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# Design for Hybrid Material Systems. A Material Augmentation Framework for Meaningful Experiences

*Impact Case Study*

**Stefano PARISI**
*Politecnico di Milano*
*Department of Design*

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| Year of completion: | 2021 |
| Discipline/field: | Design (area: Materials for Design) |
| Type of Doctorate (e.g. PhD, DDes, ArtD) | PhD |
| Supervisor(s) | Prof. Valentina Rognoli |

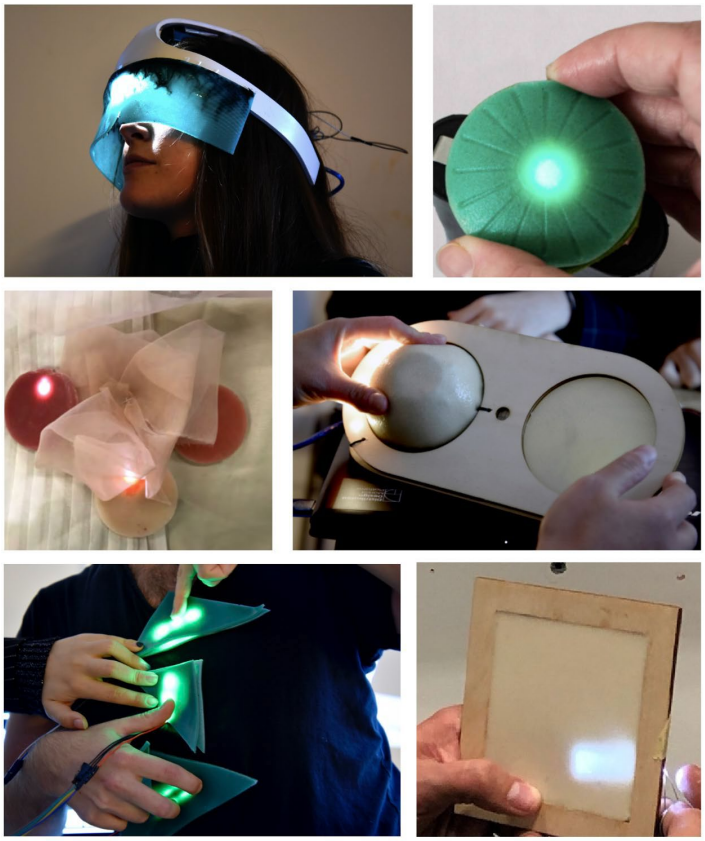
## *Abstract*

The PhD research is focused on the emerging field of Hybrid Material Systems, i.e., material-based systems combining inactive materials, smart material components, and embedded sensing, computing, and actuating technologies. They arise as potential enablers of meaningful dynamic and interactive experiences as tangible interfaces in a diversity of applications, from smart objects to wearable devices and interactive environments. However, the design space lacks a systematised set of directions and a roadmap to approach the specific requirements of these materials.

*Photo Courtesy of Ziyu Zhou*

Although designers and labs worldwide are experimenting with these materials, the results are still underdeveloped prototypes and experimental demonstrators. Technological limitations related to the seamless integration of components in the materials still exist, but in a future perspective will be solved with the increasing miniaturisation of components. For this reason, the research adopts a speculative dimension. Besides technological aspects,

one emerging and crucial challenge is identifying meaningful and purposeful ways for materials augmentation. Indeed, these novel materials imply complex and novel experiences that designers need to comprehend and master to design or integrate them into applications that foster people's appreciation and acceptance. Materials Experience appears as a critical notion for understanding, augmentation, and integration into a concept artefact. The research is positioned at the intersection of design, new materials, and interaction. However, the research's focal point is material, instead of technology, as the aim is achieving a material augmentation, instead of technology integration, therefore starting from the material. For this reason, the research considers a material-centred approach focused on the physical and tangible components of materials, technologies, and processes instead of the digital ones, e.g., software. The research focuses on Hybrid Material Systems based on alternative bio-based materials with embedded electronics and smart components, which offers great potential as a raw material for tinkering and iterative experimentation and responding to the demand for more sustainable materials.



The purpose of the research is to develop a methodological framework for design practitioners and students to understand and design for Hybrid Material Systems, enabling material augmentation for meaningful experiences. Therefore, the central question is: what is a proper framework to design for Hybrid Material Systems? The principal question is framed into sub-questions to find the necessary elements building the framework: 1) What are such materials, their components, and categories, 2) What are the relations between their layers? 3) What are the fabrication processes and techniques for materials augmentation? 4) What are the design tools and methods to ideate and support them? 5) What are the meaningful experiential patterns they enable and imply for users and designers? 6) What might be the potential application and societal implications?

To answer those questions and ultimately build the framework, a set of studies based on interviews, questionnaires, and observations, preceded by preliminary studies and case studies, has been performed, using a mixed-methods design mainly based on qualitative data. A systematic literature review was conducted to identify the State of the Art. Since the research is at the intersection of Design, Materials and Manufacturing, and Human-Computer Interaction, literature from the three areas has been reviewed. Part of the literature review focuses on

identifying methods and tools to Design (to ideate and prototype) with and for Hybrid Material Systems used in education and practice. Literature was an iterative and progressive effort that helped identify gaps in the research area and craft and refine the research questions. Preliminary studies, like best examples collection and classification, aim to propose a first framing and mapping of Hybrid Material Systems, resulting in defining an Ontology (what Hybrid Material Systems are and how they are defined), Anatomy (what the components of Hybrid Material Systems and their relations are), and Taxonomy (what the categories of Hybrid Material Systems are). Two case studies follow using a qualitative observation and analysis protocol based on the model of Materials Experience to unfold the critical experiential pattern and issues enabled and implied by Hybrid Material Systems, by self-observation and participants observation through a workshop. Finally, Research-through-Design has been applied through design workshops with students and personal experimentation, testing tools, methods, and contents, and producing concepts, prototypes, samples and observations.

The resulting guidelines, tools, and methods have been progressively tested and updated through the workshops. The research outcomes are a body of knowledge around the topic, formalised in a methodological Framework to Design for Hybrid Material Systems through material augmentation for meaningful experiences. This framework is a modular blueprint consisting of four phases (Introduce, Experiment, Shape, and Ideate) with supporting tools, recommendations, and methods. It can be used both in practice and the education of designers, aiming to understand Hybrid Material Systems and design for them. The research's methodological framework's foundational inputs are materials and their relations with technologies and fabrication techniques, scenarios, and materials experiences, allowing meaningful experiences through establishing a multi-disciplinary design space. This contributes to informing and updating the current theoretical and methodological framework for materials design, considering methods, tools, and enablement for practice and education, including practical implication in formalising novel teaching experiences and updating materials libraries.

## *Summary of impact beyond academia*

Within the PhD, the candidate published his research activities and results in 3 journal articles, 14 chapters in books or books series, and 8 conference papers. He participated as speaker to 10 academic conferences and symposia, and to 4 events for companies and the general public.

The principal result of the thesis is a methodological framework to design for Hybrid Material Systems by proposing a flexible and modular process and tools that can be used in design practice and education. It was tested in 4 different workshop formats with design students at a Master level (Higher Education) (n. 2 5-day workshops and 1 2-day workshop involving a total of 85 students), students of professionalizing masters (n. 1 3-day workshop involving 28 students), and companies and design professionals (a series of 4 half-day workshops involving a total of 10 enterprises). Form these activities a total of 28 projects were developed in the form of concept ideas (n. 9) and prototypes (n. 19).

The research had a direct impact in design education, supporting the training of young designers and practitioners providing knowledge, skills, and competencies to face the upcoming challenges of smart integration. Therefore, the research has direct and indirect implications also in industry, transferring knowledge and skills about Hybrid Material Systems so that young designers could be updated and could respond to the demand of the industry – and ultimately accelerating the development and application of emerging materials.

Additionally, the research contributed to identify areas of intervention and to formalize contents within the EU-funded Erasmus+ project DATEMATS (https://www.datemats.eu/) (Knowledge & Technology Transfer of Emerging Materials & Technologies through a Design-Driven Approach Agreement Number: 600777-EPP-1-2018-1-IT-EPPKA2-KA). With a program of activities for students, companies, and general public, the project had an impact both on Academia and Industry. I report some examples of indicators of the impact directly related with the activities of the candidate:

- Publication of 1 Open Educational Resource (June 2020): The candidate is the author of 1 Open Educational Resource (OER) in the form of a video lesson, available on the project website and related platforms, personally edited and presented by the candidate. The video has received a total of 151 views (January 2022). In addition, the candidate coordinated the production of two other OERs authored by colleagues. Including these two other video lectures, a total of 660 views were achieved (January 2022).

- Organization of a workshop aimed at companies (T4.3 Knowledge Transfer Lab), which involved 35 participants (27 companies) both in person and remotely, and reached more than 118 users (October 2020).

## *Underpinning research, context and summary of methodology*

To answer research questions and ultimately build the framework, a set of studies based on interviews, questionnaires, and observations, preceded by preliminary studies and case studies, has been performed, using a mixed-methods design mainly based on qualitative data. A systematic literature review was conducted to identify the State of the Art. Since the research is at the intersection of Design, Materials and Manufacturing, and Human-Computer Interaction, literature from the three areas has been reviewed. Part of the literature review focuses on identifying methods and tools to Design (to ideate and prototype) with and for Hybrid Material Systems used in education and practice. Literature was an iterative and progressive effort that helped identify gaps in the research area and craft and refine the research questions. Preliminary studies, like best examples collection and classification, aim to propose a first framing and mapping of Hybrid Material Systems, resulting in defining an Ontology (what Hybrid Material Systems are and how they are defined), Anatomy (what the components of Hybrid Material Systems and their relations are), and Taxonomy (what the categories of Hybrid Material Systems are). Two case studies follow using a qualitative observation and analysis protocol based on the model of Materials Experience to unfold the critical experiential pattern and issues enabled and implied by Hybrid Material Systems, by self-observation and participants observation through a workshop. Finally, Research-through-Design has been applied through design workshops with students (2 carried out by the candidate, and 2 observed by the candidate) and personal experimentation, testing tools, methods, and contents, and producing concepts, prototypes, samples and observations.

## *References produced by researcher from/during doctoral research*

Parisi, S. (2021). Design for hybrid material systems: a material augmentation framework for meaningful experiences. In: O. Pedgley, V. Rognoli, E. Karana (eds.). Materials Experience 2. Expanding Territories of Materials and Design. Elsevier. ISBN: 978-0-12-819244-3

Parisi S., Rognoli V., Sonneveld, M.H. (2017). Material Tinkering. An inspirational approach for experiential learning and envisioning in product design education.

The Design Journal, 20:sup1, S1167-S1184. ISBN 978-1-138-09023-1 https://doi.org/10.1080/14606925.2017.1353059

Parisi S. (2020). Towards a definition of ICS Materials in Design Education: Approaches in specific teaching methods. In Ferraro V., Pasold A. (eds.). Emerging Materials and Technologies: New approaches in Design Teaching Methods on four exemplified areas, 92-104. Design International. Franco Angeli. ISBN: 9788835104513

Parisi S., Rognoli V., (2021). Design for ICS Materials: the development of tools and methods for the inspiration and ideation phases. In: Rognoli V., Ferraro V. (eds). ICS Materials: interactive, connected, and smart materials. Design International. Franco Angeli. ISBN-13: 9788835115649

Parisi S., Holzbach M., Rognoli V. (2020). The hybrid dimension of Material Design: two case studies of a Do-It-Yourself approach for the development of Interactive, Connected, and Smart materials. In: Karwowski W., Ahram T. (eds) Intelligent Human Systems Integration 2020. IHSI 2020. Advances in Intelligent Systems and Computing, Vol. 1131, pp. 916-921. Springer, Cham. ISBN: 978-3-030-39511-7

Lecture "ICS Materials: definition and approaches" by Stefano Parisi. Available on youtube, vimeo and http://www.datemats.eu/ . June 2020.

## *Details of impact*

Publication of published his research activities and results in 3 journal articles, 14 chapters in books or books series, and 8 conference papers. He participated as speaker to 10 academic conferences and symposia, and to 4 events for companies and the general public.

Development of a methodology to design for Hybrid Material Systems and a related design toolkit constituted by: 1 concept canvas, case-specific scenario boards, and a deck of Hybrid Material Systems cards (final version: 48 cards)

Co-organization of 4 different workshop formats with design students at a Master level (Higher Education) (n. 2 5-day workshops and 1 2-day workshop involving a total of 85 students), students of professionalizing masters (n. 1 3-day workshop involving 28 students), and companies and design professionals (a series of 4 half-day workshops involving a total of 10 enterprises).

Resulting in a total of 28 projects in the form of concept ideas (n. 9) and prototypes (n. 19).

The contents developed were implemented into 1 Open Educational Resource (June 2020): The candidate is the author of 1 Open Educational Resource (OER) in the form of a video lesson addressed to companies, designers, and students. The video has received a total of 151 views (January 2022). In addition, the candidate coordinated the production of two other OERs authored by colleagues. Including these two other video lectures, a total of 660 views were achieved (January 2022). https://vimeo.com/428492519; https://www.youtube.com/watch?v=F90BgTmdM0c.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