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BlingCrete:
Materials Development as Transdisciplinary Research Process

Heike Klussman and Thorsten Klooster

Abstract: This article describes the development of a light-reflecting concrete. Since 2009 the authors have headed the BlingCrete working group at the University of Kassel, Germany. This group, which brings together experts from the fields of visual art, architecture, interaction design, industrial design, experimental physics, and materials research, is devoted to developing new material concepts. The BlingCrete project began as a series of artistic experiments with light-reflecting materials and the phenomenon of retroreflection. It is thus an exchange initiated from the artist's position, in which ways of knowing and working that are specific to the sciences are harnessed in order to position and deploy them in artistic contexts—and vice versa. At the threshold between visibility and invisibility BlingCrete reveals the contradictions of material representation. The research project picks up that thread using such observations to generate further lines of inquiry and reconceive boundaries. With magnetic positioning we ultimately depart the spectrum of the visible for the invisible realm of nanoscale electromagnetic fields.

Keywords: Surface design, retroreflection, materials research, magnetic positioning, art and science

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BlingCrete:
Materials Development as Transdisciplinary Research Process

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> God made solids, but surfaces are the work of the Devil.
> (Wolfgang Pauli, quantum physicist, 1900–1958)

Interfaces define the reality of the world we live in. In the development of cell membranes, in the form of skin or the immune system, in the delineation of ecological habitats they govern and catalyze life processes. Phenomena at the boundaries between materials play an important role in many areas, whether visibly and functionally in everyday culture or hidden from view, as in the applied sciences, in nanomaterials research, or on the level of biotechnological and chemical processes (catalysis, filtration, electrophoresis). A connection to art can be seen in the material manifestations of surfaces and their representation in photography, film, and digital media. Conceptions of "boundary" appear in Marcel Duchamp's neologism *infra-mince* which describes the nearly imperceptible division (or simultaneous delay) between two contiguous states or events.[1] In architecture terms such as "facade" and "shell" refer to multilayered relationships (Fig. 1). In likening the house to a second skin that augments our senses, Michel Serres has provided perhaps the clearest articulation of the topos of the building's envelope or clothing as a synthetic extension that helps to connect us to our environment.[2]

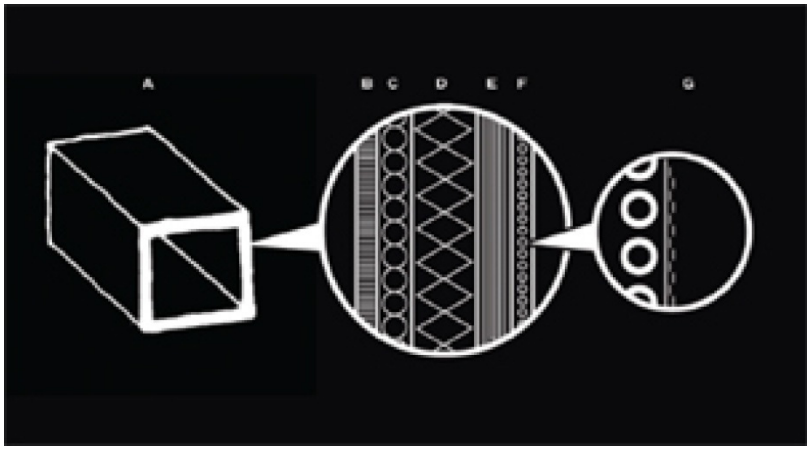

Fig. 1. BlingCrete represents a shift of attention from the appearance of materials to the performance of surfaces.

In this context concepts of "membrane" and "surface" stand for the potential openness of a system, concepts of "boundary" for its closure. Indeed, potential connections to the environment are largely defined by the permeability of the shell. This coupling factor determines our fundamental viability, irrespective of our level of technology, culture, or mastery of nature: We survive as closed systems by being open systems.[3]

The thematic range of this introduction holds relevance for the BlingCrete project, which is under development in the context of a transdisciplinary research process at the University of Kassel. That process brings together experts from the fields of visual art, architecture, interaction design, industrial design, experimental physics, and materials research. It is, first of all, a project devoted to realizing a material concept: a light-reflecting concrete. This new

material combines the positive qualities of concrete (fire resistance, strength, construction technology) with the property of retroreflection. Retroreflective surfaces reflect incident light (natural or artificial) precisely back to its source. This optical phenomenon is produced by glass microspheres embedded in a concrete substrate.

The idea for this substance arose from artistic experimentation with light-reflecting materials used in road construction, whose high flammability precludes their use in permanent indoor applications. It is worth noting in this connection that the path to the solution can be portrayed as a transfer process which, even on the technological level, necessitated a conversation, initiated by addressing the concept of boundaries in order to achieve its objectives. But the combination of glass and concrete in a single composite is significant for other reasons as well, considering that with this combination BlingCrete unites two of the most antithetical positions imaginable in material aesthetics, which are linked to seemingly axiomatic discourses in visual art and design. We would like to show how, through the analysis and creative interpretation of such antagonisms, BlingCrete has evolved via the materials-development process from visual art into an experimental system that catalyzes both artistic and scientific lines of inquiry in equal measure and promotes dialogue about them. The substantive aspects of the term “surface” define a space for interdisciplinary negotiation in which the project unfolds. BlingCrete is both materials development and the prototype for a transdisciplinary research process.

BlingCrete: Concept

The BlingCrete project began as a series of artistic experiments with light-reflecting materials, and as an investigation of the specific phenomenon of retroreflection, in preparation for an artistic intervention in urban space (Fig. 2).[4] We experience the phenomenon of retroreflection in daily life, for example, when we drive toward a construction site, a road hazard, or a crosswalk and see the reflective road markings light up at a certain moment: For an instant they almost blind us to our surroundings, only to melt back into the surface of the pavement a second later as we drive past.

Fig. 2. Heike Klussmann’s Catwalk, an installation incorporating a 60-meter-long retroreflective surface.

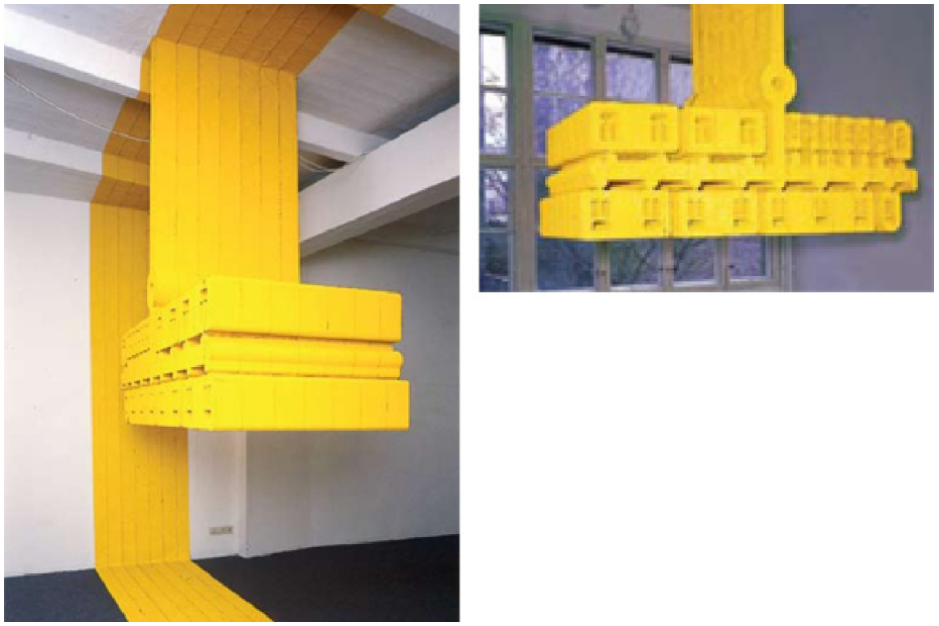

Fig. 3. Elongated strips of retroreflective tape, seemingly drawn through the room on an endless belt, form the sculpture Yellowesque by Heike Klussmann.

Thus BlingCrete is, first of all, an exchange initiated from the artist's position, in which ways of knowing and working that are specific to the scientific disciplines are harnessed in order to position and deploy them in artistic contexts—and vice versa. The process begins in the visual arts, investigating the visual potential of retroreflection as the light-induced movement of one form as it approaches another. This movement is the perceptible interval between action and reaction, which under other circumstances would go unnoticed. Two-dimensional strips of retroreflective material combine with a given spatial situation to create a sculpture that makes us reconceive that space as pictorial space. What we had regarded as substantial suddenly appears as a transient phenomenon. Sculptures such as *Yellowesque* or *Reflex Block* demonstrate the illusionistic, perception-shaping effect of retroreflection in relation to set spatial boundaries (Fig. 3). We know we've seen something, but we remain unsure whether the thing we perceived was a hallucination or the expression of a coherent reality. It becomes clear that retroreflective surfaces do not represent a static energetic state; rather, they enable us to devise fluid transitions and, in a sense, to set architecture in motion (Fig. 4).

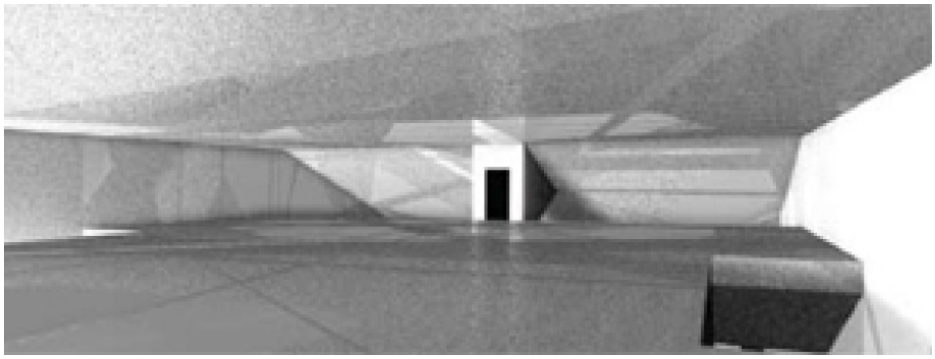

Fig. 4. This study for the Wehrhahn subway line in Düsseldorf illustrates how BlingCrete may be used to design surfaces that facilitate dynamic, energetic transitions, seemingly setting the existing architecture in motion.

In the logic of the visible BlingCrete is the concept of a subtle surface that mediates between matter and light and indirectly points to the relationship between mass and surface. At the threshold between visibility and invisibility BlingCrete reveals the contradictions of material representation. The research project picks up that thread using such observations to generate further lines of inquiry and reconceive boundaries. The motivation lies primarily in development and only secondarily in the impact of such boundaries. With magnetic positioning (see below) we ultimately depart the spectrum of the visible for the invisible realm of nanoscale electromagnetic fields.

BlingCrete: Technology

Concepts of "surface" and "boundary" have influenced the development of the material in multiple ways. One example is the technological concept behind it. Technologically speaking, BlingCrete employs a strategy borrowed from the materials-research branch of the applied sciences of functional surface design as the "animation" of material. In a sense BlingCrete is an adaptation of the nanotechnological strategy of thin films, a key technology in terms of the macro-level functionalization of surfaces.[5] Thus the project positions itself among the new materials that are becoming increasingly important in design and architecture. It is also a technology-transfer project that depends on communication in order to achieve its objectives.

In the manufacturing process, specially designed matrices are used to embed 3-mm glass microspheres to a depth of 51 percent of their diameter into the otherwise nonspecifically structured surfaces of concrete structural elements and components (Fig. 5). Thus positioned they refract rays of incident light directing them precisely back to the source from which they were emitted. Because the density of the cement paste is critical for the solidity of the element and for the bond between concrete matrix and microspheres, a new type of high-strength concrete known as UHPC (Ultra High Performance Concrete) was developed for BlingCrete. The material's behavior is enhanced through the addition of nanoparticles to minimize internal porosity. This produces enhanced cohesion between the components of the concrete structure, and thus a higher-density substance. The result is a new composite material, which through what one might call a permanently integrated dialogue with light gives rise to a distinctive dematerialized aesthetic (Fig. 6). On the materials-research level BlingCrete thus represents a new genre of materials with their own logic of effect, which is not easily described in terms of the conventional categories of heavy and light or form and construction.

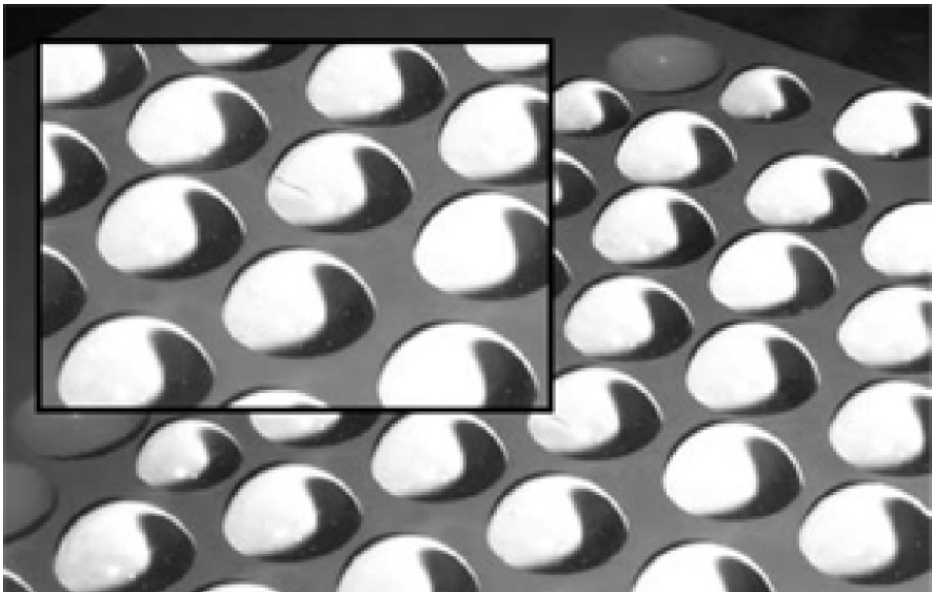

Fig. 5. The optical phenomenon of retroreflection is produced by glass microspheres embedded to a depth of 51 percent of their diameter in concrete. Thus positioned, they refract incident light precisely back to its source.

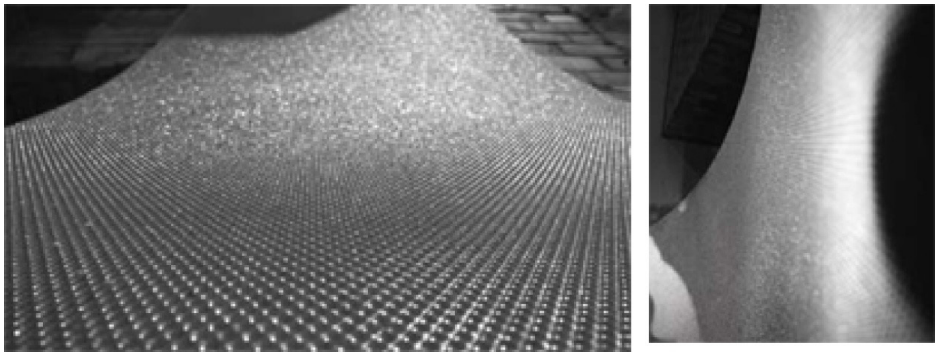

Fig. 6. Through what one might call a permanently integrated dialogue with light, the combination of glass and concrete gives rise to a distinctive dematerialized aesthetic not easily described in terms of the conventional categories of heavy and light.

The activation of the BlingCrete surface is contingent on the positions of surface, light source, and viewer. At a certain moment the reflective effect becomes perceptible, establishing a relationship between motion and a (material) property experienced as a state. Neither material factors nor the objects of the subject's perception and action are sufficient by themselves to convey this property. The physical phenomenon of retroreflection transmitted by the material enables a flexible slice through a single, mutable whole. The concrete (the surface) changes from a passive to an active state (Fig. 7). It makes no difference whether sunlight or a carefully positioned artificial light source is involved, or multiple light sources of different colors, directed at the surface from different positions.[6]

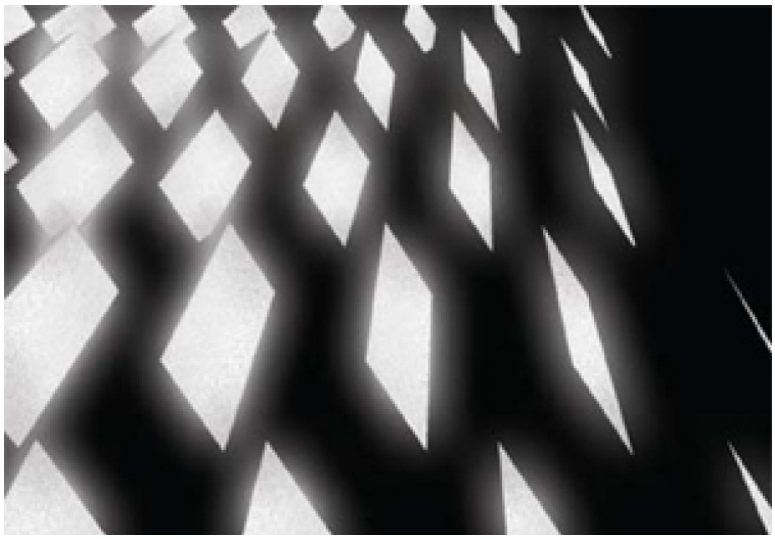

Fig. 7. The activation of the BlingCrete surface is contingent on the positions of surface, light source, and viewer; it changes from a passive to an active state.

The functionalized-surface concept employed here is, as previously noted, borrowed from materials research, which speaks—with apparent rationality—of the function of surfaces. One example is the protective function, but one can also speak of the energy-generating function, or of light-generating or climate-regulating surfaces. To guide our efforts we have divided our work into subject areas: nano, energy, light, climate, and information. With the same lucidity they bring to the categorization of technological developments, these terms also delineate po-

tential applications with contemporary relevance for research *and* design. Taking the surface as our conceptual and technological starting point we investigate the possibilities for "animating" materials. In this sense BlingCrete has staked a position in a field of current developments that may be grouped under the heading of "intelligent surfaces." Design theorist Ramia Mazé describes these developments as a shift of attention from the appearance of materials to the performance of surfaces: "As structural, chemical and computational properties are integrated at nano-, micro- and macro-scales, even the most traditional material might become more dynamic."[7]

By now, materials research has arrived at the molecular level, where electrostatic forces outweigh the gravitational and inertial forces that prevail in macroscopic space.[8] As a consequence many new materials are characterized as much by their optical and physical macro-properties as by micro- and nano-level scalar effects: "Thus the sea change we sense is subtle and subversive because it is occurring below the surface of visible artifacts."[9] Together with Italian materials researcher Ezio Manzini we can speak of a technologization of materials that is making it increasingly possible for designers to predetermine material behavior instead of making allowances for it.[10]

Magnetic Positioning

With regard to further development we are interested in possibilities and strategies for structuring surfaces according to determinable principles, and for functionalizing and designing them by means of mutually interdependent processes. There are fundamental similarities between this line of inquiry and nanotechnological attempts to develop methods for controlling and deliberately arranging atoms, molecules, and particles.

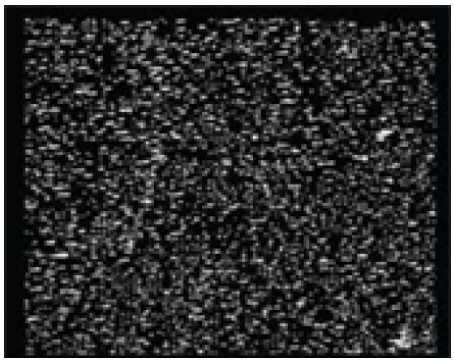

Fig. 8. SEM image of a particle field manipulated by magnetic stray fields. Magnetic positioning is used to reposition and deliberately arrange particles on the nanoscopic level.

Here we find two opposing approaches: the selective positioning of individual particles (which are arranged according to modular principles) and the systematic generation of particle fields. One recent method is known as magnetic positioning, i.e. the use of magnetic fields to structure particles.[11] We begin by recalling that in physics, (almost) everything revolves around the wave-particle principle. Wave-particle duality is a paradoxical concept intended in part to explain the nature of light. It describes particles as location-probability distributions of quanta, which are determined through measurement, and whose spread can be represented as waves. The wave phenomenon spans dimensions, so to speak: Unlike other natural forces, waves act in comparable ways on the nano, micro, and macro levels. Much the same is true of magnetism.

Fig. 9. Processing simulation of a magnetically structured field of glass microspheres in a concrete matrix.

On the nanoscopic level, magnetic positioning is used to reposition and deliberately arrange particles (Fig. 8). This led us to investigate ways of using magnetic effects, which we employ on the macro level to alter matrices with micro- and nanoparticles. Simulated particle fields created with the help of various algorithms and the use of Processing, have enabled us to learn more about these forces. We have also been exploring possibilities for generating weakly structured patterns and nonspecific particle formations (noise, Fig. 9). Our next step will be to apply these simulated processes to the concrete matrix– microsphere system, using one specially developed procedure to magnetize the spheres. This approach generates models with their own structural logic, aesthetic, and function, which do not address the relationship between material and form in the conventional sense of perfection. Fundamentally conflicting forces can also be harnessed for design. The results include objects for installations, real-time parametric simulations, images (Fig. 10), and video sequences, as well as material samples and structural components. Inherent in this approach is a scientific methodology based on the premise that forces can only be perceived by their effects. The results depict natural forces as transformative processes affecting the states of surfaces.

Fig. 10. Magnetic positioning: usage scenarios.

BlingCrete with its concrete and glass components has also proved to be a simple but consistent and fully parameterizable model capable of simulating and illustrating on the macro level specific concepts and nanoscale processes from materials research and experimental physics. Moreover, the dialogue between the disciplines involved in the project has come to focus more and more on the concepts and paradoxes of experimental physics, which begin to emerge with the Bohr model of the atom—a model, which, though it may in some senses be considered obsolete, still hangs above the entrance to modern physics.[12] Activities in the field of materials research are constantly producing changes in the discourse model, and vice versa. On the discourse level the discussion of scales (nano, micro, macro), which are essentially scientific in nature, leads to new lines of inquiry and interchange between experimental physics, visual art, and design. Postulates, levels of meaning, and implications such as these show how BlingCrete has evolved from visual art, via materials development, into an experimental setup that catalyzes both artistic and scientific lines of inquiry in equal measure and promotes dialogue about them.

BlingCrete: Process

With the statement about diabolical surfaces quoted at the beginning of this article, physicist and Nobel Prize winner Wolfgang Pauli summed up his research into the physics of surfaces. To quantum mechanics, the theory that explains the effects and interactions of elementary particles, Pauli added the concept of electron spin. In the world of physics the Pauli principle explains the electron shell structure of atoms and the solidity of matter: When two atoms collide, they do not pass through each other because that would require their orbitals to overlap, forcing two electrons to occupy the same place.[13] The Pauli quote refers to the fact that molecules have different properties on material surfaces and interfaces, where they are in contact with three different types of molecules: those in the bulk below them, others of the same type beside them, and still others involved in interactions with the contiguous phase.

Whereas the notion of "surface" was our subject at the start of the project, in the course of our research it has become a level of dialogue. The concept of "surface" encompasses widely disparate ideas, holding equal significance in technology research, the arts, and the humanities. Because of this complexity, we feel it is appropriate to bring together contemporary developments from various disciplines. In our everyday experience, the things around us are made up of matter. At first glance they are bounded by their surfaces, which seem to enclose their inner lives. But even the ancient philosophers of nature sensed the inscrutability of this perception. Far from being a continuum, matter, so they conjectured, was instead made up of tiny basic building blocks that were *átomos*— indivisible.

New technological developments at and beyond the bounds of the visible promise to reclaim new parallel worlds in physics, chemistry, and biology for a macro world bumping up against its limits. In the applied sciences there is increasing overlap between pure science and the practically oriented strategies of engineering. This new praxis follows the dictum that "making is knowing." In this context concepts of membrane, surface, and boundary open up a space for interdisciplinary negotiation. On the process level the development of BlingCrete can be seen as a process of exchange in which ways of knowing and working that are specific to the scientific and artistic disciplines are harnessed in order to position and deploy them in contexts other than their own, thereby generating friction. Disparate fields are opened up in dialogue with other disciplines, in a process of investigation and imagination. Our common research interest focuses on generating mutual inspiration and channeling it toward the realization of concrete results, and also on exploring ways of working (process and production) in art, science, and technology: their inherent similarities, parallel developments, and differences. We want to know whether it is possible to establish new relationships, find procedures and solutions, and reconsider questions from a different perspective.

The strength of artistic activity lies in the fraught relationship between autonomous action and the confrontation with real-world conditions. It is precisely this *betweenness*—neither being subsumed by the factual nor becoming the vanishing point of some other, imagined world-that we see as a singular quality of our work. Our actions are characterized by concrete interventions in very specific contexts, which question perceptual models such as those bound up with the terms invention, experiment, art, and technology. Such models gain meaning and purpose only through a process of negotiation, which, with its changes of direction, intersections, and differentiations, is always tied to a context. The point is to open up a new way of perceiving, to create a form of open-ended discontinuity, to play with positions, and to make systems more fluid.

Translated by Patrick Hubenthal

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Endnotes

[1] The *infra-mince*, in the words of Duchamp, is "the possible encompassing the incipient; the transition from one to the other takes place in the *infra-mince*." Quoted in Hanimann, 1986, p. 135.

[2] See Benthien, 2001, p. 38.

[3] See Reichholf, 2008, p. 137.

[4] "Parkhaus—Stadt im Regal," an exhibition in a parking garage in Berlin, May 4-18, 1997.

[5] See Klooster, 2009, pp. 76-82.

[6] BlingCrete's properties open up a variety of design possibilities in architecture and traffic safety engineering. Potential uses include the permanent marking of safety hazards (stairs, curbs, pavement edges) as well as designs for structurally integrated wayfinding systems and innovative structural elements (facades, floors, ceilings). Thanks to its haptic qualities, BlingCrete can also be used in tactile guidance systems for the blind.

[7] Mazé, 2007, p. 35.

[8] "Miniaturization is beneficial for enhancing mechanical stability, increasing mechanical resonance frequencies, increasing lifetime and increasing the efficiency of actuating forces in direct comparison to those forces causing material fatigue." Viereck et al., 2008, p. 135.

[9] Mori, 2002, p. xiv.

[10] See Manzini, 1989.

[11] The work of project group members Arno Ehresmann and Dieter Engel (Experimental Physics Group 4, Institute

of Physics, University of Kassel) is critical in this context. See Ennen et al., 2007.

[12] One fundamental and exceptional paradox stands out clearly here: Atoms, which are, of course, the building blocks of matter, are essentially formed out of nothing. "All atoms are, in essence, made up of empty space with tiny wave packets whirling around in it." Landua, 2008, p. 41.

[13] Because of their spin, Rolf Landua describes electrons as "antisocial particles." Landua, 2008, p. 40.

Figures

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Fig. 2. Klussmann, H. (1997). *Catwalk* [installation with retroreflective pavement marking material], in "Parkhaus—Stadt im Regal," an exhibition at the Parkhaus Behrenstraße, Berlin. Photo: Silke Helmerdig.
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Fig. 10. Klussmann, H., & Klooster, T. (2010). *BlingCrete / magnetic positioning of concrete—mapping* [computer simulation].

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Heike Klussmann is an artist and a professor of art and architecture at the University of Kassel. She is a graduate of the Berlin University of the Arts and also studied at the Kunstakademie Düsseldorf. Her work has been shown in recent exhibitions at the Zeche Zollverein in Essen, the KW Institute of Contemporary Art in Berlin, China Art Objects in Los Angeles, the Berlinische Galerie Museum of Modern Art, Óbudai Társaskör in Budapest, and the Akademie der Künste in Berlin. Her many honors and awards include first prize in an international competition to design Düsseldorf's new Wehrhahn subway line, as well as an Artists Grant from Villa Aurora in Los Angeles, the Goslar Kaiserring Grant, and a foreign residency stipend from the city of Berlin. She has presented workshops and lectures at the Bauhaus Kolleg in Dessau, Akademie Schloss Solitude in Stuttgart, and the BAU trade fair in Munich, among other institutions. Since 2009, she has headed the BlingCrete transdisciplinary working group, which is devoted to the experimental development of new material concepts in the context of art, architecture, and science.

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Thorsten Klooster is an architect in Berlin and the editor of the book *Smart Surfaces—And Their Application in Architecture and Design.* He is a former member of the Technical Science Research Group at the Fraunhofer Institute for Production Systems and Design Technology in Berlin. From 2002–07, he was a design instructor at the Brandenburg University of Technology, where his research areas included new materials and functional surfaces. In 2007 he founded the firm TASK Architekten in Berlin. He has presented workshops and lectures at Akademie Schloss Solitude in Stuttgart, Università IUAV in Venice, and the University of Michigan, among other institutions. He is currently a referee for the 2013 IBA Hamburg's "Smart Material Houses" competition. Since 2009, he and Heike Klussmann have headed the BlingCrete working group at the University of Kassel, which is devoted to the experimental development of new material concepts, with an emphasis on the functional design of concrete surfaces. BlingCrete brings together experts from the fields of visual art, architecture, interaction design, industrial design, experimental physics, and materials research, and is funded by the AIF industrial research group.