

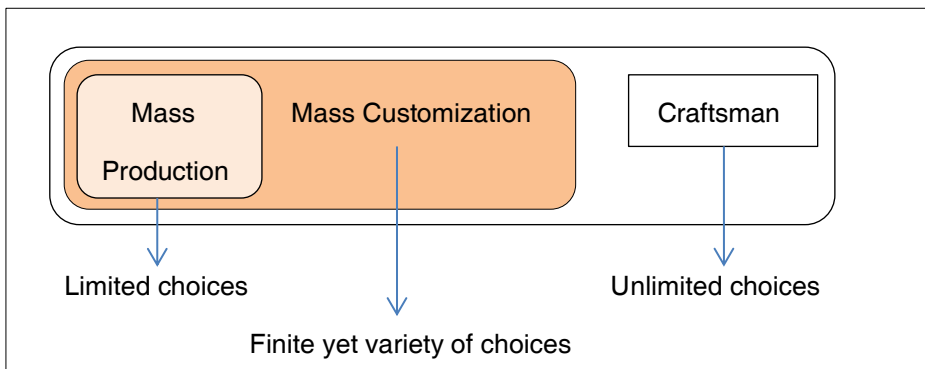
Lastly, mass customization is not for both everybody and an individual. It has its own limits, even though custom clothing makes its own way according to users' wants. People's preferences towards custom items differ sharply. However, customized products are still adopting traditional way of mass production with few changes. There are several problems with mass customization.

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<sup>20</sup> David Hogue, The Future of Online Experience #2: Custom Products, 2008,  
< <http://www.fluid-blog.com/2008/11/14/the-future-of-online-experience-2-custom-products/>>



First, the cost of customizable products is intrinsically more expensive than mass-produced products. For example, the price of a single custom t-shirts' starts at \$14.95 but when a user adds an image, a text, or both, the cost will increase to a minimum price of \$20.95. Furthermore, technological difficulties in regard to providing goods at reasonable prices cause slow delivery times and additional costs. Different price policies among many companies make users confused about choosing the right items at a reasonable cost. Also, when compared to individual customization like craftsman, mass customization is finite yet offers a variety of choices.



(Arun N Nambiar, Mass Customization; Where do we go from here?, 2009)

Fig.7. Comparison of product variety

The above figure shows that craftsman offers limitless selections in comparison to product strategies, mass customization and mass production. But it will have its own problems moving into the future. For instance, it will be hard to provide a large quantity of products in a short time. It means that craftsman is not cost-effective for production. However, technological innovation might be a good solution for the next step of craftsman. From this point of view, this thesis is mainly focused on individual customization, which means providing versatile options for each user to change user-oriented styles with a piece of clothing. The purpose of the next step in this thesis is to locate impending problems of mass customization in detail.

“Mass-customization systems have three key capabilities: elicitation (a mechanism for interacting with the customer and obtaining specific information); process flexibility (production technology that fabricates the product according to the information); and logistics (subsequent processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer). Those-

elements are connected by powerful communications links and thereby integrated into a seamless whole.<sup>21</sup>

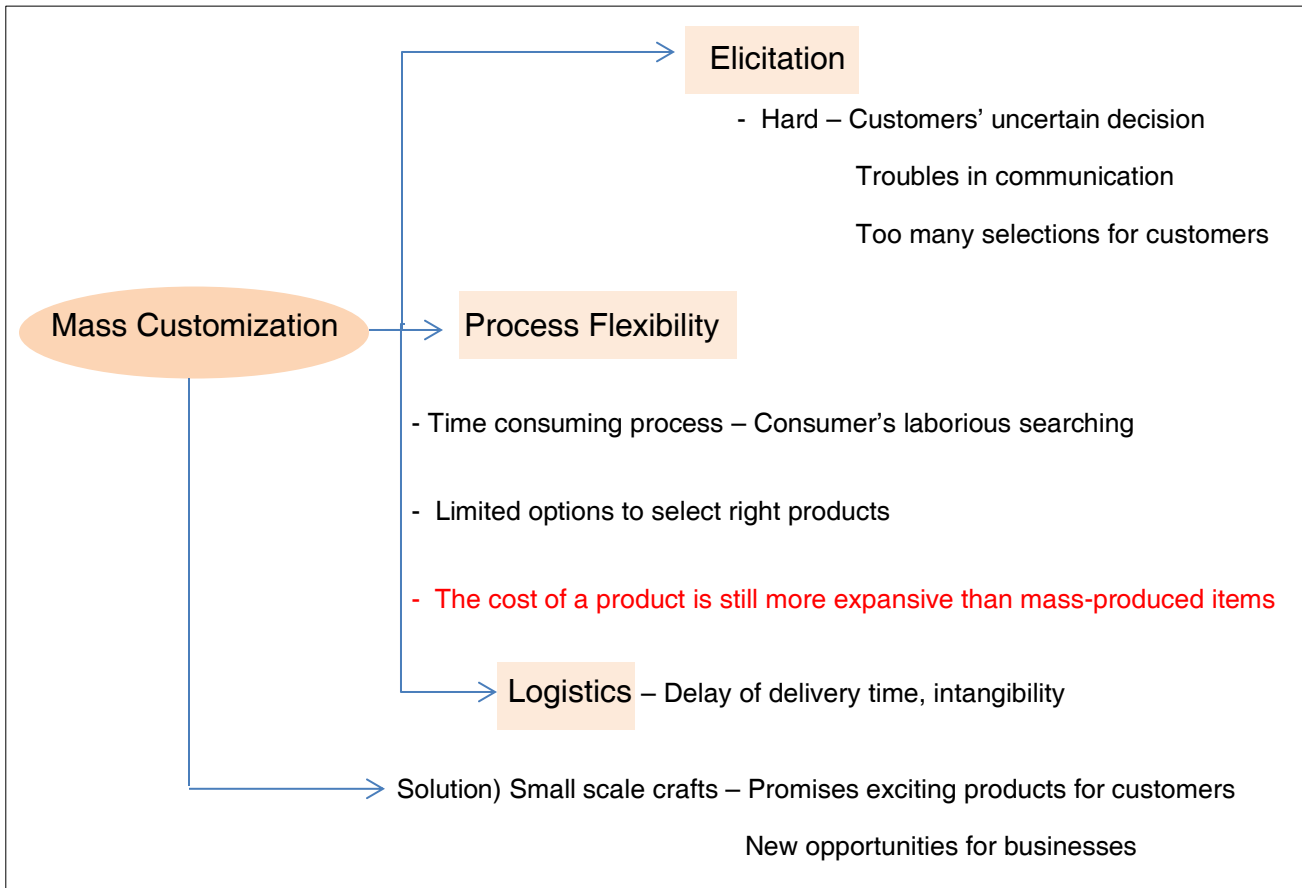


Fig.8. The limits of Mass Customization (Resource: MIT Sloan Management Review 2005)

Even though mass customization is strongly connected to three capabilities there are still problems to solve. For example, elicitation (one of mass customization's three key capabilities) is not easy for retailers. Customers often have trouble deciding what they want and then communicating or acting on their decisions. Also, buyers are easily overwhelmed by too many selections on a store shelf or a web page. For process flexibility, retailers should reduce the cost associated with a consumer's laborious searching and they should treat a variety of different tastes toward products, and not limit options for users. Lastly,

<sup>21</sup> Paul Zipkin, The Limits of Mass Customization ,2005, { MIT Sloan Management Review; Spring2001, Vol. 42 Issue 3, p81, 7p, 1 cartoon}

when it comes to on-line services for custom products, customers have a difficult time selecting the right products due to the intangibility of the medium.

The solution toward problems of mass customization might be small-scale crafts since they promise exciting products for customers and offer new opportunities for businesses. What if a piece of custom clothing gives users tangible experience in the ability to change their styles? This should be possible through technological innovations like E ink or we might find fine solutions through customization of products in analogue mediums. Below is a discussion of the challenges of mass customization and the reasons why both buyers and companies are skeptical about mass customization.

#### External Complexity & Internal Complexity

Both Thorsten Blecker and Nizar Abdelkafi describe two main challenges of mass customization in their article, "Mass Customization: State-of-the-Art and Challenges":

...Many customers are still reluctant to buy customized products and companies are also skeptical about the feasibility of the strategy in practice. The difficulties in implementing a successful mass customization are mainly due to two main problems, which we call them external and internal complexity. External complexity refers to the uncertainty encountered by customers when they intend to customize their products. On the other hand, internal complexity is experienced inside the company's operations. It refers to the problems faced by the company because of the extensive product variety induced in mass customization. (Blecker and Abdelkafi, 2006, p.14)

The following figure shows the causes of two terms, external and internal complexity.

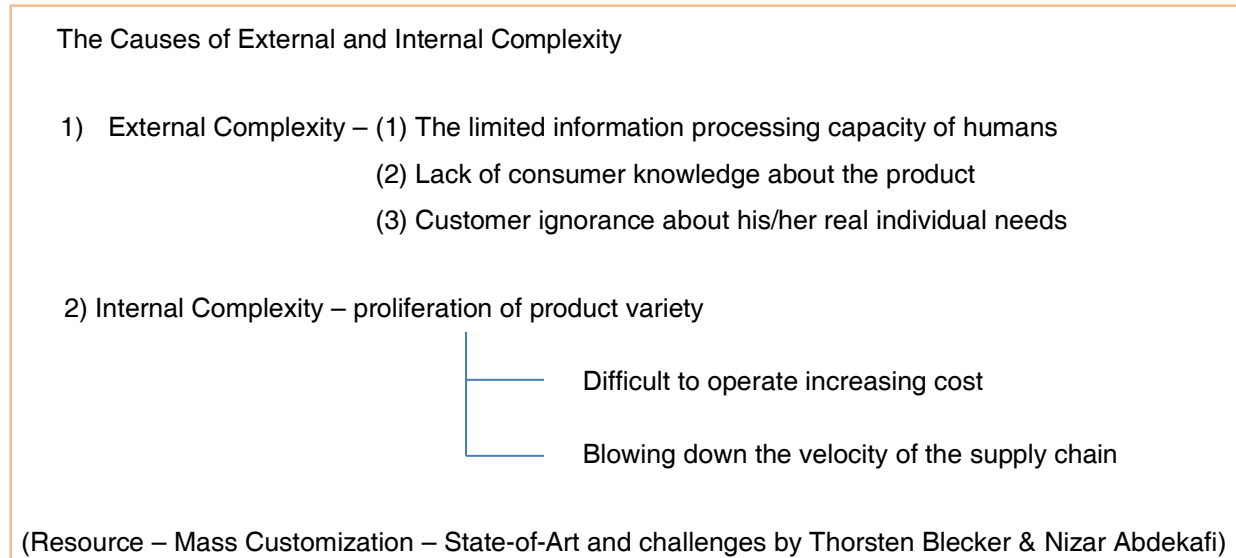


Fig.9. The Causes of External and Internal Complexity

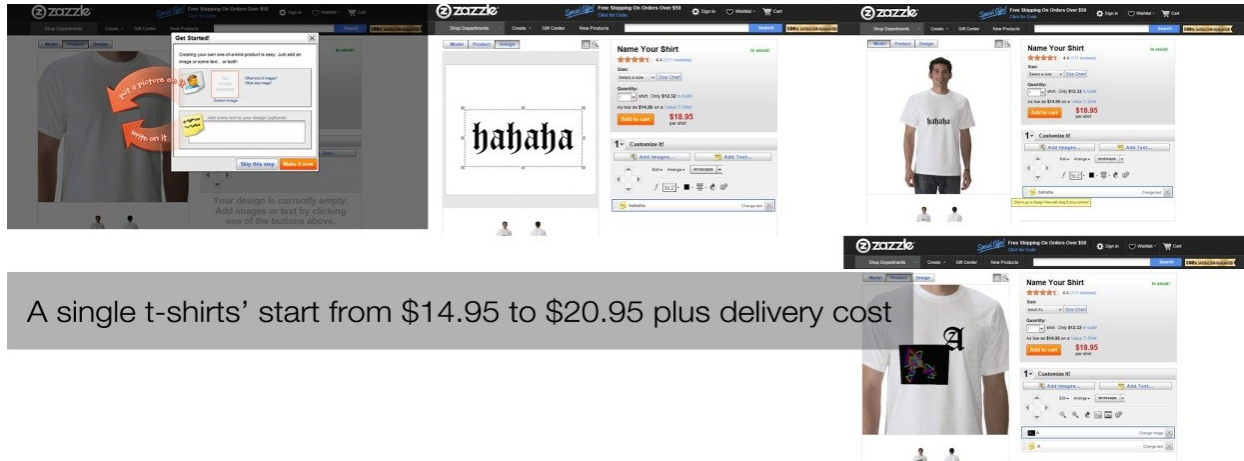
External complexity happens through various customers' reactions to customized products. Specifically, standardizing user-oriented customization is difficult because there are many different individuals who are looking for unique items. In addition, shoppers' unintentional purchasing behavior causes external complexity. In terms of internal complexity in mass customization, merchandisers have a hard time offering reasonable prices for customers because delivery costs and installing various options require extra money from buyers as an alternative to mass production. For these reasons, I conducted an experience with custom clothing through usability testing on the Zazzle website in order to understand the problems.

The Problem of Online Customization – Usability Testing on Zazzle website.

Process (The order of making custom t-shirts on Zazzle)

- 1) Select a specific item
- 2) Select gender and age
- 3) Select size, style, color, price in general

- 4) Put a picture on t-shirts and add some texts
- 5) Select specific size and quantity
- 6) Make it now



[www.zazzle.com](http://www.zazzle.com)

Fig.10. Usability Testing of Custom T-shirts

From the usability testing on Zazzle website, I found two problems. One is that it is too difficult to control relocating an image and a text on t-shirts. Another is that custom t-shirts' price is still more expensive than printed t-shirts.

Based on five challenges—irrational consumption, waste of natural resources, de-individualization, fewer responses between people and clothing, and the problem of mass customization—I planned to develop ideas and concepts to solve them. Most importantly, providing user experience for wearers is the focus of my idea development since user satisfaction through voluntary activities through creating their own styles can be the start of individual customization as an advanced mass customization. Also, the activities can possibly help users express their individuality onto the clothing, increasing responses between people and clothing. In regard to the problem of the waste of natural resources and irrational consumption, if wearers like the interactive clothing, they will wear it often. Thus, the result is helpful to customers who can then invest in fewer clothes and that behavior might affect the production rates of clothing, and therefore have a positive effect on our environment.

## 05. Idea Development

After doing research on current clothing's problems, I strongly feel that we have to develop enhanced clothing for the new generation. Clothes are not only a kind of fashion but also an important medium to connect a wearer to another person since we wear clothes every day and go everywhere wearing them. In addition, clothing has actually been the best portable device for carrying various tools.

The purpose of this process is to find the best way of changing styles through a piece of clothing. From various experiments, I hope to get a solid solution to solve the problems mentioned earlier.

The idea development will be focused not on normal clothes but on customizable clothing, which is a helpful to human beings'. And I hope that it can give immense pleasure to our lives. The clothing must function as both a fashionable wear and a functional garment in order to change from just one look to various styles.

According to the problems that I noted previously, irrational consumption of clothing is caused by negative feelings toward old-fashioned clothing. This fact leads people to buy clothing frequently. Also, mass production, which uses many natural resources, is related to this kind of consumer' behavior. In addition, a garment from mass production isn't helpful to people to express their individuality since there are many similar clothes. Current clothing is merely considered aspects of visuals and materials when they are produced, so they don't offer any more than such things as the sense of sight and a tactile sense. If a new and smart piece of clothing can be changed every day by users and it offers new senses, consumers may feel more interest in the clothing. Furthermore, with consumers wearing the clothes continuously, we will be able to solve the aforementioned problems.

For these reasons, I decided to design customizable clothing in both ways: analogue and digital. Custom clothing is a reasonable option to achieving customers' satisfaction and for rational consumption because consumers can make sure of their satisfaction through the process of customizing clothes. Also, in order to encourage people to buy less clothing, customers have to get long-term satisfaction from clothing.

## **1) Change the look in an analogue way**

The Purpose of Design – 1. Changing the look of clothes easily

### 2. Use of fashion pieces of fabric

My goal is to develop a better garment that can be pleasurable, leading to continuous interaction between clothing and wearers as current clothing doesn't offer more than one look. A piece of clothing with various looks makes people feel like they are wearing something new every day.

There are several ways to change the look of typical clothes in order to show individuality. People can change their clothing by attaching and detaching cultural patterns, signs, symbols, etc., on their garment. This allows people to show their distinctive personality by using their design sense. There are a number of traditional ways of changing styles such as piercing, tattoo, make up, accessories, hair colors, unique fabrics, materials, texture, initial marks, shoes, glasses, socks, stockings, and the gorgeous body itself.

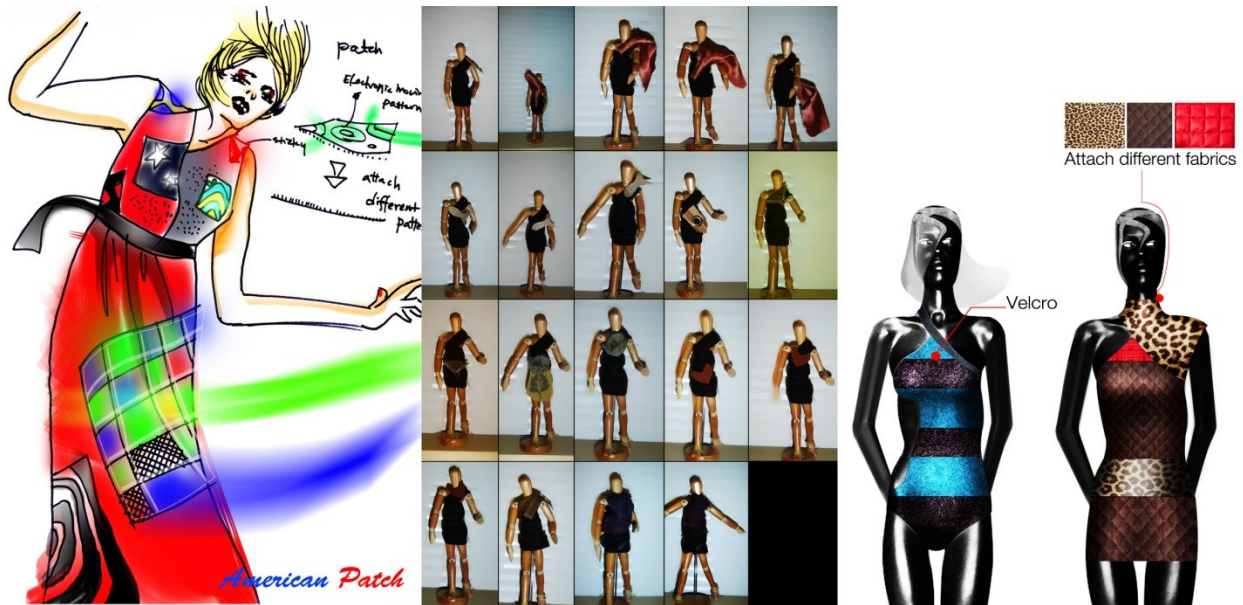
When merely concerned with the alteration of clothing itself, a first thing comes to my mind is Velcro since it is easily attachable as well as detachable. This means that Velcro allows people to decorate or to express their own style very naturally. Other ways of changing styles are the use of a fabric net, a snap button, natural light and shadow, and varied textured fabrics.

Here are my experiments to show changes of the look in analogue ways:

### (1) Velcro

My initial idea is using Velcro inspired by American patchwork and quilting. By attaching and detaching different colors, and patterns, and the textured loop side of Velcro on a hook side, with: a piece of plain clothing as a base, people are able to make various styles.

However, the problem is the surface of Velcro can get dirty easily through contact with foreign substances. Also, Velcro isn't a long-lasting material. In addition, when people want to use an extra piece of Velcro to make a certain look, additional costs are incurred.



Velcro - Idea Development and Experiment

### (2) Fabric net

The biggest benefit of fabric net is that it is porous like fabric mesh and has many holes that help the air pass through. For this reason, fabric net is usually used for summer clothes. The size of a hole can be differentiated by varied types of fabric net. Also, it has less weight than other fabrics, which enables us to



create clothing like scarves with it. In particular, fabric net has been used for traditional clothing such as the sari in India due to the dry and hot weather conditions.

Fabric net reminds me of knit work. The only difference between fabric net and knit work is merely the need for hands without a hooked needle. A wearer is able to make diverse styles by putting a different colored or textured thread into the hole of a net or by hanging different elements from it like jewelry. It also helps to make unique patterns on the net. However, in order to express their distinctive style, a user should continuously buy different types of materials such as accessories and threads.

Images on a next page are one of my Idea developments, Fabric net.

### Change the look in an analogue way - 02. Fabric Net



Fabric net – Research and Idea Development



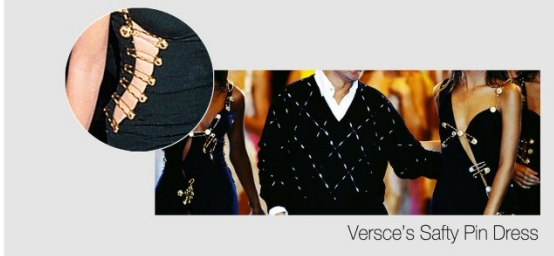
Fabric net – Execution

### (3) Snap Buttons

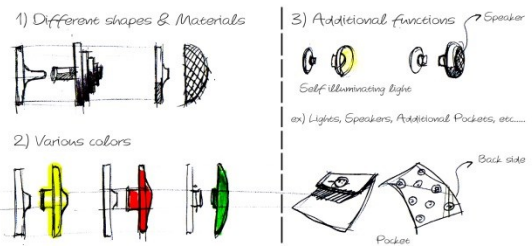
Personally, this concept is the most interesting one during the stage of idea development. To make this real, I spent a lot of time to complete the project since it required fastening a lot of buttons on a plain white t-shirts. The initial idea came from LEGO blocks. These are a very well made customizable product. Assembling pieces has a positive potential to develop concepts because the functionality and even the look can be radically changed by each unit. For instance, if one piece is a small wireless speaker, it will have a specialized function to deliver the sound and the style can be altered by diverse shapes, colors, or textures.

## Change the look in an analogue way - 03. Snap Buttons

Inspirations - fasten pieces of fabric



Ideation



### Snap Button – Research and Ideation

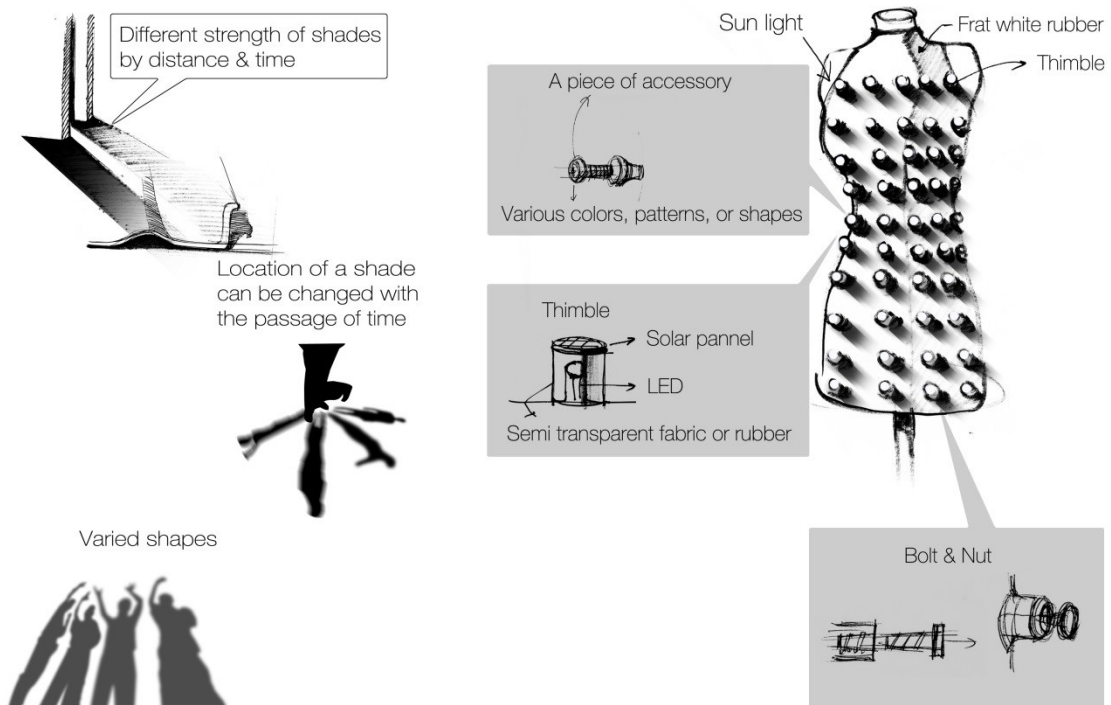


### Snap Button – Execution

#### (4) Light and Shadow

Images of shadows can be dramatically utilized in dark spaces but the shadow effect is strongly influenced by a given environment. Below are my experiments using shadow effects on a piece of clothing.

Change the look in an analogue way - 04. Light & Shadow



Light and Shadow – Idea Development



Light and Shadow – Execution

### (5) Surface

This experiment started from the following question: Can people feel different textures on a piece of clothing? The purpose of design is layering different textures by a wearer as custom clothing. Most recent clothing styles merely offer one or two textures. Using many textures is not necessary for the beauty of clothing itself. However, by providing a textual user experience, a normal piece of wear is able to become a responsive garment. The experiment was initiated from twining different textured and colored thread on the very basic form of a dress that I designed. In the result, I appreciated that I was able to feel different textures on the garment with my hands. It makes me feel like it is a totally different item of clothing from the original one.



Surface - Multi-layered Textures

As I studied the change of look in an analogue way, I had so many ideas, questions and imaginations. I wanted to share them with people. But yet, creative solutions were not coming out. My several experiments were temporary solutions, not innovative and long-lasting ones. The reason why these ideas are still yet too far from a final solution is that they were time consuming, not cost effective, and not very attractive visually. For these reasons, my journey to find new solutions will go to the next level: find an easy and original way to alter the look of a piece of clothing digitally.

## 2) Change the look in a digital way

The objective of Design – Reduced time of changing looks

Changing styles anytime and anywhere

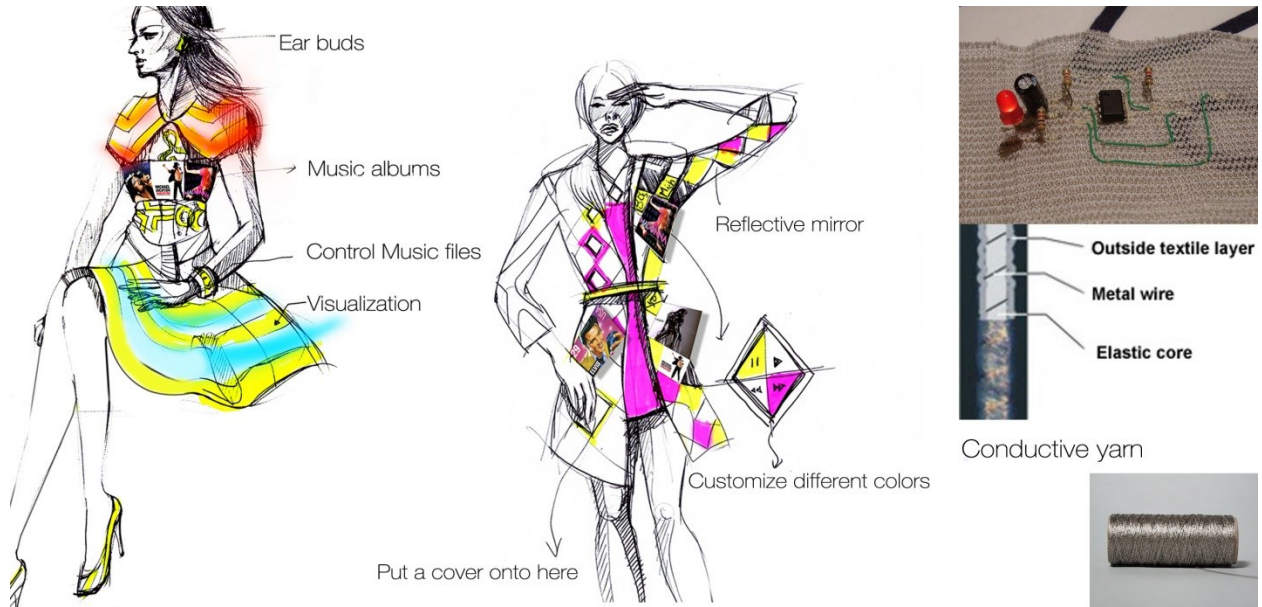
Enhanced mass customization: Individual Customization

What I found most fascinating with ideations is customizable clothing, yet it needs to solve the problems that analogue solutions had: they are time consuming and require laborious work. Also, they have limits for changing styles anytime and anywhere, and they are more money-intensive solutions. The activities of transforming styles will be very distracting for some users due to these reasons, while using technologies in order to design responsible and customizable wear automatically is to solve the problems that I mentioned. At first, I had to think what technologies are mostly matched with customizable clothes.

(1) Collectibles ( A fabric album cover is connected to conductive yarns)

There is no doubt why music is so popular among all generations. Yet, current music industry is losing a lot of profits due to illegal downloading. Also, cell phones now include many functions including a camera, an mp3 player, etc. It has become consumers' most favorite portable device. Contrary to the trends, consumers who purchase a vinyl album by a musician must appreciate the tangible and believe that the value of music is more than the sound. Many people also consider album jackets as valuable collectibles just as they do the LPs themselves. Currently, the young seem to be very interested in communicating with other people about their musical tastes or personal opinions in regard to music videos on websites like You Tube and Facebook. Furthermore, the visible value in music is similar to that in fashion in that both of them communicate with people visibly as well as tangibly and both can be with people everywhere as they are portable.

Album covers represent each year's overall trends. When people put some images of 1970s album jackets onto their clothing, they might feel like they are wearing clothes from the 1970s.



Collectibles: Album Cover – Idea Development

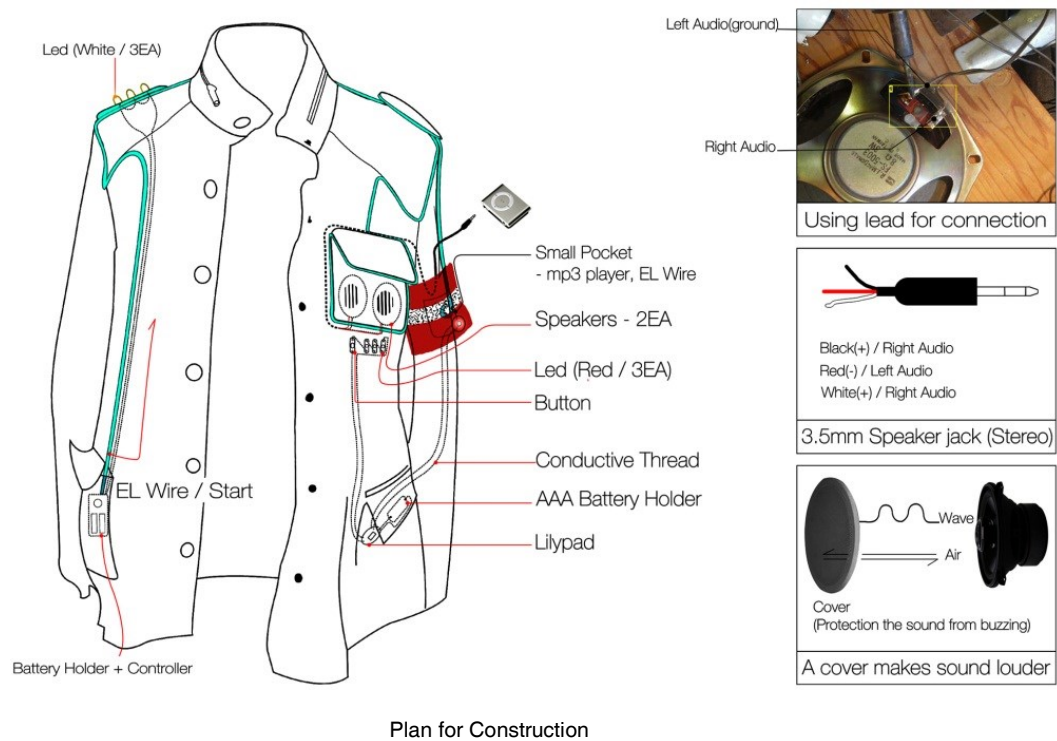


Collectibles: Album Cover – Ideation



## (2) EL(Electro Luminescent) Wire

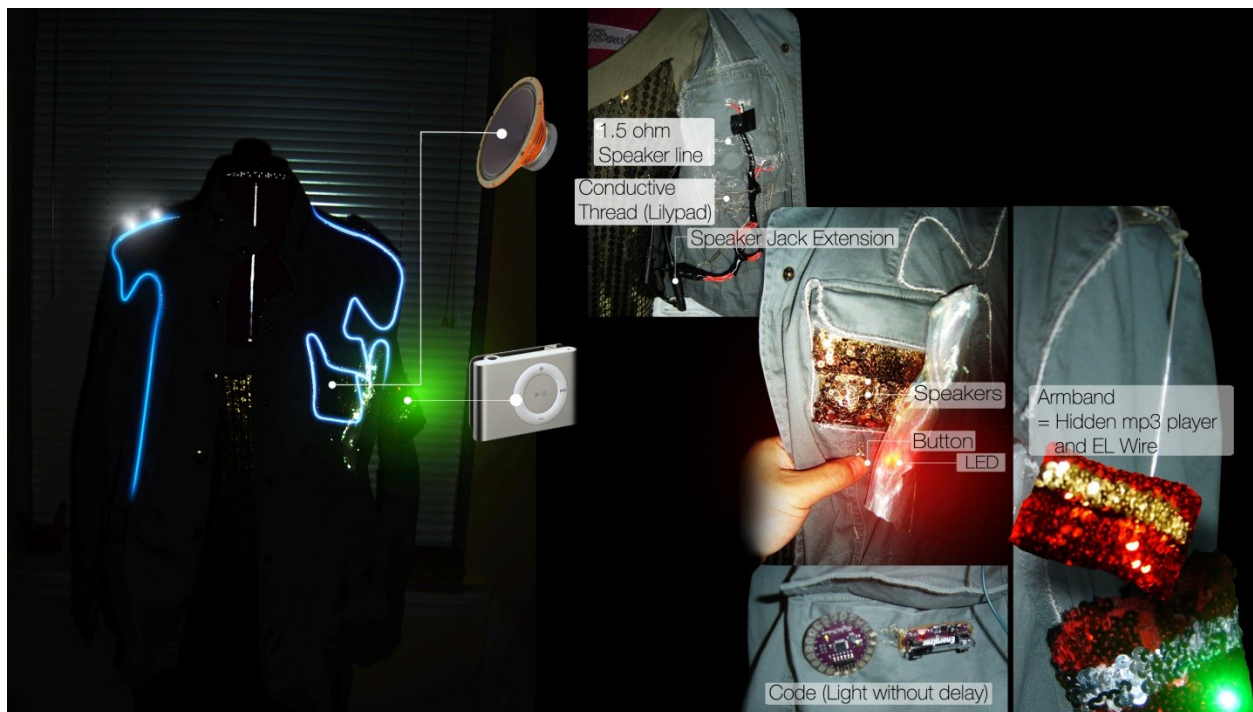
Using light emitting materials such as LED, light pannels, and Luminex are a visually effective way to show customized design at night and currently designers as well as many consumers are interested in them as one of the favored factors in DIY(Do IT Yourself). Arduino is one of the software programs to make lights interactive between users and clothes.



For variations in lights, a EL wire has three options: blinking for one second, just lighting, or blinking for five seconds. By pusing the button, its controller, these effects can be activated. A user can customize an EL wire's location and shape because it is flexible enough to bend. Also, it is reusable for creating different styles.

Sound is also a kind of customization since a user can select songs that he/she wants, I therefore added two speakers with their speaker lines and an audio jack to connect to an mp3 player.

Arduino was used for activating LEDs



EL Wire – Execution

Here is the code that I applied to the interaction between a button and an Led by Arduino.

### Blink without Delay

*/\* Blink without Delay*

*Turns on and off a light emitting diode (LED) connected to a digital pin, without using the delay () function. This means that other code can run at the same time without being interrupted by the LED code.*

*The circuit:*

*\* LED attached from pin 13 to ground.*

*\* Note: on most Arduinos, there is already an LED on the board that's attached to pin 13, so no hardware is needed for this example.*

*This example code is in the public domain.*

*<http://www.arduino.cc/en/Tutorial/BlinkWithoutDelay>  
\*/*

*// constants won't change. Used here to  
// set pin numbers:*

```

const int ledPin = 13; // the number of the LED pin

// Variables will change:
int ledState = LOW; // ledState used to set the LED
long previousMillis = 0; // will store last time LED was updated

// the follow variables is a long because the time, measured in milliseconds,
// will quickly become a bigger number than can be stored in an int.
long interval = 1000; // interval at which to blink (milliseconds)

void setup() {
  // set the digital pin as output:
  pinMode(ledPin, OUTPUT);
}

void loop()
{
  // here is where you'd put code that needs to be running all the time.

  // check to see if it's time to blink the LED; that is, if the
  // difference between the current time and last time you blinked
  // the LED is bigger than the interval at which you want to
  // blink the LED.
  unsigned long currentMillis = millis();

  if(currentMillis - previousMillis > interval) {
    // save the last time you blinked the LED
    previousMillis = currentMillis;

    // if the LED is off turn it on and vice-versa:
    if (ledState == LOW)
      ledState = HIGH;
    else
      ledState = LOW;

    // set the LED with the ledState of the variable:
    digitalWrite(ledPin, ledState);
  }
}

```

*Created 2005 by David A. Mellis, modified 8 Feb 2010 by Paul Stoffregen.*

### **(3) Digital Hanger**

Technology makes everything possible and easier!.

Wire transmission enables us to share data with people anywhere and anytime. The ideation of Digital hanger started from a wireless technology: if people want to change the image of their clothing at once, the technology will be useful to apply.

In addition, a liquid crystal display monitor on t-shirts has been shown to the public and it encourages us to bring our media anywhere and anytime. (<http://www.t-shirttv.com/n/>)



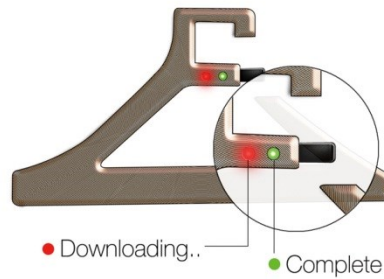
Digital Hanger – A product meets fashion

Scenario

1) Purchase images & mp3 files from websites



2) Data transmission - Transmit data to Digital Hanger



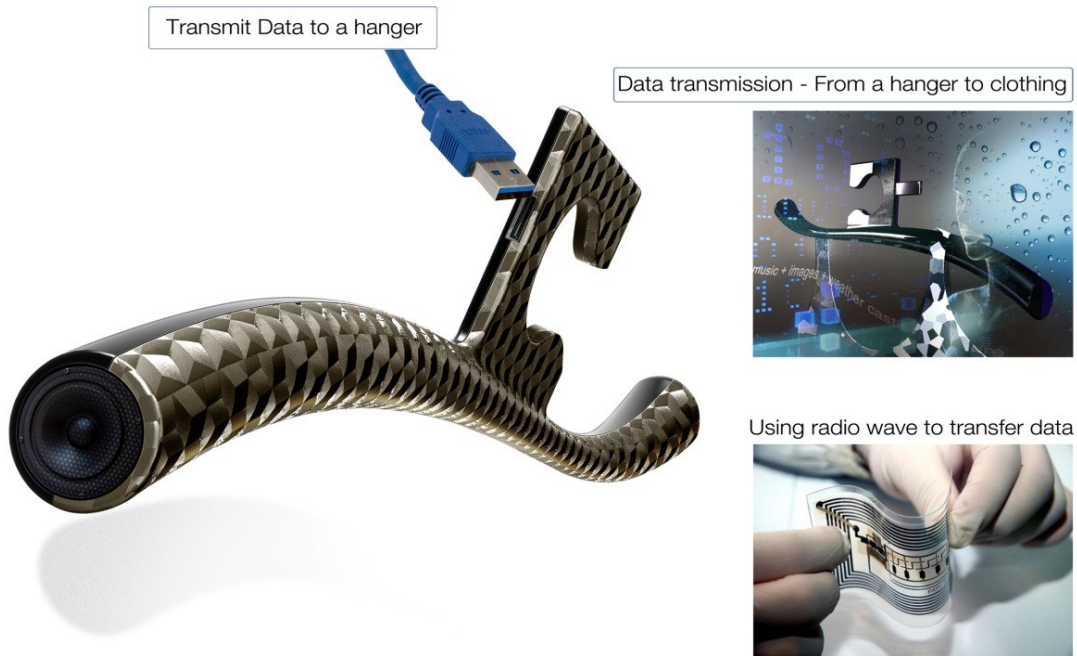
3) Transmit data to clothing



4) Show how to play a wearable



Digital Hanger – Ideation (Scenario)



Digital Hanger – Execution

Through the experiments I would change the look of clothes in both ways: analogue and digital, I needed to do research promising into technology more like E ink. Obviously, modifying the styles by analogue is not very effective, as is shown in several experiments. Therefore, I decided to design customizable clothing digitally. The final ideation of Digital Hanger became the base of this thesis's final concept. Specifically, this technological solution of interaction between a wearer and a clothing was inspired by Digital Hanger's wireless data transmission.

## 6. Final Concept Development and Execution

### 1) Final Idea and Concept

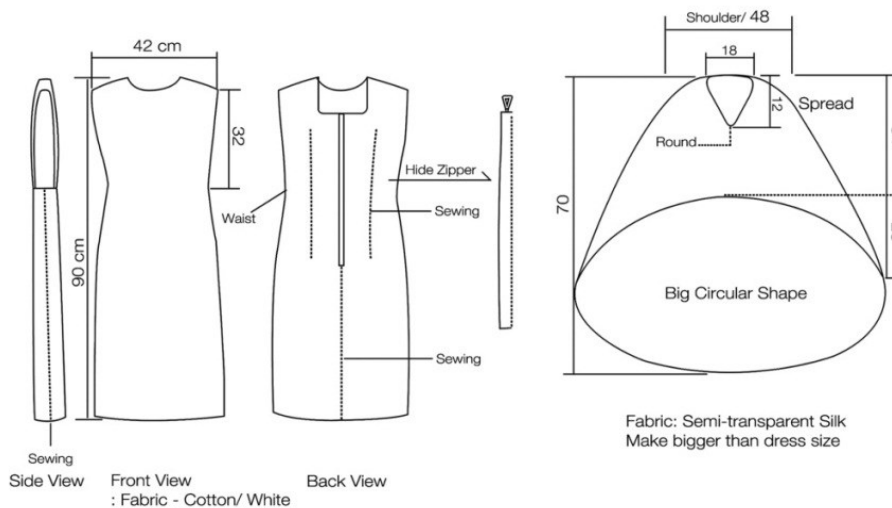
Clothing will be able to turn a normal garment into a piece of art. After developing ideas, I set one direction that a wearer can change patterns on a piece of clothing with digital display technology, e-ink which is readable, rugged, and eco-friendly. Furthermore, it has been developing rapidly as natural inks on a flexible display.

The clothing's patterns will basically be changed by E ink. After people finish an original pattern, they can put the pattern on their clothes. By doing so, the wearer will own the only garment of its kind in the world. It means that the garment is specially customized by each individual. Also, one piece of clothing might express a myriad of looks by displaying original patterns on a digital garment. If a user likes the clothes, he/she will wear the item for a long time.



Pattern Changing Clothing – Final Concept Sketches

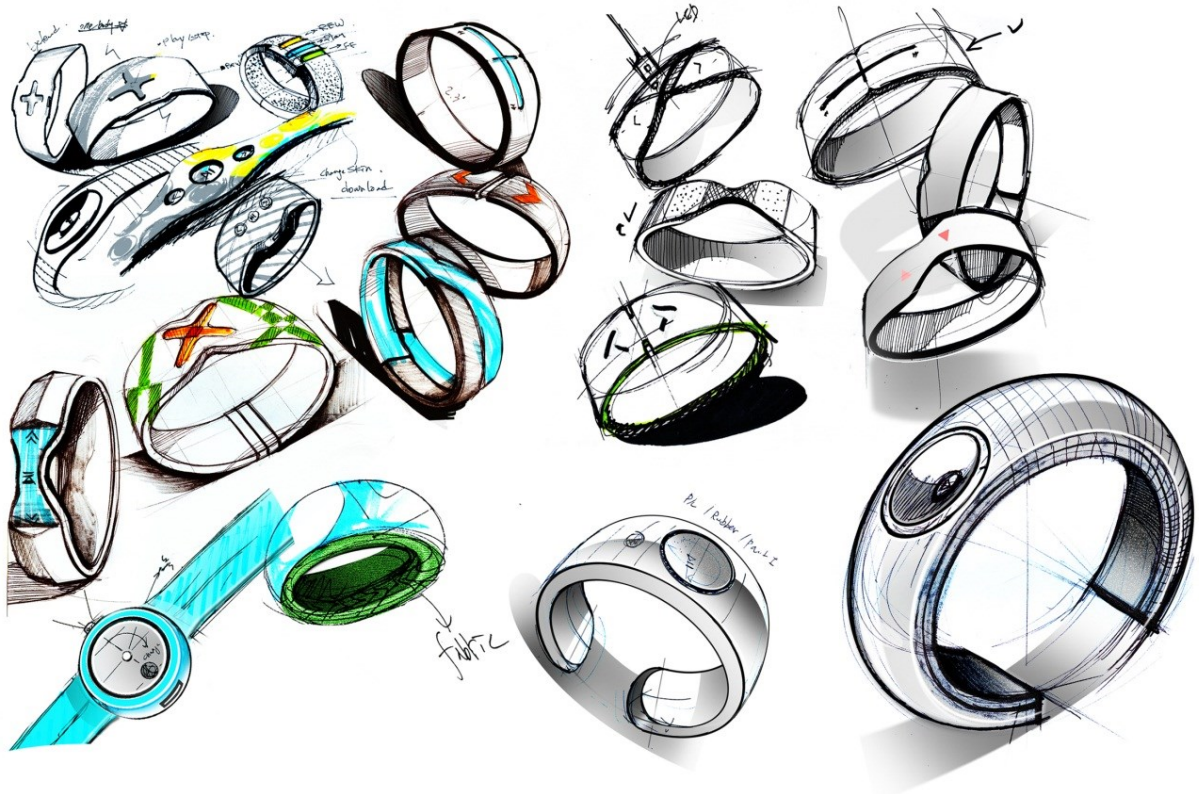
When I started sketching dresses, I focused more on how to show the effective visual changes in the clothes. Using a wide space of clothing may help to show dramatic changes of images. Experiments with overlaid layers will bring more imagination and stories to the clothes. Therefore, I decided to design a semi-transparent mantle with a plain white dress.



Pattern Changing Clothing – The Draft of a Dress and a Mantle

In order to interact with the digital clothing and the wearer, has to have a device that is able to receive and transmit data. The device is called a controller. It helps wearers to change images on a piece of clothing and it also enables us to save data and to transmit data between users and clothes. In addition, I expect this wearable controller will help people to share their original patterns and to display each one's clothing. The purpose of this design is not to create a thing to hold but to wear because of its mobility and convenience. There are a lot of wearable devices or objects on the market such as watches and jewelry. Today, the watch has become not an essential item but a fashionable item or accessory. To match the style with the garment that I designed, I chose a shape like a white bracelet.

Below are my final concept sketches of a controller/ a data receiver.



Idea Sketches: Controller/ Data Receiver 01

With all the new technology in today's world, wireless transmission plays a critical role in sharing data files with others anywhere and anytime. However, the problem of a controller on the right is physical connection. It is not the right solution in the future because if engineers and designers plan to design a product with a USB slot, they have to consider its space. As a result, the product must be thick enough to wear. For this reason, I plan to innovate this old solution by adopting wireless technology.



Controller Modeling



Moreover, a physical connection needs another device to access the data. To improve a controller's overall look and function, I adopted as the display technology - a flexible and transparent OLED. An OLED controller allows people to check various images and select a specific image that they want to put onto their digital garment.

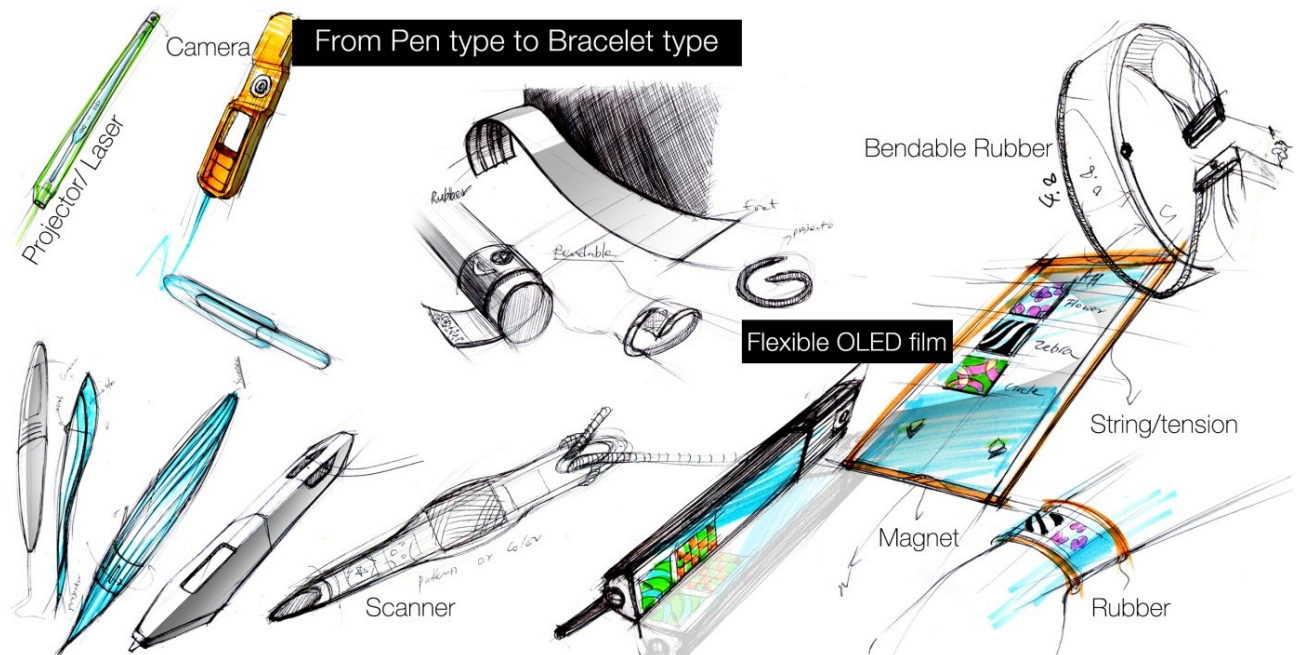
As Ryan Kim describes OLED in his article, "CES09: OLED displays getting thinner, more flexible":

Organic light-emitting diodes are still early in their deployment...Sony is big into OLED after having shown off a new 11-inch display last year at CES. This year, the company is showing a prototype that is just under a millimeter thick as well as bigger displays in the 21 and 27-inch range... it's not only brilliant in color and contrast, (more than 1 million to 1 contrast ratio on Sony's latest screen) but it's super thin and flexible because it doesn't require a backlight like an LCD display... You can also create OLED displays that are transparent so you can see through to the other side. Or you can just make some very simple lights that are bright and energy efficient.<sup>22</sup>

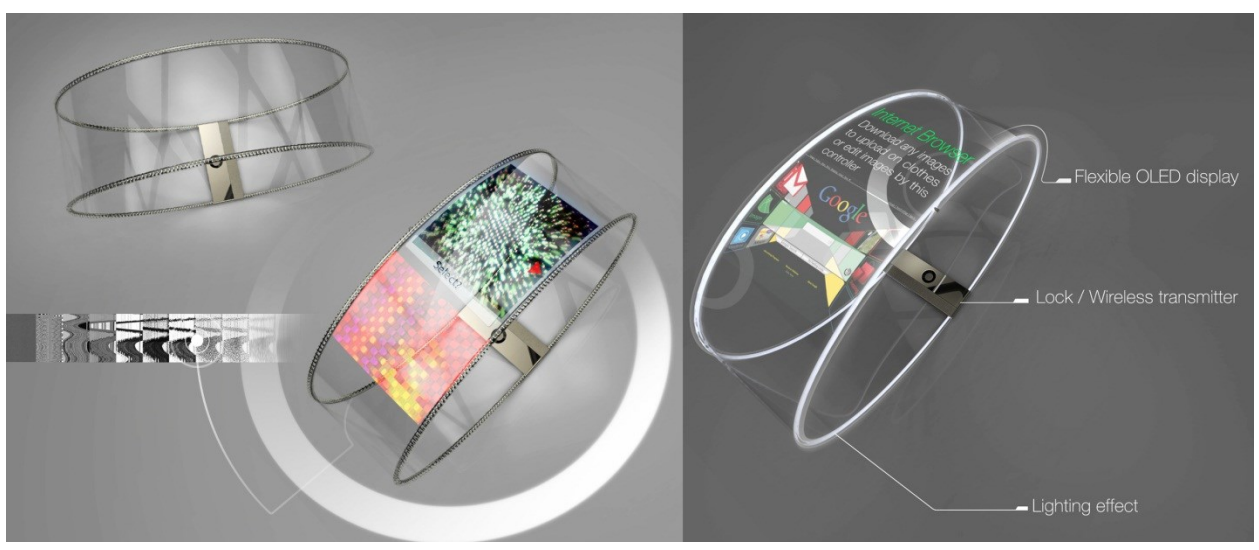
For data transmission between a computer and an OLED controller, NFC (Near Field Communication) will be used instead of using a physical connection like a USB. Therefore, if any surface could be a display, based on touch screen technology, you could control and edit images on a piece of clothing in any condition.

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<sup>22</sup> Ryan Kim, CES09: OLED displays getting thinner, more flexible, 2009  
<<http://blog.sfgate.com/techchron/2009/01/08/ces09-oled-displays-getting-thinner-more-flexible/>>



Pattern Changing Clothing – Idea Sketches: Controller/ Data Receiver 02



Pattern Changing Clothing – Controller Remodeling

## 2) Pattern study

**Why pattern?** Because a pattern is the most effective way to show personality as a fashion-conscious individual and is an original activity to create one's own patterns. It offers users a lot of fun to customize clothing digitally and also helps to build artistic sensibilities.

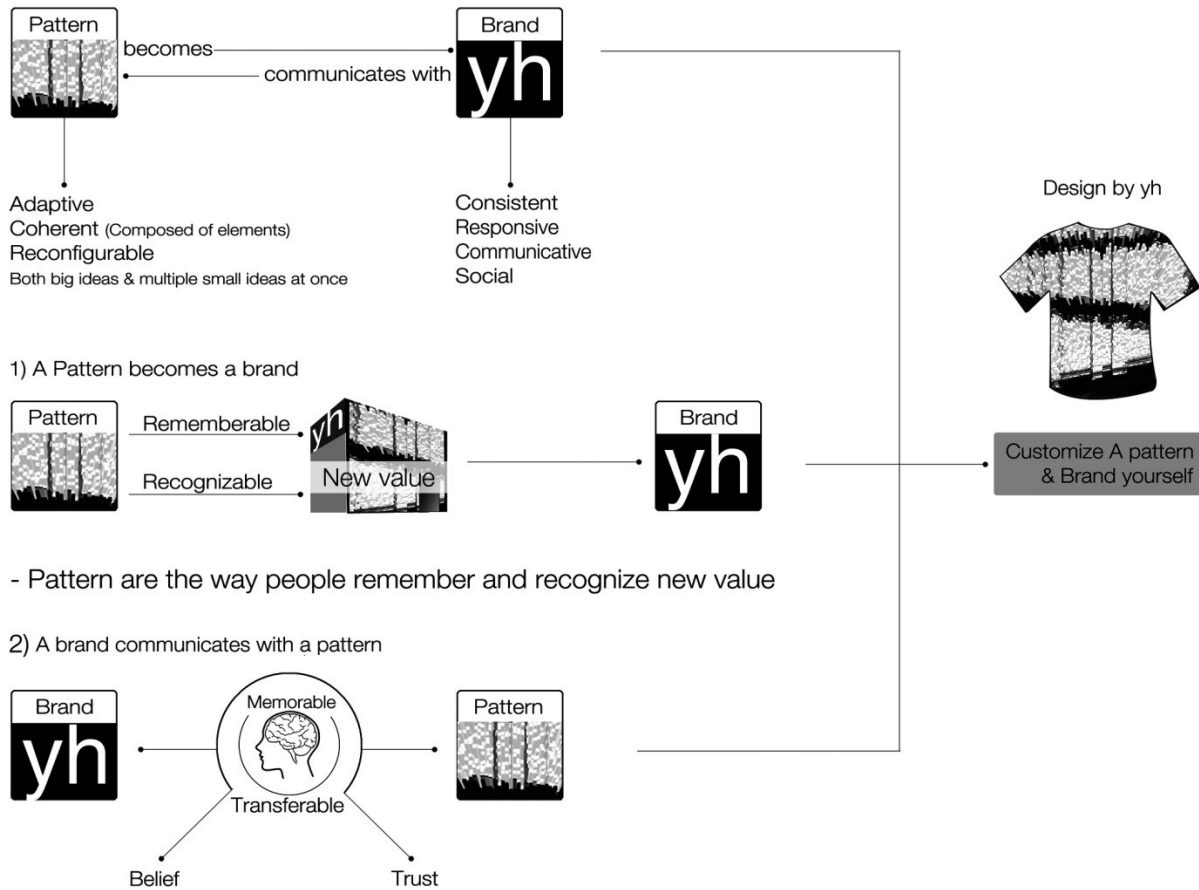
Here is why a pattern can represent a personal identity and can be an effective way of transforming looks visually.

Marc Shillum, who has helped shape some of the world's most prestigious brands, and has received numerous awards as a designer, writer, creative director and strategist and as a principal at Method, describes brands as patterns in his article, "Branding Is About Creating Patterns, Not Repeating Messages" in Contagious Magazine:

Brands are no longer definitive. They are temporal. Brands are informed by multiple voices, and they exist in multiple mediums and through multiple contexts...we all know that brands are increasingly accessed digitally, but a less considered consequence is that the interface through which a brand is accessed has become a primary identity element."

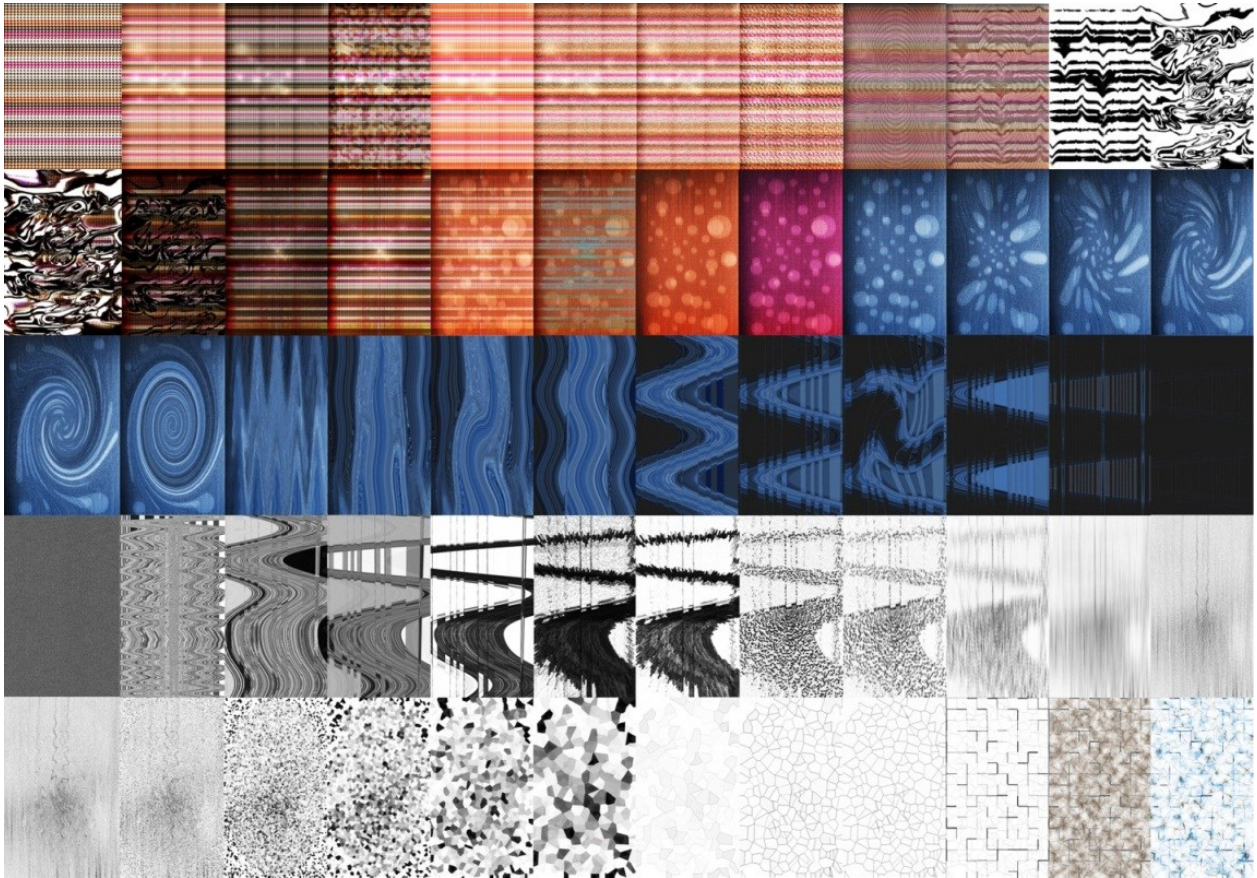
(Shillum, 2012)

## Brands as Patterns & Brand yourself



Brands as Patterns and Brand

First and foremost, I started to create patterns to show visual changes on a piece of digital clothing based on the study of pattern. In order to change visuals on a piece of clothing smoothly, I created one image and modified the style of the image by using the filter tool in Photoshop. The purpose of the varied pattern is to show different textures from jewelry to jeans. Also, changing colors is one of the options to show how one garment expresses different styles.



Various Patterns

Through the pattern study, I noticed that the patterns are very flat and two dimensional, even if their visual changes seemed very natural, so I decided to research patterns and started to create original images based on questions about what elements of patterns or images can change overall looks radically.

There are several elements that can be used for making patterns or images on a piece of clothing. The elements will be:

- 1) Accessories (Belts, Jewelry, Bags, etc.)
- 2) Unique portraits of celebrities - Fame factor
- 3) Different textures
- 4) Three dimensional images (3D)
- 5) Lines, dots, space
- 6) Optical illusion

7) Famous brand pattern (Gucci, Louis Vuitton, etc.)

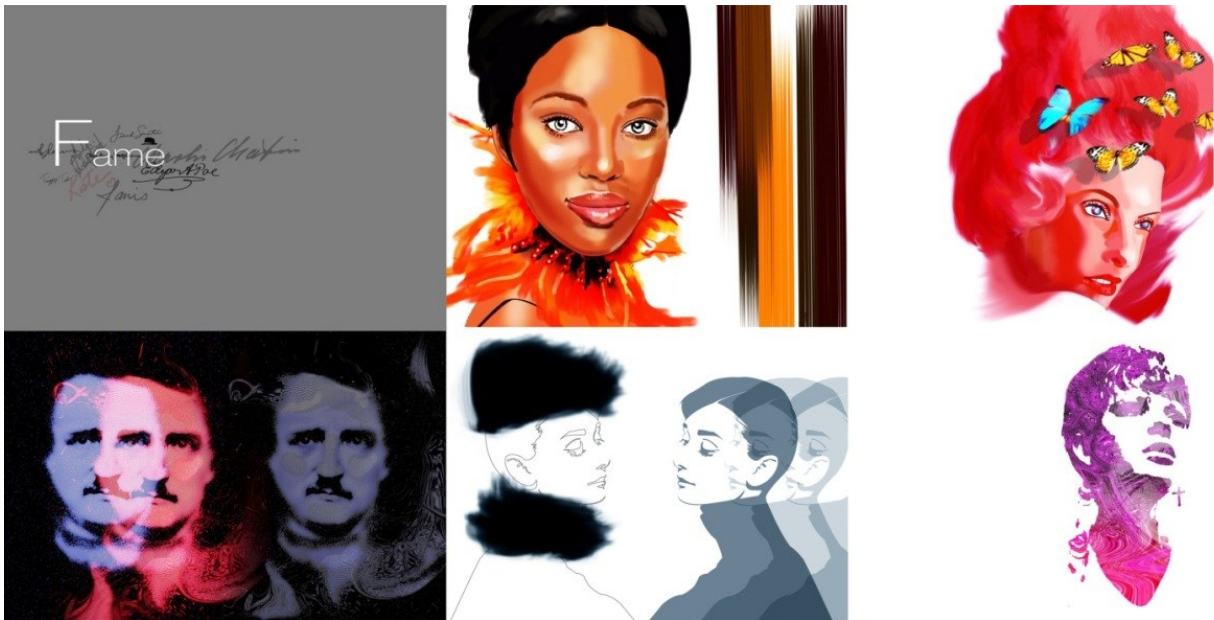
8) Art and craft

9) Each year's color trends



Pattern Study – Accessories

Next images are inspired by famous people. I created portrait images using my imaginings of their unique characters, so all of the images are original. Someday, I hope people are able to create their own portraits in clothing using their unique artistic sensibilities.



Pattern Study – Fame Factors



Pattern Study – Fame Factors (Application)

The look of clothing can be differentiated by the number of original images. Thus, whenever a wearer creates one original image, a user has various options to alter the look of a garment depending on how many images are used for patterns. It is relatively easy to show individuality because creating images is not a difficult task for ordinary people. In addition, a pattern is able to change from unskillful creations to the higher-quality ones, even though the original images are not of high quality. Therefore, when it comes to individual customization, putting created, unique images from image-making programs such as Photoshop onto clothing and changing the images on a garment on a daily base enables wearers to change styles with a piece of clothing easily. Also, in this way the garment is distinguished from custom clothing.

The look of clothing can be differentiated by diverse textures, fabrics, and dividing a surface, even if the outer shapes of clothes are the same. The following figures will show how these factors affect the overall appearance of clothing.



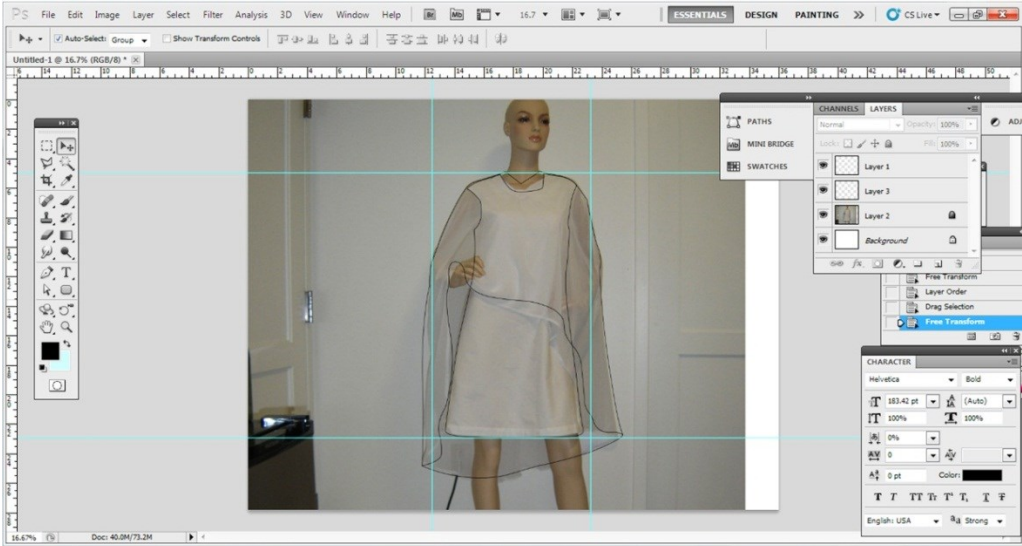
Pattern Study - Textures and Fabrics

### 3) Final outcome

For presentation, I planned to use a projector. This project is a concept product in the year of 2060. Therefore, making a real piece of clothing completely covered by E ink was nearly impossible because it is not invented yet. For this reason, I started mapping the clothes by using Photoshop after taking a picture of a model with clothes. And I used patterns that I created from pattern study. Then, consecutive images were projected onto the surface of clothing. Before completing the mapping of a pattern on



clothes, wrap order from the transform menu on Photoshop (Photoshop/ edit/ transform/ wrap) must be used as it is the key to project mapping because the order of wrap helps to cover the pattern three dimensionally.



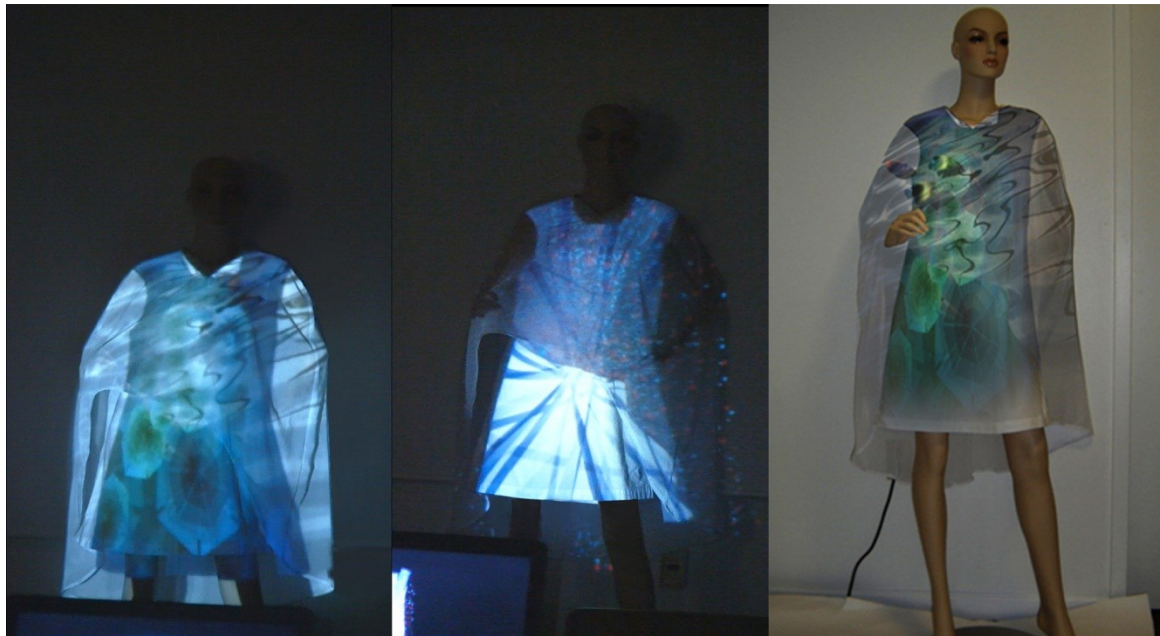
Projection mapping

Here are my videos explaining how to virtualize patterns on clothes using a projector.

Dress with mantle - <https://vimeo.com/40682862>,

Dress - <https://vimeo.com/40682863>

Pattern study - <https://vimeo.com/42758558>

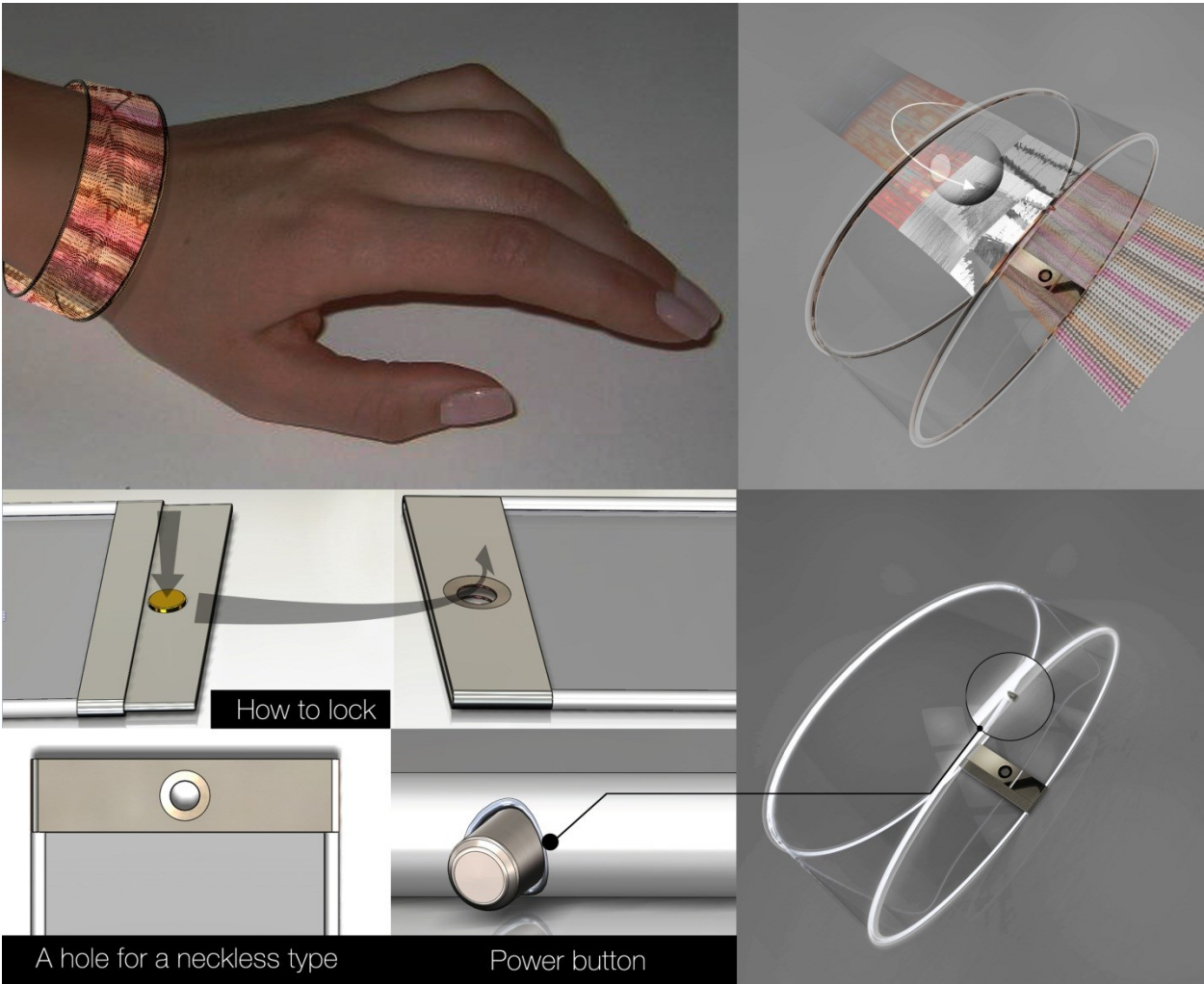


Projection Mapping – Execution

Customized clothing is a reasonable option for customer's satisfaction and for rational consumption because consumers can make sure of their satisfaction through the process of customizing clothes. Also, in order to encourage people to buy less clothing, customers must get long-term satisfaction from a piece of clothing. Therefore, I planned to design Pattern Changing Clothing using E ink. Through creating the clothes' patterns as individual customization, which is an enhanced area of mass customization, people might express their personality as a symbol of their tastes in art, music and literature, etc. Once a user creates a single image, he/she can pattern easily by selecting how many times he/she copies the image.

A controller/data receiver plays a crucial role in this project since its use is the new way of controlling the data and sharing them with others. For instance, wireless communication between a controller and any hardware that has the only image that created by a user makes it possible to transmit data without a physical connection. When a user finishes transmitting data from hardware to a controller, the user can visualize the image/pattern by using a controller.

It is difficult for someone to see what they look like without a mirror, so a flexible OLED displayer will show what she is wearing and what next pattern is available to provide options for changing styles.

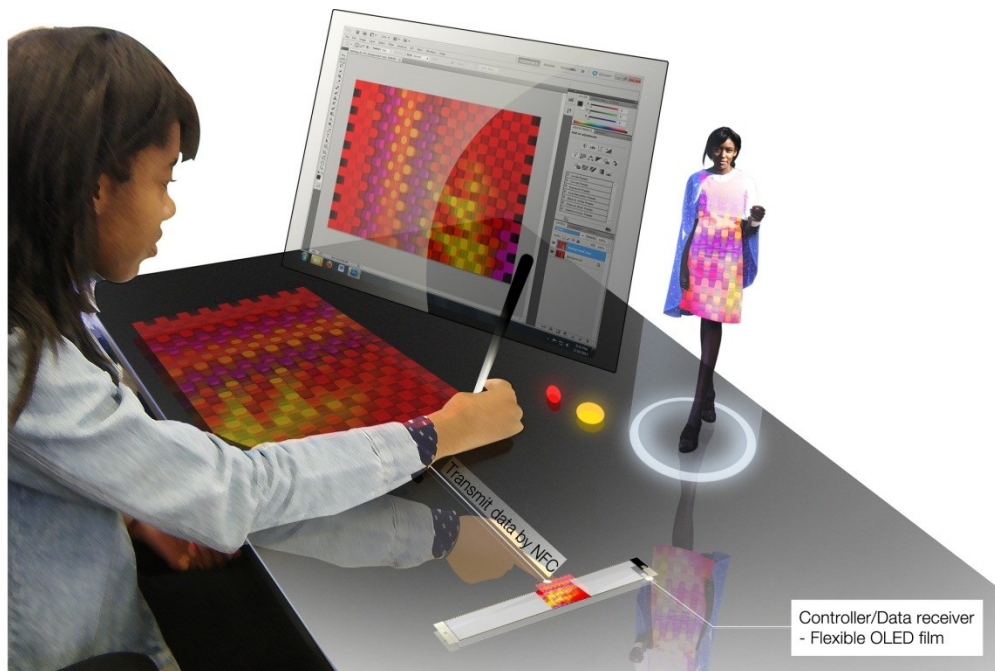


A controller/ Receiver's function

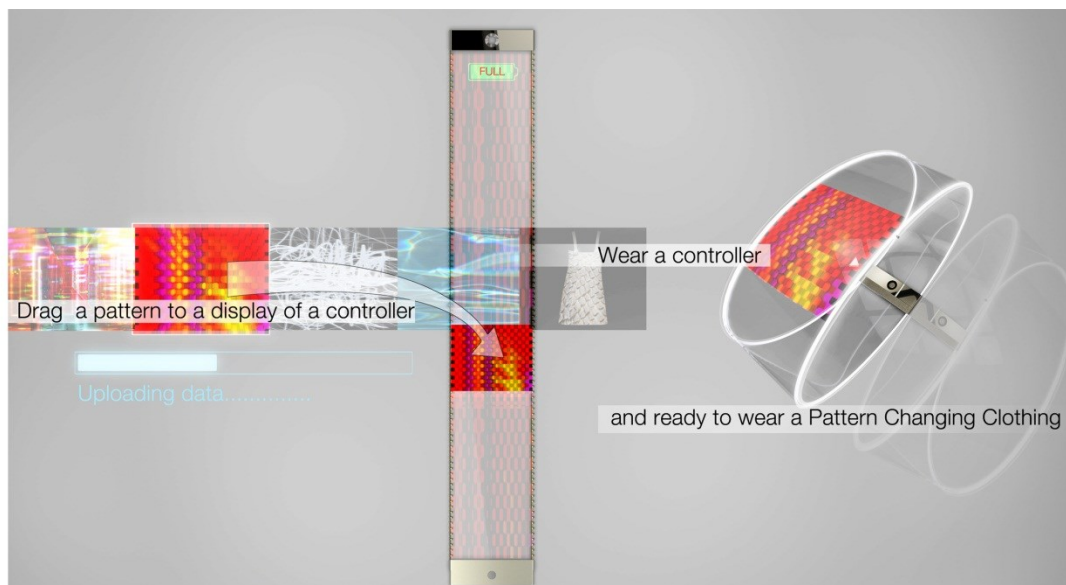
## 4) Scenario

01 Creating patterns by an image editing program/

Data Transmission to a controller by NFC

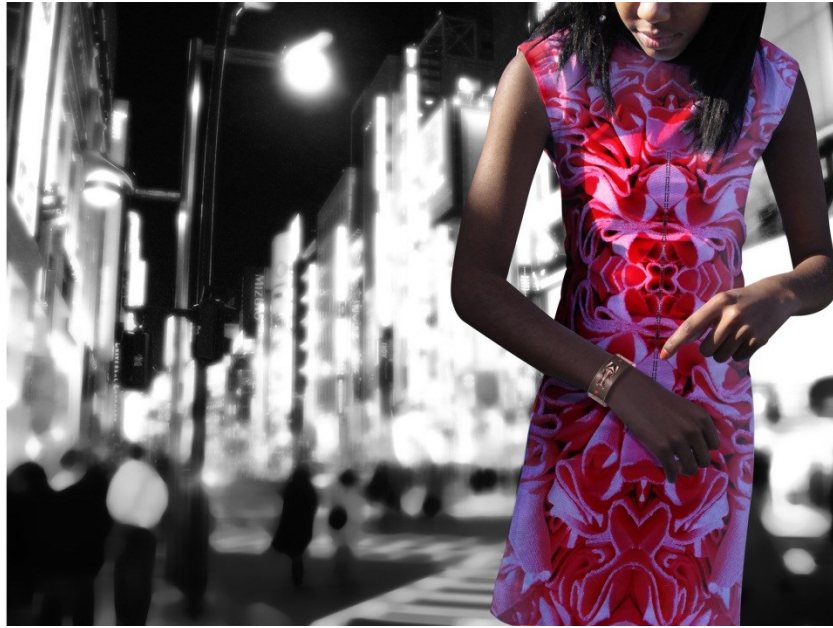


02 Transmitting data to a controller and its GUI



03 Transmitting data to a garment (Pattern Changing Clothing)/

Putting a pattern onto clothes by using a controller



04. Changing patterns according to atmosphere or mood



Graduate Thesis show at Bevier gallery (March 4 2013)



Application of various patterns



## 5) Related technology and washable issue

### (1) Power source

Outdoor - Solar panel on a back side of a piece of clothing

Self-charging clothing: Power can be automatically charged by any movements.

Another way of charging the power is self-charging by vibrations, which can be initiated by a wearer's body movement. In her article, "Self-charging clothing will power gadgets"; Liz Williams describes Self-charging clothes (FIED garments—The Flexible Integrated Energy Device):

Australian researchers are developing a new line of clothing that will power small electronic device and automatically recharge through movement... It will look like an ordinary garment but have extraordinary capabilities... As the person wearing the garment moves, the vibrations they create can be harvested and channeled into recharging the battery or powering plug-in electronic devices.<sup>23</sup> (Williams, 2007)

Indoor - Wireless power transmission enables us to get a product's power source without any physical connection. Its power can be transferred by electronic coils, which are producing electromagnetic waves. If both gadgets have same frequency, those items can communicate with each other.

As noted by Symbian Freak, "WiTricity employs near field inductive coupling through magnetic fields, which interact far more weakly with surrounding objects, including biological tissue. In particular, it is based on using strongly coupled resonance to achieve high power transmission efficiency."<sup>24</sup>

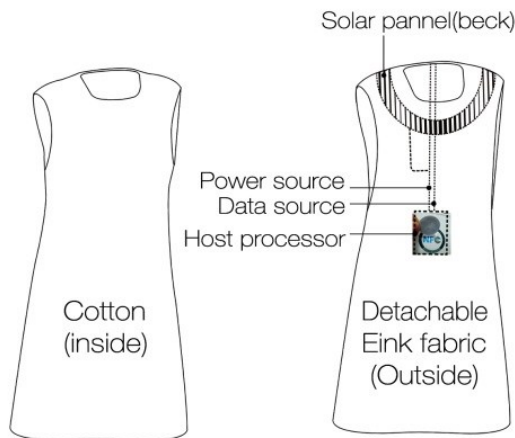
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<sup>23</sup> Liz Williams, Self-charging clothing will power gadgets, 2007,  
<<http://www.cosmosmagazine.com/news/1661/self-charging-clothing-will-power-gadgets>>

<sup>24</sup> Symbian Freak, Wireless Power Next Big Thing? Breakthrough in wireless power pulls plug on cables, 2009,  
<[http://www.symbian-freak.com/news/009/01/wireless\\_powe\\_pulls\\_plug\\_on\\_cables.htm](http://www.symbian-freak.com/news/009/01/wireless_powe_pulls_plug_on_cables.htm)>



Based on the research, I planned to get a power source through outdoor solar panels and transmit data by NFC. The next image displays the plan.



## (2) Data transmission

### The process of data transmission (scenario)

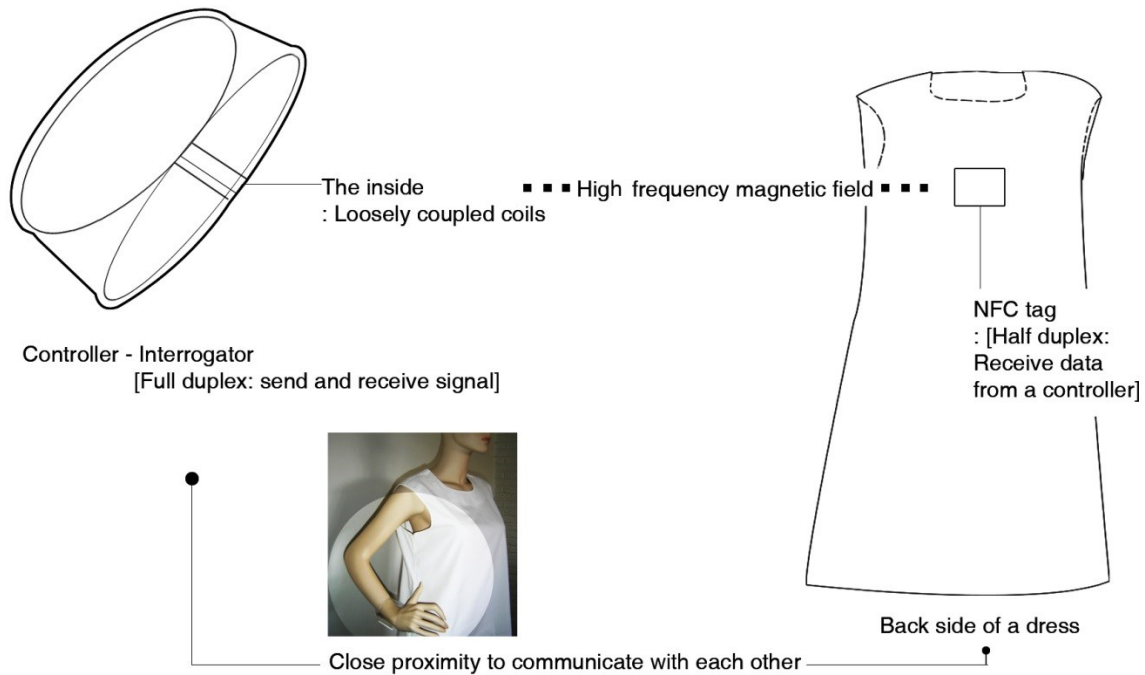
01. Download images or create patterns by image editing software like Photoshop.
02. Store images in a controller by wireless data transmission
03. NFC(Near Field Connection) – Data transmission through NFC from a controller to a piece of clothing (Pattern Changing Clothing)

NearFieldCommunication.org defines Near Field Communication (NFC): It is a form of contactless communication which allows a user to exchange data among digital devices through wireless communication by NFC compatible connection. It uses electromagnetic radio fields instead of utilizing radio transmissions. In the future, all forms of near field communication technology will interact with other NFC compatible devices.<sup>25</sup>

Based on the principle of NFC, I represent how to communicate between a dress and a controller. The following image on the next page shows the plan.

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<sup>25</sup> NearFieldCommunication.org, Near field communication, 2013, < <http://www.nearfieldcommunication.org/>>



Data Communication by NFC

### (3) Washable issue

Why do people think that washing by water is the best way to clean their clothes? Instead of doing that, users can use some fabrics or tissues to clean the surface of clothing or can use detachable E ink clothes. For example, the inside of clothing is washable and detachable anytime and the outside of clothing is made of a thin and transparent E ink displayer.

### E ink

The goal of this thesis project, Pattern Changing Clothing, can be displayed through E ink technology. Therefore I researched the principle of E ink and its development to prove the possibilities of E ink on the clothing.

On the E ink website, <http://www.eink.com/technology.html>, E ink (electronic ink) is described;

E ink is the creator of electronic ink- the optical component of a film used in Electronic Paper Displays, Although futuristic sounding, electronic ink is actually a straight forward fusion of existing knowledge of chemistry, physics and electronics to create this new material. It's so much like paper, it actually utilizes the same pigments used in the printing industry today...Electronic ink is made up of millions of tiny microcapsules about the diameter of a human hair. Each microcapsule contains positively charged white particles and negatively charged black particles suspended in a clear fluid. When a positive or negative electronic field is applied, corresponding particles move to the top of the microcapsule where they become visible to the user. This makes the surface appear white or black at that spot. (E ink, sept.12.2012)

Based on the research, I illustrated the principle of E ink.

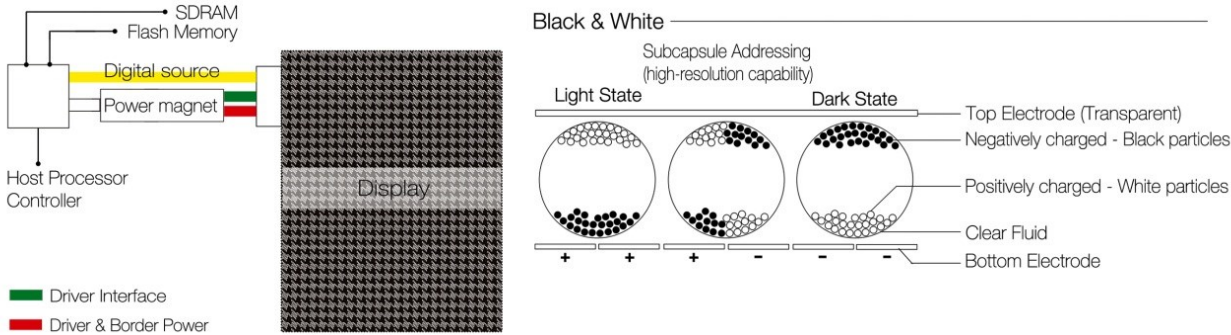


Fig.11. Principle of E ink – Black and White

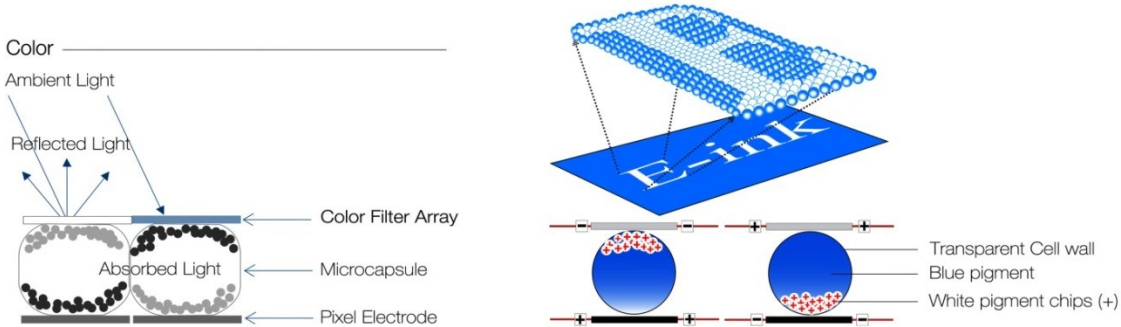


Fig.12. Principle of E ink – Color

It is hard to believe that E ink will be used as a display technology on a fabric, but two videos (E ink on cloth, E ink on Tyvek cloth) which are related to show how it will be applicable to clothing.<sup>26</sup> It is not a future concept of changing visuals on clothes. There are several concepts that are already developed using E ink SURF.

Besides, my previous pattern study showed how the look of clothing can radically be changed by different patterns or images on a base form of a wear. Users who are wearing Pattern Changing Clothing are able to create various patterns easily though image-editing programs, then simply put the images they created onto the wearable. E ink technology will help to display various styles on a piece of simple E ink clothing. The video I mentioned before shows that E ink isn't fully the same as pixelated E ink screens like E-readers but its technology will develop more than today's.

The following sentence will describe E ink SURF:

“SURF displays are divided into discrete segments that can be controlled individually to convey information using letters, numbers and icons. Creative shapes and layouts enable unique form factors and overlapping images. The result is a black and white display with the readability of paper that is less than 650-microns thick.” ([http://www.eink.com/display\\_products\\_surf.html](http://www.eink.com/display_products_surf.html))

Several concepts of E ink surf show that it is possible to display various images on clothes thanks to its thickness and its characteristics—segmented, ultra-thin, rugged and flexible displayer.

Here are the advantages of Pattern Changing Clothing;

### **1) Long-term satisfaction**

- Various looks in one piece of clothing might help people wear the clothing for a long time.  
: This behavior leads customers to reduce over-consumption and corporations to reduce over-production of clothes.
- Wearers easily find new interests in this new piece of clothing.

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<sup>26</sup> E ink on YouTube, E ink on cloth, 2011, <<http://www.youtube.com/watch?v=J17KgbjYMro>>

E ink on You Tube, E ink on Tyvek cloth, 2011, < [http://www.youtube.com/watch?v=\\_tF2GddZqkg](http://www.youtube.com/watch?v=_tF2GddZqkg)>

## **2) Individuality on clothing**

- Pattern Changing Clothing's unique expressions enable us to show our individuality naturally.
- Wearers can brand themselves through showing and creating a new pattern.

## **3) More responses between users and clothes**

- Changing the look of clothing anytime and anywhere gives wearers much pleasure.
- Users can share favorite images and sell their own patterns to others via wireless data transmission.

## **4) Individual Customization (Unlimited choice)**

- The new individual customization's offset disadvantages of mass customization (unnecessary processes, slow delivery time, and discrepancies between customers' expectation and real goods' quality).

# **7. Conclusion**

The motivation for this project is my interest in fashion. Whenever I see various clothes in fashion magazines, I always consider how to apply fashion items to product design. As a result, this interest leads me to enter the field of fashionable technology. My thesis started from a hypothesis: if a garment can be developed into more than a piece of clothing, it will be able to offer a wearer new user-oriented experiences.

Throughout the process, I focused clothing's beauty and believed that customizable clothing encourages wearers to complete their own styles, hoping that they will be able to find their ego through the process of styling the clothing. For this reason, I began to find various methods of changing styles in an analogous way. Positively, I found that users are able to express their individuality, making different styles with their own artistic sensibilities. However, they have to spend a lot of time, energy and money to create varied styles. I was able to meet with new display technology, E ink when I researched visual technologies.

A pattern is usually used for a corporation's identity. If the means of a pattern can be individualized adopting E ink, new way of making styling will be possible. Also, advanced display technologies, such as

E ink SURF, encourages me to develop a more flexible and thinner fabric displayer concept like Pattern Changing Clothing. When this E ink clothing displays different patterns, users will be able to make various styles with just one garment.

When it comes to its possibilities in the future, wearers can share their own thoughts and artistic senses with others through their own patterns in the clothing. Moreover, this clothing's final goal is to give much fun to users using advanced wireless technology, since the technology will make sharing patterns each other possible.

Wearable computers are especially useful for applications that require computational support while the user's hands, voice, eyes, arms or attention are actively engaged with the physical environment. They didn't come up with a garment. When people see early wearables, they seem to be heavy and could be considered wearable computers, not clothes. From this point of view, a garment made of any fabric is a better material because it offers users flexibility to move around freely. For this reason, I planned to focus more on its basic functions than on the wearable's functionality. Thus, the functionality of customized clothing was designed to create a new look or a new beauty through technology.

More importantly, I designed this final outcome to be more flexible and more comfortable in order to offer active motions to these users, who want to create new styles with a piece of digital clothing. For this reason, I planned to adopt E ink technology because it is thin, rugged, flexible, and segmented.

In terms of a designer's responsibility, designing pleasurable products is very important. From this aspect, Pattern Changing Clothing has a positive effect on the pleasurable relationship between users and products because it offers users the joy of creativity like D.I.Y. Also, it is a kind of individual customization with a piece of clothing as the base. When users create new patterns, they can change styles easily every time and everywhere using E ink. I hope that these activities give wearers great satisfaction by using a piece of clothing. Individual customization is one of the benefits of Pattern Changing Clothing.

Thank you very much.

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