Value added creation with advanced mass-customized textile labels

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Abstract. Process-oriented value-added creation in textile networks for mass customization tries to close the backlog and the research gap for mass customization in textile networks by using IT-based security labels according to the research projects “Profund” and “TechProTex - Etikett”. Special attention will be paid to the complex product identification and tracking to both B2B and B2C markets. By using the developed platform, the cycles for the new development of a product are significantly reduced. New labels printed with various identification features and QR Code are available in four security levels. The identification is counterfeit-proof, customer-friendly as well as the basis for future-oriented cross-company textile value chains.

1. Initial point

The importance of counterfeit products and brands is growing worldwide. Such products are having increasingly serious consequences, especially for small and medium-sized companies (SMEs), such as costly proofs of complaints or product liability, loss of image and loss of turnover. The marketability of SMEs in the textile chain thus depends, on the one hand, on the reliable differentiation between original and fake goods. On the other hand, both the market and the more and more automated production environment are oriented towards digitally networked, customer-integrated and smart value creation with security requirements at a high level.

Especially in the case of process-oriented mass customization in textile networks, SMEs must establish, demonstrate and ensure trusting cooperation with each other in the B2B sector. For this purpose intelligent framework conditions and tools that can be easily integrated into the textile chain are needed [1-2]. At the same time customers are an increasing part of textile manufacturing and sales processes. Technical textiles are not only becoming smarter but are also more transparent and informative, thus promoting so-called customer integration competence.

The development of textile based materials in combination with IT-based technologies for a new material protecting label is seen as a sustainable solution. This label was developed as a combination with digital-based identification and information scenarios with individual, counterfeit-proof markings with suitable printing technologies within the research project “TechProTex - Etikett”. Individual, integrable security features were combined to form a marking that is highly resistant to counterfeiting in the long term. The paper refers to a label service concept with scalable security levels that can be adapted to different application areas in the context of a future-oriented textile label. This label is considered in the context of mass customization and envisioned SME cooperation from the research project “Profund”.

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Included are basically visible and invisible functions, in particular directly readable information such as brand, manufacturer, size or maintenance instructions and additional data that can either be accessed directly via a QR code or encrypted for an authorized user group, such as batch or tracking number, material origin or production details. As a reference object, an online platform with product information was developed. Manufacturers, dealers and customers can virtually zoom in on the details of the textile product and get more information about it. It is assisted in a targeted manner and integrated into the textile life cycle.

The increasing demand for ecologically and fairly produced textiles and the knowledge of their origin can also be channelled through the new label and transferred into a format that is very effective in the media. In the context of social digitization, successful textile manufacturers and service providers need new tools both to visualize their products and to occupy their social reputation in terms of transparency, credibility and ethical responsibility.

2. Approach
The structuring and realization of the future-oriented label is based on the individual development modules within the framework of customer-specific ready-to-wear production, printing, labelling technologies, process modelling, data management and logistics.

A different label structuring was created by process engineering, modelling and development of the connection between textile material and securing marking particles. The basis was a digital printing ink that could be used in the label as well as pastes for screen and transfer printing. The printing technology was adapted to the finishing of various flat linen products or to the finishing of contract textiles with innovative, customizable labels and integrated into the textile manufacturing process.

Process modelling led to a coded, copy-protected and controlled information deposit as well as to the provision of necessary interfaces, algorithms and visualizations. For example, it was planned to make the information to be read more flexible in various national languages. By incorporating this flexibility into the data solution, the textile labels can be produced cost-effectively in larger quantities. The prerequisite for this is the use of interfaces between printing systems, merchandise management systems, readout units and data management.

The question of an economic vision to organize and configure textile value creation was analyzed both in a corporate network and in the B2C sector. Requirements and information structures at the manufacturing, customer and sales levels have been classified and converted into security levels that can be implemented by the label.

3. Results
3.1. Mass-customized textile labels
Invisible security features (anti-counterfeiting) were added to the label and the textile product, both in terms of printing technology (screen printing and micro valve printing) and textile technology, in particular in terms of textile surface formation and ready-made clothing. The printing of the security features was realized by developing a special ink for application by means of a micro valve nozzle and two pastes suitable for screen and transfer printing. In order to achieve the security-compliant and IT-functional distribution, these security inks and printing pastes were applied to the respective textile surface in defined geometries using screen or digital printing processes.

It was possible to produce the marking spots using the direct printing process and, based on this, the complete label. Two formulations based on polyurethane and polyvinyl chloride were developed. Figure 1 shows an example of a section of a white polyester fabric screen-printed under UV radiation. The layer quality is sufficient for use in corporate wear.
As result, different demonstrators were produced. Figure 2 shows a printed label with QR code, security feature and the logos of all partners involved. The label information can either be accessed directly via a QR code or selected (e.g. batch or tracking number, material origin or production details) or made available in encrypted form to an authorized user group.

Four security levels have been implemented:

- **BASIC** (Additional information without identification): Open accessible additional information without identification, ohne key, without additional security features.
- **ADVANCED** (Additional information with identification): Open accessible additional information, information with access control, e.g. special information on batches, 2D QR code identifies up to batch level, simple PIN (by manufacturer) on product/label as key for access.
- **LOWTECH** - Identification with individual code and marking characteristic, e.g. batch no.: same as level 2, PIN has a higher security architecture, e.g. 2 parts, simple visible or invisible marking, identification without much effort.
- **HIGHTECH** - High security level with identification, code and more than one security feature: same as level 3, PIN with even higher security architecture, highly secured - MasterPin, complex marking as integrated high-tech marking, technology or specialist knowledge required for identification.

Non-destructive reading of the marking is ensured by a hand-held reader that is individually adjusted to the exact luminescence frequency of the printed label. Commercially available sensors can be used (e.g. Tailor-Spec as a mini spectrometer variant), which can also be used as an offline system or in the industrial workflows and have production speeds of up to 100 per second. Identification is carried out automatically according to the key-lock principle. End devices can be connected via a USB connection and the reading of the label marking can thus be coupled with an existing enterprise resource planning system.

In order to be able to provide the desired information content of the label for each individual customer at each security level, data from different areas of the textile chain as well as from the different actor
groups were considered. In addition to the usual consumer information, additional information such as the origin of individual textile components, ecological footprint, collection recommendations or other technical details on textile construction are of interest. Information on the article number, relevant certificates, quality gradations and even error messages are also important for retailers. On the other hand, the industrial or manufacturer side, is more interested in test values, serial numbers and information on the routing of the textile chain or on product and brand piracy. In total, the most important 150 items of information were worked out in grouped data categories, of which approx. 85% were transferred to information technology structuring.

The large number of label variants and individual conceptual views that can be implemented in terms of textile, information and market technology have been combined and addressed to form a standard for mass-customized labels (figure 3). The individual elements of the information are aligned to the target groups in blocks and are subordinated to the four security levels. This results in a roadmap for each label variant, depending on the specific application.

![Figure 3. Mass-customized label standard.](image)

Depending on the intended visibility, the textile technical implementation takes place on the one hand with QR code, symbols, fonts and textile labels and on the other hand with QR code including key, pigment coding or textile coding. In principle, the physically produced label is always accompanied by its virtual image. In addition to the actually embodied product characteristics, information on proper laundry care and trade information, this enables the storage and visualization of further data levels. The mass-customized label with its QR code is understood here as a bridge to a comprehensive information pool (portal) to which further scenarios can be linked in the future, such as assistance systems, big data or self-learning modules. Entering the virtual image is controlled by the different key strengths and positions in the security levels.

### 3.2. Complex product platform

The safe and smart textile label acts as an advantageous customer-specific bridge between textiles, platform and textile chain. In various scenarios, the mass-customized label connects the user with the information to be provided. On the basis of mass-customized labels and MC-specific issues [1-3], a
Proof of Concept (PoC) has been developed which shows how IT-based security labels can be implemented along the Co-Creation (CC) process.

The MC idea is reflected in the PoC by the fact that a platform is proposed which can be used by any number of providers for value creation process coordination (similar to a social network for value creation processes). The CC concept is taken into account, as the customers of the network also have access to the platform in order to be integrated into the CC process and to increase the quality of value creation. The PoC addresses the issue of process modularity by storing the solutions as configurations of a production process instance. The knowledge base is populated with existing company data. It can be further extended by newly created solutions on the platform, thus creating a learning system [4].

With the customer-specific product presentation, the label information can either be called up or selected directly via a QR code, for example via batch or tracking number, material origin or production details. Encrypted access to product data or settings is also possible for an authorized user group. This makes the textile product clearly identifiable, traceable and customer-friendly. As a reference object, an online platform with product information has been developed. The demonstrator refers to the developed platform (Figure 4).

![Figure 4](image)

Figure 4. Product information linked and readable with the label of TDL (Textildruckerei Lunzenau GmbH, Penig, Germany) - Backend view.

In an initial pilot phase, interested textile companies and fashion labels were able to apply the mass-customized label to their articles and show customers individual information, pictures or data of the production history, depending on the security level. The origin of individual textile components and the ecological footprint of the whole textile chain are playing an increasingly important role. The rising demand for ecologically and fairly produced textiles and the knowledge of their origin can be channelled through value added creation with advanced mass-customized textile labels and transferred into a format that is very effective in the media. In the context of social digitalization, successful textile manufacturers and service providers need new tools both to visualize their products and to demonstrate their social reputation in terms of transparency, credibility and ethical responsibility.
4. Conclusions
The mass-customized label provides secure and unambiguous identification and traceability of textile products from the moment they are used. It supports a realignment of strategic management and innovative business models for digitally networked value creation. The label accompanies service-centric business models, co-creation of complex products through smart standardization and improvement of customer integration competence, and MC-oriented optimization of value creation processes. As an IT artefact, the label thus becomes part of both the marking and traceability solution in interaction with the underlying IT platform and a cross-company textile value chain. As a link between textile and clothing products and a future-oriented information and development data platform close to textile applications, it creates the possibility of maintaining a digital twin. A connection to different platforms (quality label, Profund etc.) is possible. Interested textile manufacturers or fashion companies can easily order an individual label with a specific QR code with the desired security level and, thus, offer their customers informative added value.

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