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TXD. From Traceability to Experience Design in Fashion Accessories Production.

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Abstract: The research illustrates how the case studies related to the theme of "logistics in fashion manufacturing" could be targeted to emphasize the user interaction with the product system. Radio-waves technologies as RFID and NFC represent a crucial key topic in fashion supply-chain traceability. Emerging technologies as photonics could represent a new step in production authenticity identification working in between advanced manufacturing processes and user experience. So advanced machines and instruments could incorporate by themselves an identification system. So, the user interaction could represent a new step of product authenticity certification. The research path focuses on product interaction according with the innovation processes fashion accessories, taking into account possible extension of supply chain innovation to the product and related user experience. This strategy focuses on the state of the art of advanced technologies already present in this manufacturing sector (i.e. laser, CNC machinery), relying on the ability of SMEs to technology transfer and cross fertilization flexibility. Laser cutting process could be implemented by photonics, so the photon beam could define a high-precision engraving on materials as metal components for fashion accessories (from micro to nano-engraving). The project uses the technologies of optical diffraction as implementation of the artifact. From photon engraving we can create optics with miniature incisions that allow light to pass through a type of hologram numerical control structures in which complex visualization have been engraved in small thin slabs. This process is therefore based on a structure in low relief with a depth of about one micro-meter, more or less the same wavelength of light. This structure is producing an effect of micro-knurling. Through an external light source, working in refraction of a knurled surface with diffractive optics (refraction angle of $\pm 30^\circ$), the user can project an image on an adjacent surface that illustrates or emphasizes contents related to the product. The process of diffractive surfaces "printing" could be provided by machines and technologies already involved in the supply chain. The research is aiming at optimizing these tools through photonics technologies. The user, by an external light source as a laser light, can create a projection by the accessory understanding tangible and intangible values related to the manufacturing steps, places and

people involved in the production of the artefact. In addition, by checking the projection, the user is the final controller of product authenticity, against fake and not legal imitations.

Keywords: Product identity, traceability, fashion supply chain, interaction design, experience design

1. Tuscany manufacturing as a model

Region of Tuscany (Italy) is characterized by some features similar to general panorama of Italian economy and by other factors much more pronounced in this area. It is a region heavily open to international trade, presenting an export percentage stabilized at around 7% of the total share of Italian exportation. Fashion sector, represented mainly by the textile and leather areas, in conjunction with the engineering sector (in particular producing machinery for the fashion system), are the ones driving in exports. Tuscany's international trade confirms the leadership of the fashion Tuscan leathers that, jointly to with yarns, fabrics, knitwear, clothing and footwear, cover about 30% of export products. Manufacturing processes of the districts are based on an articulated division of production between many small and medium companies (SMEs) specialized on a single activity (i.e. in textile sector: spinning, twisting, warping, weaving, finishing). The "work for third parties" (subcontracting) is the form of relationship more diffused in this area. Coordination of the production is done by SMEs who take care of the design of the sample, in conjunction with the various aspects of logistics and SMEs' network organization (Cianfanelli, Kuenen, 2010). The research on Tuscany manufacturing system has being done by mapping the companies' districts in the territory – in touch with companies associations and Province of Florence - and by direct contact to the manufactures. The research focuses on Tuscany as a model of made in Italy manufacturing, Other Italian fashion production areas could be related to the same manufacturing model (especially in fashion system).

2. The user interest for manufacturing values

"The economic and financial crisis is comparable to a cyclone. We're just beginning. The cyclone will transform the socio-cultural paradigms orienting them towards a era of change leading to the "explosion" of communication and consumption models as we have known so far. (Morace 2010). If the systems of consumption and user-product interaction will change, as a consequence, the production system will suffer some setbacks. Therefore, the "craftsmanship" supply chain could present some significant changes and new business visions. High-range manufacturing processes could highlight the product quality to the customer, producing new product concepts and brand awareness strategy. Then, the economic situation is offering a new strategic perspective.

The return to the "substance", as searching for tangible qualities, could be at the center of new user-centred project, highlighting the value of making quality. This phenomenon has accelerated strongly in recent years and it is primarily related to the objects of use, neo-craft attendances (often not in relationship with mass production) in everyday life. The skill and the technical component become the "soul" of creativity, defining contemporary meaning of the "industrial product". The digital

research is fascinated and "swallowed up" by this design dimension, through projects that are aiming at highlighting the values of making, the precision of craftsmanship, the time dedicated to the creation and the "genius" of those who create the artifacts.

3. Research key points: advanced craftsmanship "invariants"

Research focused mainly on industrial districts, usually called "fashion sector," strategic asset of "made in Italy" manufacturing (particularly in Tuscany). Based on specific historic case studies, the research defines a paradigm of "invariants" of advanced craftsmanship (Goretti 2013):

1. Technology transfer ability of SMEs:

This concept is, often, a phenomenon endogenous of the advanced craftsmanship, a dialectical relationship "transferor-transferee" between the operators of the production district for product development and production. Otherwise, actions of "productive transfers" from one sector to another allow the manufacturer to develop and to implement a particular technology in different product areas. These transfer processes lead to application of knowledge into new product areas with a "self-discipline" attitude of companies, without any industrial innovation plan previously defined.

2. Innovation cross-fertilization:

Processes of exchange and transfer of knowledge between different productive sectors, establishing new supply chain clusters and changing the traditional framework of the production chain.

3. The persistence of traditional "craft rites" within advanced craftsmanship context:

We can often find key elements of the supply chain arising as "invariants" elements of manufacturing process. These artisanal rites are since centuries immune from transformation and innovation of production systems. "Archetypal gestures" of craftsmanship.

4. Logistics innovation in the supply chain:

Innovation in production logistics and management of subcontracting in the area are strategic elements to make craftsmanship processes effective on the market.

5. subcontractor SMEs "subjection" vs Fashion Holding and international fashion brands, in spite of SMEs engineering design skills (in particular in production districts in Tuscany), this knowledge is often not supported and promoted by globalized fashion brands (main SMEs customers).

The subcontractor is often a "problem solver" or "factotum" able to make the "dreams" of design offices real. Many design team and art directors go from all over the world to Tuscany, to produce high-range artifacts. SMEs have the main role in product development for the great company, resulting essential to obtain a sample or a collection. This craftsmanship value offered by the SME companies is often completely hidden in the global market scenario.

The Combination of traditional craftsmanship processes and innovation in logistics and manufacturing could represent a significant stage to face future challenges of PMI networks and

made in Italy productions. Craftsmanship heritage absorbs the innovation, then new technologies could be implemented into the advanced craftsmanship supply-chain. As laser cutting or numeric control machines became part of this production framework, as Identification technologies are a significant innovation in logistics of high-end manufacturing as new advanced technologies could be part of this value chain. The research will highlight new potentials of including emerging advanced optical technologies into the made in Italy supply chain, as an experience design and communication booster for product tangible and intangible values.

4. Mission and boundaries of the research

Research aims at identifying new design strategies related to product and supply chain through interaction with tangible and intangible values of high-end manufacturing. Therefore, we have developed an evaluation tool to interpret the complexity of “made in Italy” supply chain. We are defining three research areas:

1. “Saper fare” related to SMEs manufacturing sectors
2. Sociological instances relating to the high-end product manufacturing, interpreting the contemporary consumer perceptions and identifying possible development scenarios of product values;
 - 3.1 Advanced craftsmanship including advanced production technology (i.e. laser cutting, CNC machines)
 - 3.2 ICT implementations on product and innovation in logistics (i.e. identification technologies).

The advanced craftsmanship processes are mainly based on the interaction between the areas 1 and 3. The contemporary “made in Italy” supply-chain develops the product on the commissions of large national and international fashion brands that “use” the “Saper Fare” and the technological innovation (innovation in supply-chain and ICT) to have a unique quality of the branded product (i.e. Chanel, Gucci). Following this process, the brand is recognized as the only warranty of quality. The supply-chain steps and the craftsmen values are completely hidden from the brand reputation.

4.1 Innovation in production as a support for advanced craftsmanship

The concept of craftsmanship (it. Saper fare) means "knowing how to do things," including the arts and skills of doing, knowledge of the materials and craft processes. When this knowledge meets innovation, when innovation absorbs the craftsman tangible and intangible skill - without to delete it - then we speak about advanced craftsmanship. One of the most interacting example of this connection between the “human factor” of craftsmanship and innovation in manufacturing is represented from laser cutting introduction into fashion production system.

The research introduces the case-history of El.En , laser innovation company based in the Florence area, leader in medical and industrial research. The company is involved in fashion production developing very innovative finishing and creative solutions for fashion accessories and clothing. Then, laser technology works as a support for the final quality, guided from the expertise of the craftsmen as a real advanced craftsmanship implementation.

Laser great flexibility makes it suitable for marking applications in the decorating and fashion industries. In laser marking applications the laser beam will touch the surface for a time short enough

to leave a mark, resulting in a decorating pattern. The laser is completely controlled by the computer, thus no human error will interrupt the workflow. In addition, you will get great uniformity between the parts along with the possibility of fast changing patterns and designs. Always with a high-level of quality. El.En engineers work with the client company to study the solution that best serves specific needs.

Laser sources are widely used for laser micro-perforation applications. When it is operated in pulsed mode, a laser source can drill accurate holes on plastic film, paper and tissues. Compared to mechanical micro perforation, laser offers speed, flexibility, resolution and accuracy. CO2 laser sources pulse with a maximum frequency of 100 Khz to get perfectly round holes, with no debris or signs of recast. Owing to those characteristics, CO2 laser sources are widely used in the fashion industry to make decorations based on micro-perforation.

Metalworking is today's most diffused laser material processing application. Laser sources provide with a broad range of CO2 laser sources and scanning heads for cutting, drilling, welding, metal applications. In metalworking, accuracy should be the top priority. Laser sources process only the right amount of metal, at the exact location and within the closest range of tolerance you can imagine. Plus, the parts will be delivered completely refined: flawless, smooth pieces, with no imperfections to the touch.

In addition, leather laser processing is widely used in the decoration and fashion industry. Cutting out intricate shapes, drilling hundreds of micro-holes or etching the most complicated arabesque is possible with laser sources. Using a laser on leather is an extremely efficient operation: since leather is a high-absorptive and low-conductive material, it takes small amounts of energy to get great results with low costs.

Laser source technology offers several advantages:

- exclusive and incomparable decorative effects;
- low operational costs;
- inexistent environmental impact;
- work safety.

4.2 State of the art of innovation in logistics in Italian manufacturing system and new interaction processes user/product

The concept of the research focuses on the state of the art of Italian high-end manufacturing concerning innovation in traceability and interactive product innovations related to logistics of manufacturing chain ("logistics in manufacturing").

By the Introduction of the identification technologies and new traceability systems within supply chain, high-end Italian product is undergoing a substantial transformation. Beyond the important improvements related to the time to market and quality control, supply chain allows new systems of interaction between user and product.

In particular, RFID (Radio Frequency Identification technologies) made a significant innovation in "made in Italy" supply chain, tracing the products and the entire logistics process. In addition, the new generation of identification technologies is represented by NFC (Near Field Communication technologies).

RFID Technologies

Radio frequency identification is an automatic identification method consisting of several components such as tags, tag readers, edge servers, middleware, and application software (Nayak 2015; Rao 2005; Chao 2007). Among these the three important components are RFID tag (also known as transponder), RFID reader (also known as transceiver or interrogator) and software for data processing. An RFID tag is a small object that can be attached to or embedded into a product, animal, or person. It consists of a tiny chip where the data is stored and an antenna to enable it to receive and respond to radio-frequency queries from an RFID transceiver. The tags contain electronic product code (EPC) and the information related to the product like the name of the company, batch and year of manufacturing, price etc. (Myny 2010).

In the field of textile, clothing and fashion accessories, radio frequency identification (RFID), is used in manufacturing, inventory control, warehousing, distribution, logistics, automatic object tracking and supply chain management. Various retailers and manufacturers (of clothing as well as consumer goods) such as CVS, Tesco, Prada, Benetton, Wal-mart and Procter & Gamble, are now implementing the technology and exploring the impact of the technology on their business. RFID technologies may improve the potential benefits of supply chain management through reduction of inventory losses, increase of the efficiency and speed of processes and improvement of information accuracy. The basic of success lies in understanding the technology and other features to minimize the potential problems. Although the technology existed for several years, the technological challenges and cost issues are the major hurdles for the widespread use of RFID. This technology has been addressed to various applications related to inventory management, production control, retail management, brand segregation etc. in fashion industry.

It is quite imperative to understand the needs and taste of customers especially in fashion industry to offer them the right product of their match. Moon and Ngai (2008) conducted a study on the use of RFID in fashion retailing and reflected that different customers behaved different at different time in their shopping experience and knowing them in depth regarding their shopping experience was very important so that sales personnel could provide them with personalized services. The interviewee in their study said that if the customer entered into the store and picked few item connected to RFID technology that would provide signal of their pattern of choices on that day so tailored advice can be provided by sales staff. As competition is intense between the brands so it is important to satisfy the customers by knowing their choice by creating their history of purchases, especially for high-end products.

NFC technologies

Near Field Communication (NFC) technology, a specified protocol within RFID, is gaining ground in fashion items. It's readable on any mobile-enabled device from within a few centimeters, and, when combined with connectable cloud software, creates new ways for brands and consumers to interact. NFC gives a unique, non-transferrable identity to each item, enabling brands to deliver value-added services that help drive revenue growth and loyalty, while also gathering customer intelligence.

NFC technology can benefit production and brand awareness in following ways:

1. Authentication & anti-counterfeiting. Research shows that as much as 10% of luxury apparel, 20% of sportswear, and 30% of sunglasses are already counterfeit today (Vandagraf International Research, 2015). With NFC and mobile authentication services, consumers can be certain they're buying genuine products, while brands and retailers can prevent revenue loss and protect their reputations.

2. Context-sensitive digital content. NFC can provide digital content and services related to the product, based on real-time shopping needs, so as to motivate on-the-spot sales. Useful details, such as color or size selectors, reviews, social feeds, and in-stock item visibility, can sway the purchase decision. Recommendations for other items that complement the outfit can create cross-selling opportunities.
3. After-sales service. NFC can enhance the user experience after the purchase, with easy access to customer care, exclusive brand applications and tools, or personalized rewards. These in turn help foster brand loyalty and repurchases.
4. Customer intelligence. Cloud-based NFC applications can track all tag interactions, for added market intelligence. So brand owners can, respecting privacy law, collect valuable data on customers' identities, their interests and habits.

IT4Fashion: sharing innovation in logistics among fashion manufacturing SMEs

IT4Fashion is an industrial and scientific conference and exhibition where fashion companies, brands, practitioners, researchers and software houses, from all the Europe, discuss on IT technologies in the field of fashion and luxury. The conference is held in Florence (Italy).

The conference represents, since its first edition, a unique event where fashion companies present their greatest success stories in the application of IT solutions, together with keynotes on new technologies and IT solutions made by leading industry experts. Traceability of production, saving manufacturing values and authenticity of the artefact are some of the main topics emerging from the conference.

Within IT4Fashion is emerging a new instance of logistics in fashion manufacturing. The conference is often relating to the new role of ICT, in particular identification technologies and interaction technologies, in creating and setting new performances product-based. So the ICT research is more and more moving from supply-chain to the final artefact, making the final output including the research values spread within the production chain. So, could we create new product performances and new final effects making the final user aware about the innovation in manufacturing? Would it be possible to make the final user aware about traceability and authenticity of productions?

Patrizia Pepe interactive screen represents a significant step in this direction. Patrizia Pepe fashion clothing brand and manufacturing supply-chain based in Tuscany (Italy) based the storage system on the RFID traceability. Then, The brand applied this technology to optimize the retail experience, introducing within its stores a multimedia totem, a touch-screen implemented by RFID active readers. This system is allowing the customer to have additional information in detail about a selected product or to combine the artefact to other items. The RFID active reader incorporated in the screen is recognizing the RFID passive tag in the garment and all the information included. By bringing the product to the screen, the monitor visualizes the item image and all the technical information. In addition the screen suggest other products related to the same look and creating a complete fashion styling concept.

4.3 From the supply-chain to the interaction process

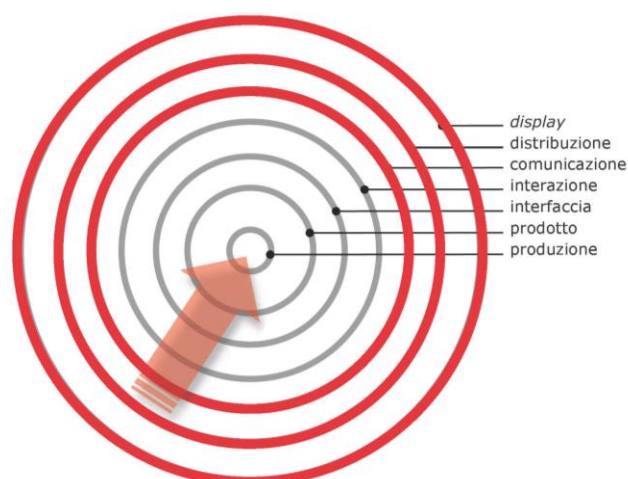


Figure 1. Example of Product-system diagram application – Shaping emotions workshop – REllab Design Campus –DIDA University of Florence (Italy)

The diagram illustrates how the case studies related to the theme of "logistics in manufacturing" are targeted primarily at the outermost level of user interaction with the product system. It is therefore proposed a project line that moves the focus of Italian research on the product-based interaction to production content and morphology of the product. The research path focuses on product interaction according with the innovation processes, taking into account possible extension of supply chain innovation to the product.

This route avoids typical aspects of "mediatic" communication and marketing strategies. Large companies have begun to feature the roles of artisans in their marketing strategies. In 2013, Louis Vuitton launched an advertising campaign centered on the craftsman. The shop windows of Dolce & Gabbana's boutiques displayed photos of both seamstresses and celebrities, working together to create clothes through various fittings and adjustments. Gucci has proposed the Artisan Corner: a network of events in their flagship store in Florence, bringing into the store the finest craftsmen, and presenting them within their production network. (Fry, Goretti, Ladhil, Cianfanelli and Overby 2016) The market trends is not explaining the intrinsic values (Goretti 2013) of craftmanship, but on the contrary making the artisanal value as a romantic and superficial effect.

The research proposes a new path in experiencing manufacturing quality and know-how. This strategy focuses on the state of the art of advanced technologies, already present in the manufacturing sector (i.e. laser, CNC machinery), relying on the ability of SMEs to technology transfer and cross fertilization flexibility. In particular laser cutting presents interesting point of interest in this context:

- High performance and wide scope for innovation;
- Wide scope of technology transfer between fashion and other scientific sectors (i.e. chemistry, physics);
- High quality of the workmanship and high-quality final effect;
- Possibilities in the miniaturization of processes;
- Giving the effect of high-quality and high-end finishing of product.
- State of the art of innovation in fashion manufacturing shows that new technologies could be implemented into production chain following used innovation processes in the supply chain. Technology transfer and cross fertilization attitude could support the insertion of new advanced technologies in the advanced craftsmanship chain.

5. Research output

5.1 Photonics implementations in laser works in manufacturing

The dramatic advances in photonics technology mean that today's industrial laser systems offer unparalleled capabilities in precision manufacturing and advanced materials processing. The potential for improving laser based manufacturing technologies is further increased with the advent of new laser source technologies and process control methodologies that aim to deliver right first time manufacturing.

According to the state of the art in this field, we can highlight new research frontiers proposing leading-edge laser based manufacturing process technologies including:

- High efficiency laser sources
- Micro and Nanosystem laser fabrication methods
- Additive fabrication through supersonic laser deposition of metals
- On-line and in-process optical diagnostics and control
- Ultra-short pulse laser interactions
- Hybrid ion, plasma, and laser machining for ultra precision applications

Hiroyuki Toyokawa, in Application of laser Compton photon beam to nondestructive tests (Toyokawa,2015), says that

"There are attractive technologies in nuclear physics and elementary particle physics especially in radiation measurement technologies. They are high sophisticated, and can be applied to industrial technology with some modifications. We applied a method for measuring cross-sections of atoms and nuclear reactions to nondestructive testing via industrial radiography."

This kind of photon beam is used to test to reliability of materials. The research propose this technology for high-precision works on metals and other materials of fashion supply chain.

5.2 Optical diffraction as a new technology transfer for fashion manufacturing

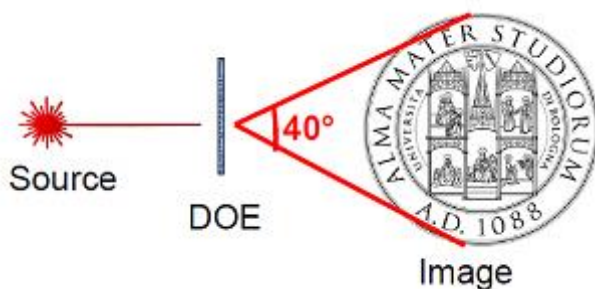


Figure 2. Diffraction Diode Emission – DIES Department University of Bologna (Italy)

"With the rising of CD technology, in which a diode laser of small dimensions interact with micro-optics in a particular high-miniaturized way, it has become clear that this combination of success, between light emission and smart diaffram provide a benefit to many technological systems of the future".

These systems present the advantages of being small in size, low cost and effective. The Micro-optics can be designed to produce a refraction, in the traditional way, or diffraction, in the form of engraving micro-systems.

“The optical diffraction allows light to pass through a numerical control hologram in which display with complex structures have been etched in small thin slabs. The result is a bas-relief structure with a depth of about one micro-meter, more or less the same wavelength of light producing a micro knurling effect. In this way, it is possible to control the light, divert or to focus in any way we want. It is possible to calculate and customize the relief on the sheet, which is then made with micro-electronic technology”, states Sverker Hård (Nikolajeff F., Löfving B., Johansson M., Bengtsson J., Hård S., and Heine C.,. 2000)

These small elements, called kinoforms, can be used in all those applications in which a control of the photons is required and where smallness and accuracy are particularly important.

“In the world of research, there are many possible applications of this technology”, says still Hård;

for example, areas of particular interest for the implementation of this type of devices could be the telecommunications, biosensor systems or the development of computer facilities which require a rapid visualization or parallel interactive processes.

“The production of such devices can be through molding in different materials, such as metals and silicon, but also in plastic. Using the molding process, indicated as “master”, it is therefore possible to produce the optics in a large scale”.

The optimal technology for such molding processes is the laser beam (which may reach quite high engraving of miniaturization values) or the systems of electron beam lithography (through which can be reached the optimized performance).

Some technical features of diffractive optics:

- It is possible to obtain projections using any kind of laser light (650nm, 635nm and 450nm)
- It is possible to use this technology at different scales of project and applied on different kinds of material;
- Reflection edge in a range of +/- 30°;
- We can obtain projections through a DOE (Diode Optics Element) or as a result of a reflection through an external source.



Figure 3. DOE Diffractive effects examples - DEIS Department University of Bologna (Italy)

5.3 Optical diffraction as project proposal

The project uses the technologies of optical diffraction as implementation of the fashion artifact.

Objective: making the final user understanding the product tangible and intangible values, in particular craftsmanship among the supply-chain, traceability and authenticity of the artifact. Making the final output of fashion supply chain communication the values of the enclosed craftsmanship. Making the communication of product quality as an intrinsic values of the item.

Action points:

1. Embossing: creating a diffraction mold by a photon beam cutting on a metal surface where we produce the micro-knurling (nano dimension). By the photon beam numeric control we can create a specific embossing effect.
2. By the embossing shapes, we create the optics that could be produced in a large scale.
3. The optics are assembled to the specific components or the final fashion item.

This technology uses optics with miniature incisions that allow light to pass through a type of hologram numerical control structures in which complex visualization have been engraved in small thin slabs. This process is therefore based on a structure in low relief with a depth of about one micro-meter, more or less the same wavelength of light. This structure is producing an effect of micro-knurling. Through an external light source, working in refraction of a knurled surface with diffractive optics (refraction angle of $\pm 30^\circ$), the user can project an image on an adjacent surface that illustrates or emphasizes contents related to the product. The process of diffractive surfaces molding could be created by machines and technologies already existing in the supply chain or through photonics innovation on existing machines.

Through the diffraction system, the user can "play" with the product, to know the information that are enclosed within it and evaluating, through the images themselves reflected, the authenticity of the product. The system of diffractive surfaces reproducible through complex mathematical functions can be useful as a system against counterfeiting.

The technology process is feasible as presented in DOE Diffractive effects examples in mobile systems. The research presents and forecasts possible technology transfers to fashion manufacturing. Optical diffraction application could follow the identification path proposed by RFID and NFC technologies, but working through an endogen innovation of the supply chain (not only through external electronic applications on the artifact). Moreover, the application of optical

diffractive methods could highlight the intrinsic attitude of SMEs in technology transfer and cross fertilization applications.



Figure 3. Dffractive effect by reflection due of an external laser source – application on a metal component of fashion accessory – REllab DIDA Department University of Florence



Figure 4. Dffractive effect by reflection due of an external laser source – application on a metal component of fashion accessory – REllab DIDA Department University of Florence

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