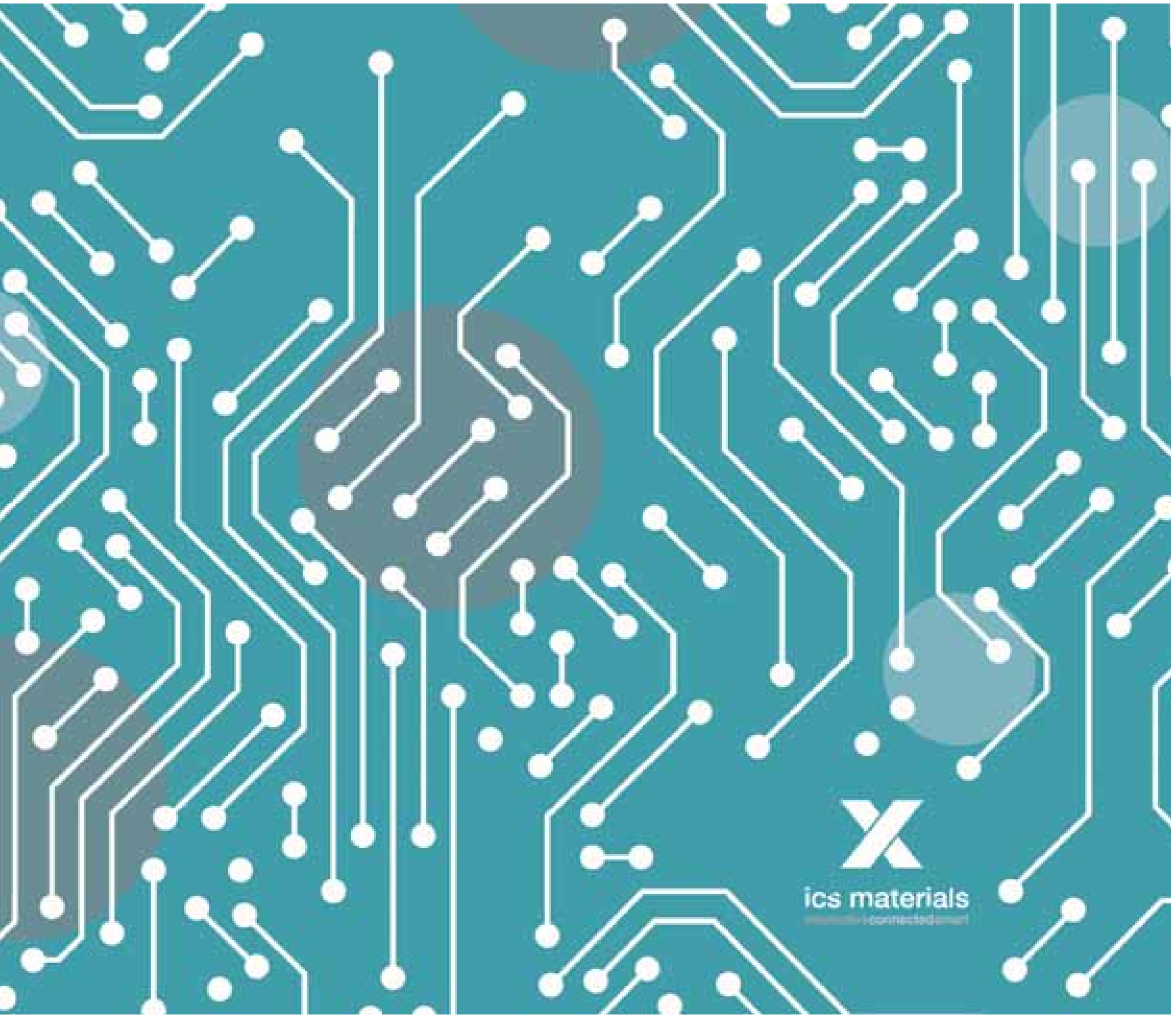
ICS MATERIALS

Interactive, connected, and smart materials

edited by Valentina Rognoli and Venere Ferraro



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Editors of this book acknowledge funding received by FARB funds of the Design Department of the Politecnico di Milano.

Cover image: Helga Aversa.

ISBN e-book Open Access: 9788835115649

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by *Davide Spallazzo* and *Mauro Ceconello*
Politecnico di Milano, Department of Design

1. Exhibit design and ICS Materials

The field of exhibition design is, by its very nature, strongly connected with innovation, since the display of products, whether they are articles for sale or cultural assets, frequently entails triggering emotions and fascinating people. Digital technologies and their employment can serve to this aim, and, not by chance, exhibition designers largely rely on their potentials to foster engaging and meaningful user experiences.

Our reflection is here focused on that branch of exhibit design that pertains the creation of permanent or temporary exhibitions for cultural spaces such as museums, namely institutions with a long-lasting tradition of employment of digital technologies.

Since the introduction of digital technologies, indeed, museums have always been privileged venues for experimentation (Parry, 2008), given their unique ability to create a safe and controlled space where the environment, the assets and people are part of the same ecosystem.

Today's museums are largely technology supported if not technology sustained, since digital technologies are permeating most of the functions both in the backstage – digitalization, inventory, etc. – and in the frontstage – exhibits, cultural interpretation, education etc. Ranging from passive display of contents through video-walls and projectors to interactive immersive environments, from traditional audio guides (Proctor, 2011) to mixed reality enhanced glasses, museums offer a thorough set of case studies on the use of these technologies.

Nevertheless, common critiques to the employment of digital technologies in cultural contexts underline (i) the detachment of the technological devices from the environment and consequently (ii) possible distraction from the objects on show towards the devices themselves (Spallazzo, 2012).

Moving from this assumption, we explore here the potentials of Interactive, Connected and Smart Materials – ICS Materials – in the exhibit design field, envisioning future applications able to shorten or even to bridge the distance between atoms and bits (Ishii & Ullmer, 1997) and trigger novel user experiences.

We intend ICS Material as «hybrid material systems that work by establishing interactions among their constituting components, and with people, objects, and environments, through the combined use of electronic, chemical, mechanical, and biological components» (Parisi et al., 2018, p. 2).

In other words, the category of ICS Materials encompasses materials that are: (i) able to establish a two-way exchange of information with human or non-human entities; (ii) linked to another entity or an external source, not only through the internet and digital network; (iii) able to respond contextually and reversibly to external stimuli, by changing their properties and qualities; (iv) programmable, not only through software (Parisi et al., 2018; Rognoli et al., 2016).

As a matter of fact, this novel category of materials, able to merge digital capabilities in the material itself, can introduce a disruptive innovation in the exhibition design field, as well as in other design branches. However, as far as we know, no experimentations have been undertaken yet, considering that these materials are often in their PoC phase and still not ready to be massively employed.

Accordingly, in the following we speculate on ICS Materials as main building material for exhibit designers, envisioning opportunities in the field and exploring three design dimensions: namely the exhibition space, the assets and what it pertains to them, and ultimately the visitors.

2. First design dimension: the exhibition space

The first reflection here advanced regards the exhibition space, intended as that space made of walls, floor and ceiling wherein the exhibition takes place.

Going far beyond the concept of *white cube* (O'Doherty, 1999), contemporary interiors of museums and exhibition spaces are increasingly becoming interactive spaces, where the architectural elements as well as the furnishing may be enhanced through digital technologies and acquire new functions and meanings. As a matter of fact, the interpretation of museum spaces as a scenography (Atelier Brückner, 2011) where a narration takes place (Dernie, 2006), implies considering all the elements that constitute the space as a unique and interconnected system, a techno-drama (Cirifino et al., 2011). Accordingly, digital technologies are increasingly being used as an integral part of the exhibition space, pervading walls, floor and ceiling and are no more only relegated to interactive devices (e.g. smartphones, interactive kiosks) at the service of visitors.

The ArtLens Wall at the Denver Art Museum is a renowned example in this sense. Designed by Local Projects as a tiled 12-meters-long interactive wall, it stands as the biggest one in a museum and transforms a wall into a digital repository for about 4.500 artworks that can be explored.

Other times, projections transform both walls and floor into interactive areas for visitors, as it happens in the *Time Machine* experience at the Wu Kingdom Helv Relics Museum in Wuxi, China by Acciona. Here the walls are transformed into the scenography of an evolving story, while the floor becomes a place where visitors can interact with digital objects, animals and natural elements. Further increasing the level of immersion, the Mori Building Digital Art Museum in Tokio, proposes a virtuous combination between physical installations and dynamic digital artworks able to change according to visitors' behavior and to influence each other.

The three examples listed above, show the ever-increasing tendency to permeate all the museums spaces with digital technologies/content and can be pointed as representative cases for the innovative use of traditional digital technologies commonly employed in the field, such as touchscreens and interactive projectors.

The devices act as mediators of the interaction between the users/visitors and the cultural contents – be them physical or digital – while the exhibit space, with its materiality, acts as a passive setting.

Moving from ICS materials standpoint, we may envision different scenarios, where the potential of digital technology is directly embedded into the material that constitutes the space, hence enabling different expressive opportunities.

The walls, instead of being flat surfaces on which to hang artworks and interactive screens or to project digital contents may become interfaces themselves, able to couple input and output. Looking at the field of Organic User Interfaces – OUIs – they can become «non-planar interfaces taking any 3D shape and morphing either actively or passively, to support direct physical interaction» (Nabil et al., p. 89).

We could imagine creating reconfigurable self-organizing smart walls (Farrow et al., 2013) able to modify their appearance according to people' interaction or following a complex scenography. Interior walls can also be non-flat living walls (Buechley et al., 2010), integrating circuitry into the graphics of a wallpaper and consequently able to modify its appearance in real time according to visitors' explicit or implicit interaction.

Shape-memory alloys and dynamic textiles as the BioLogic Fabric developed at the MIT (Yao et al., 2015) may be used to create shape changing surfaces, able to respond to external stimuli (heat and humidity respectively) and modify their appearance and ultimately functioning. The ceiling and the walls can open/close according to the temperature and humidity to maintain the environmental comfort or to allow/deny transparencies or create performative lighting scenarios.

ICS materials could also serve to transform the museum surfaces into a space of memory, able to keep track of each visitor and her/his interaction. Making reference to the concept of traces as evidences of material engagement (Giaccardi et al., 2014; Robbins et al., 2016), walls and floor can be empowered by ICS materials to be at the same time interfaces for visitors, triggering storytelling and interpretation, but also act at a socio-cultural level, by recording «where people, practices, and the materials of the technology intersect» (Robbins et al., 2016, p. 3).

3. Second design dimension: the cultural assets

The environment is just one of the elements constituting an exhibition space, that can serve to valorize and enhance the key contents of a museum, namely the assets it holds and displays, and their connected values.

Far from being mere objects to contemplate and not to touch, museum assets are interpreted today as triggers of multifaceted stories, often activated through digital technologies, and even valorized for their materiality (Dudley, 2009)

The traditional display of objects behind thick protective glasses with small or even non-existent interpretive labels is giving way on the one hand to technology supported solutions able to multiply the cultural interpretation and, on the other hand, to a more direct relation between assets – or their copy – and visitors.

An innovative project following the first strand is Collider Case, an interactive showcase able to superimpose images, animations and texts on the objects, by exploiting the transparent flat surface of the showcase, holographic solutions and projections.

Looking at the ICS materials field, similar – even if not comparable – results, can be achieved with low-tech solutions, by exploiting the chemical properties of materials that react to the current flow. Electroluminiscent and electrochromic inks (Österholm et al., 2016), for example, can easily turn a transparent panel into a space for labels. Different graphics/texts can be made visible on the same panel only when required, to let visitors follow a story, or simply to match their language.

Therefore, the potential of ICS materials can be exploited to enhance the interpretation of the objects on show, but it can also be at the basis of experiences based on the tangible interaction paradigm (Hornecker & Buur, 2006).

As a matter of fact, one of the last trends in the field of digital enhanced exhibition design sees technological solutions that allow for a fuller integration between the technology, the materiality of the objects and the physicality of the visit experience (Bannon et al., 2005; Petrelli et al., 2013).

Made popular in the Human Computer Interaction field after the publication of the book *Where the action is* (Dourish, 2001), tangible interaction grew in popularity together with an increasing interest in the materiality of the visit experience shown in museum studies (Chatterjee, 2008; Dudley, 2012; Pye, 2008). Accordingly, since the first decade of the new millennium, projects based on this paradigm emerged (Bannon et al., 2005) and count today several applications (Duranti, 2017).

In 2007, the VIRTEX presentation method, by Daniel Pletinckx, for example, employed a bigger 3D-printed replica of a small ivory cross embedded with a gyroscope that allowed users to move a 3D model by actually manipulating and rotating the replica.

Other times, visitors are asked to interact with a realistic replica. It is the case of the Drinking symposium installation at the Allard Pierson Museum of Amsterdam. Here, visitors are involved in a simulated drinking symposium in the Ancient Greece and must perform a libation with a replica of a Greek drinking bowl (*kylix*) or lay on a daybed. Both the kylix and the daybed are embedded with sensors and modify the state of a virtual world when activated: by lifting the kylix, visitors animate a virtual character that lifts his kylix, toasts and drink wine, while other actions follow those of the visitors.

Clearly, the two projects described above, introduce a completely novel way of triggering digital interpretive contents in a museum, by avoiding the traditional Graphical User Interfaces in favor of a direct interaction with physical objects, namely employing Tangible User Interfaces. The next step of evolution we foresee here by employing ICS materials is that imagined by Hiroshi Ishii and colleagues at the MIT media lab in 2012, by theorizing the radical atoms (Ishii et al., 2012). The authors hypothesize the interaction with dynamic materials, in which all digital information has physical manifestation so that people can interact directly with it. If the hypothetical «digital clay» referred to by the authors can be somehow too radical as an interface for the museum field, we can imagine coupling input and most of the outputs in the same manipulable asset. A replica covered with smart textiles (Nilsson et al., 2011), for example, can react to visitors touch by highlighting details on the object itself and triggering a coherent audio description. Instead of using capacitive sensors and led lights, the same result can be achieved with programmable textiles, just to name a renowned example.

4. Third design dimension: the visitors

The third element composing the exhibition design ecosystem, as described at the beginning of the chapter, is the visitor. Evidently, visitors are the main addressees of the solutions/projects discussed till now, but the focus here is on the personal devices commonly employed in an exhibition space and on scenarios of future applications enabled by ICS materials.

Ranging from traditional audioguides to the most advanced augmented reality mobile apps, the panorama of cultural interpretation supported by technology is still dominated by the same paradigm: location-aware display of contents triggered more or less voluntarily by visitors through a device (Spallazzo, 2012). A long-lasting story, considering that the first audioguide was introduced at the Stedelijk Museum of Amsterdam in 1952 (Tallon, 2008) and that multimedia guides in cultural field date back to 1994, with the project iGo, developed for the Minneapolis Institute of Art (Damala, 2009).

Contemporary solutions are mostly based on mobile apps following the Bring Your Own Device – BYOD – business model, exploiting personal visitors' smartphones to trigger interpretive experiences, activated at specific locations or along the entire visit experience (Proctor, 2011). Likewise, wearable technologies, such as the smart glasses for mixed reality, are getting grip even if they are still immature and not so diffused. Examples such as the Keith Haring exhibition augmented with smart glasses at the San Francisco's De Young Museum in 2014, are now spreading.

Analyzing the evolution briefly traced above, that moves from public devices, such as audioguides, to personal smartphones, and finally to wearable systems, we could imagine that in the next future museums will invest on the visitors' body as trigger of cultural interpretation.

Looking at ICS materials, systems such as the DuoSkin by MIT Media Lab and Microsoft Research can play a relevant role in transferring controls directly to the human body. DuoSkin is a tattoo interface made of gold metal leaf able to sense touch inputs, to display outputs thanks to thermochromic ink, and allows wireless communication (Kao, Holz, Roseway, Calvo, & Schmandt, 2016). The controls, normally performed on the mobile screens, may be done on a tattoo that visitors may receive at the ticket desk, potentially aware of their language and preferences.

We could also imagine making the devices completely disappear and merge all the scenarios envisioned in the previous paragraphs to create a unique dynamic exhibition space able to respond to visitors' bodily movements and gestures.

As a matter of fact, the paradigm of embodied interaction (Taylor et al., 2015), that transforms the human body into the main controlling device can be coupled with the potential of ICS materials to create what we can call an organic exhibition space. Organic, since (i) it can modify its shape and functions according to diverse inputs over time, (ii) it is innervated by a network that connects every element, and (iii) it demonstrates smartness in its ability to match visitors' needs and will.

5. Final remarks

The scenarios of employment of ICS materials as well as the vision about an organic exhibition space advanced in the chapter are, in great part, far to be achieved and mostly relying on materials and solutions in their PoC phase.

Nevertheless, they can be interpreted as a glimpse from a future that is near, from a technological point of view, but requires a radical change in the way of thinking interactivity in museums.

Despite the contemporary work of the most renowned exhibition designers tries to seamlessly integrate digital technology in the exhibition space and make it disappear to trigger a memorable user experience, the relation between technological devices and the ecosystem made of space, assets and visitors is still seamful. The interaction, indeed, is still relying on input given through devices and separated outputs that may favor detachment and distraction from the assets on show, as pointed at the beginning of the chapter.

The exhibition designer of the near future will need to follow a logic of integration, by imagining interaction both at the micro and macro level. Imagining the integration between atoms and bits at the atomic level (Ishii et al., 2012) or at the level of computational composites (Vallgårda & Redström, 2007), indeed, means profoundly modifying the way we imagine interaction and design for it.

ICS materials are paving the way towards a holistic view of interaction, in which every element is connected to the others, and its able to modify itself in a continuous process of adaptation and evolution. In this sense, designers must think of the exhibition space as an ever-changing organism.

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