MATERIAL PARADIGM *CLASSIFICATIONS*

MATERIAL SCIENTIST

bond type_ ionic, covalent, metalic, vander waals

molecular structure_ branch, link, matrix

crystalline pattern_ simple, face-centered, body-centered

ENGINEER

state_ solid, liquid, gas

structure_ amorphous, crystalline

origin_ natural synthetic

composition_ organic, inorganic, alloy

processing_ cast, hardened, rolled

property_ emissivity, conductivity

environment_ corrosive, underwater

application_ adhesive, paint, fuel

cost_ $, $$, $$$

recyclability_ good, fair, poor

ARCHITECT

division 1_ general requirements
division 2_ sitework
division 3_concrete
division 4_ masonry
division 5_metals
division 6_ wood and plastics
division 7_ thermal-moisture protection
division 8_doors and windows
division 9_ finishes
division 10_ specialities
division 11_ equipment
division 12_ furnishings
division 13_ special construction
division 14_ conveying systems
division 15_ mechanical
division 16_ electrical

[csi master format]

COMPOSITION

PERFORMANCE

APPLICATION

MATERIAL PARADIGM *TRANSMATERIAL*

MATERIAL SCIENTIST + ENGINEER +

bond type_ ionic, covalent, metalic, vander waals

molecular structure_ branch, link, matrix

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[csi master format]

COMPOSITION + PERFORMANCE + APPLICATION

MATERIAL PARADIGM *NANOTECHNOLOGY*

MATERIAL SCIENTIST + ENGINEER + ARCHITECT

COMPOSITION + PERFORMANCE + APPLICATION

MATERIAL PARADIGM *METAMATERIALS*

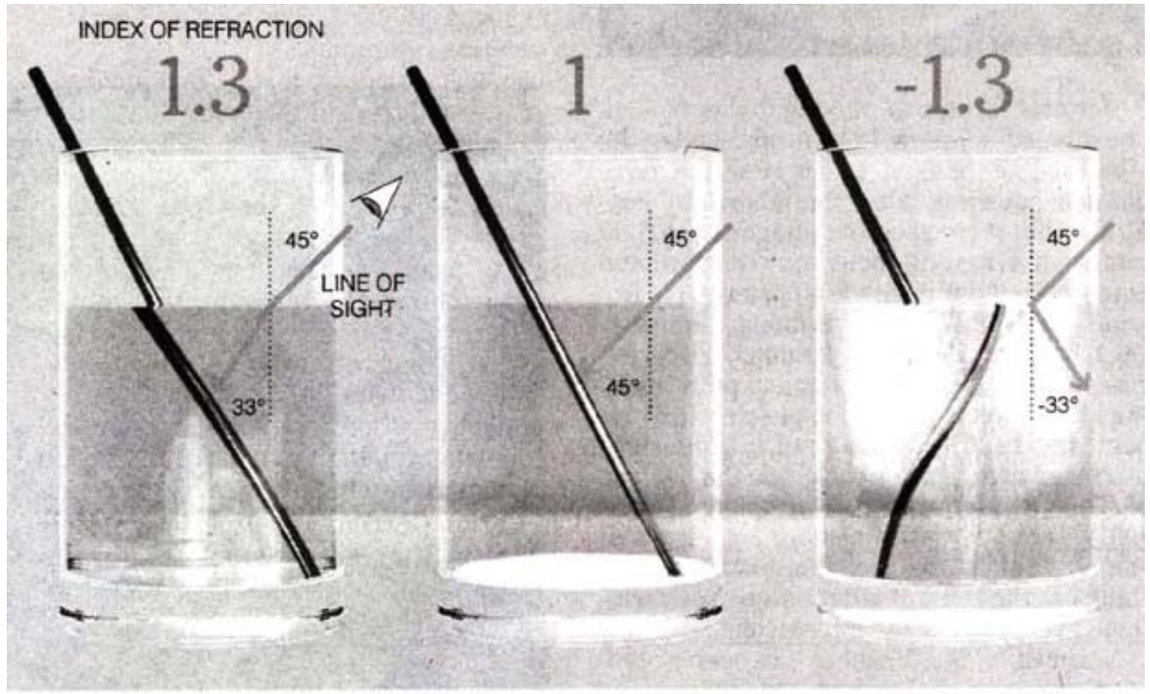
MATERIAL SCIENTIST + ENGINEER + ARCHITECT

COMPOSITION + PERFORMANCE + APPLICATION

MATERIAL INDEX: META

classification_ **metamaterial**
subclassification_ **Electromagnetic**
subsidiaries **Terahertz metamaterials**
Photonic metamaterials

Metamaterials manipulate the electric and magnetic fields in lightwaves and the alter the index of refraction. Electromagnetic metamaterials hold the potential to open many new doors due to their capability to direct wave propagation at the electromagnetic level. This means a redefinition of entire systems such as low density materials that can carry increased performance but remain lightweight and small. They are a subsidiary research area of both physics and electromagnetism. Therefore most true metamaterials are in the electromagnetic spectrum and fractal off from there, for example there are Terahertz metamaterials, Photonic metamaterials, Tunable metamaterials, and Nonlinear metamaterials.



POSITIVE REFRACTION
With a refraction index of 1.3, water bends light inward, closer to the perpendicular.

NO REFRACTION
A hypothetical liquid with a refraction index of 1, the same as the surrounding air, would not distort light.

NEGATIVE REFRACTION
A hypothetical liquid with a negative refraction index would bend light the "wrong" way.

One of the largest classifications of electromagnetic kind are Negative Index Metamaterials, which are artificially created synthetic materials that cause light to refact or bend in ways it can't naturally. They obey the laws of physics but reverse many of the physical properties that govern the behavior of normal optical materials.

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subclassification_ **Electromagnetic**
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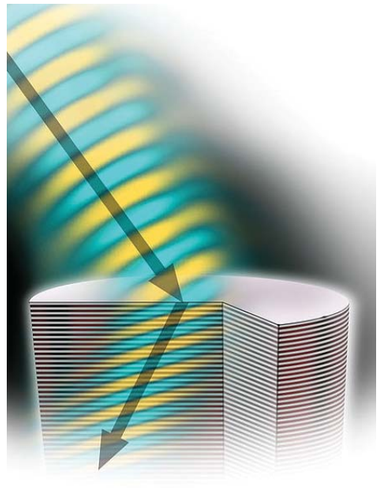
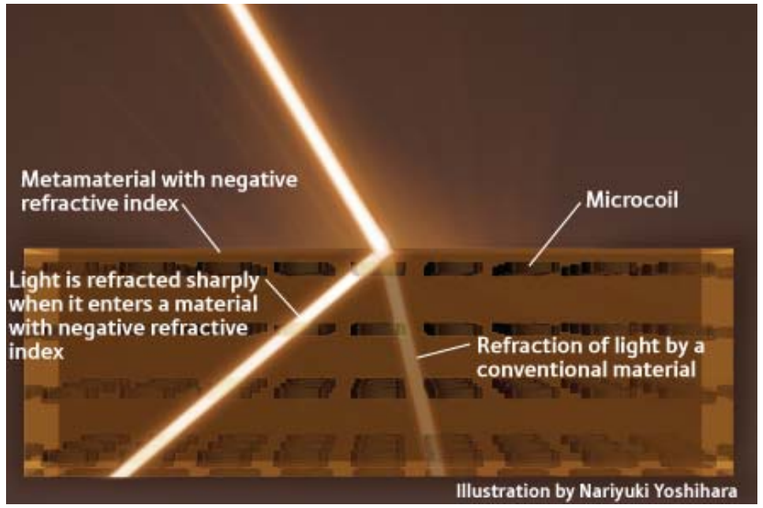
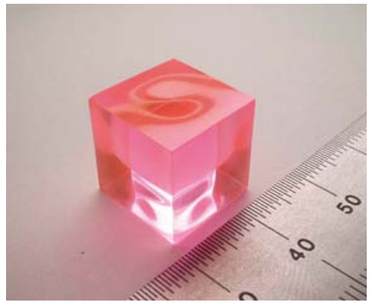
Photonic metamaterials





light bending in unnatural ways

In 1999, Rodger M. Walser of the Unversity of Texas at Austin defined metamaterials as "Macroscopic composites having a manmade, three-dimensional, periodic cellular architecture designed to produce an optimized combination, not available in nature, of two or more responses to specific excitation."



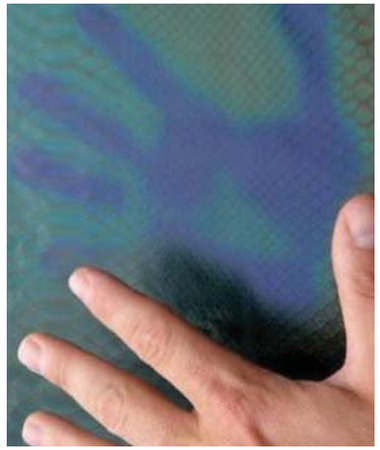
left: this is a cube of optical memory in which information is recorded three dimensionally. It can store about 250 gbs of information, and this technique could be applied to an optical disc of 12 cm across by 1.2 mm thick and would hold as much as 1 petabyte (which is one million gigabytes).

MATERIAL INDEX: CHROMIC

material type : **type I**
stimuli : **heat, light, electricity, stress, chemical**
result : **color changing**

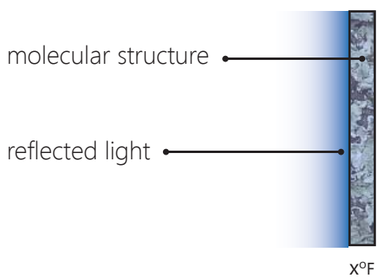
Material color and transparency is determined by its internal molecular structure. As light waves encounter a material, certain wavelenghts are allowed to pass through the material while others are reflected back, thus giving the material its color properties. In response to environmental stimuli, chromic materials alter their molecular structure, thereby changing which light wavelengths are reflected back off the surface and which wavelenghts pass through through the surface. This shift in molecular structure is what the eye percieves as a shift in color. Below are common material types and the external stimuli that act upon them.

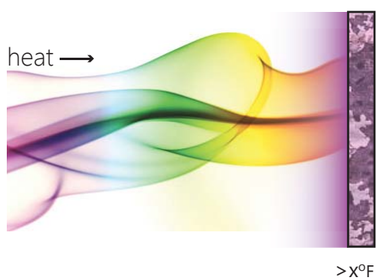
THERMOCHROMIC:

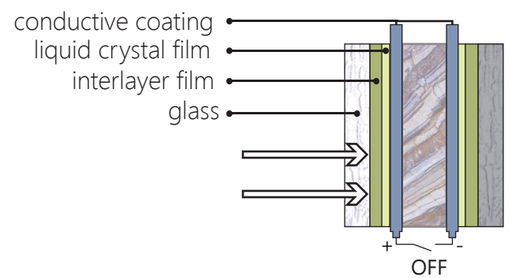


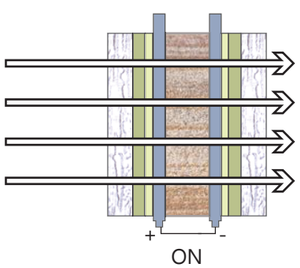
PHOTOCHROMIC:

ELECTROCHROMIC:









MATERIAL INDEX: MAGNETORHELOGICAL

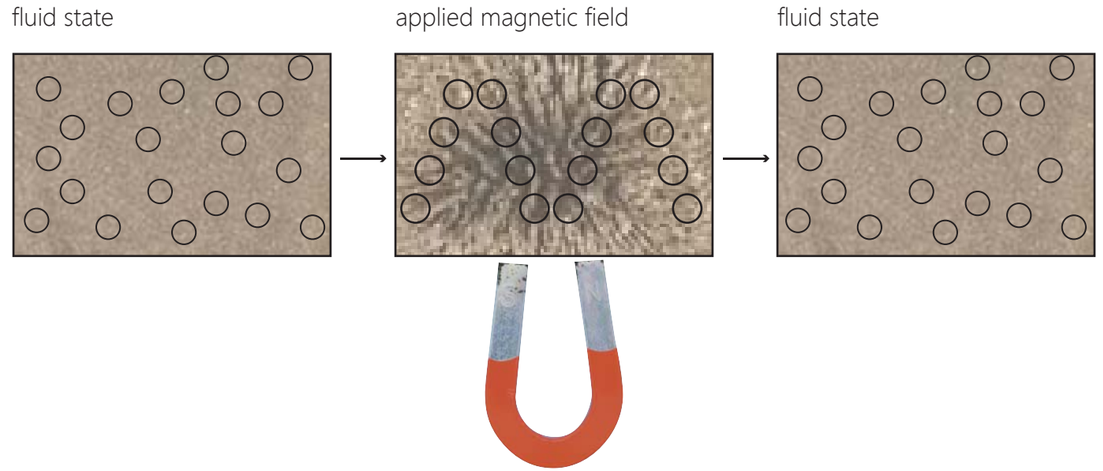
material type : **type I**
stimuli : **magnetic field, electical current**
result : **phase/form changing**

A magnetorheological material is primarily composed of magnet filings or powder dissolved in an oil base. In its resting state, it takes the form of a fluid and its molecules are free flowing. When a magnetic field is applied, both the viscosity and the form are dramatically affected. The molecules reorganize in a rigid state along the lines of the magnetic field. When the magnetic field is removed, magnetorheological materials return to their resting fluid state.

BEFORE:

AFTER:

FERRO FLUID :: PROTRUDE FLOW

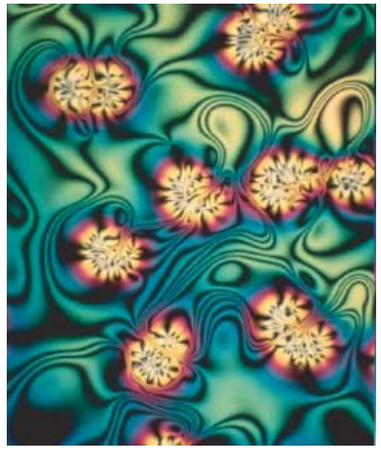


MATERIAL INDEX: TROPIC

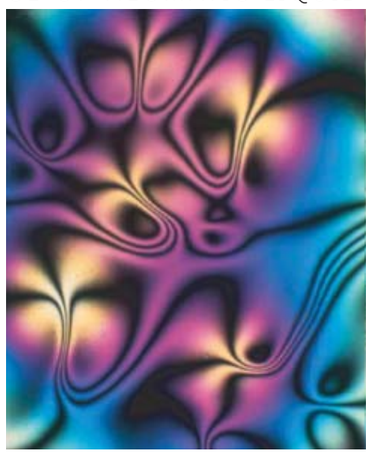
material type : **type I**
stimuli : **heat, light, electricity**
result : **phase/property chaning**

Tropic materials are activated by a change in phase. In response to environmental stimuli, tropic materials change their phase, and in so doing, they alter their micro-structure. In changing phase, tropic materials can demonstrate new properties, such as conductivity, transmissivity, volumetric expansion, and solubility. For example, shown below is neumatic liquid crystal films, which are commonly found in LCD screens. These crystal films exist in a phase in between crystalline solids and isotropic liquids. The crystals can align in response to an electric current and thus change what wavelenghts of light are reflected or allowed to pass.

PROGRESSIVE PHASE CHANGE OF NEUMATIC LIQUID CRYSTAL FILMS:

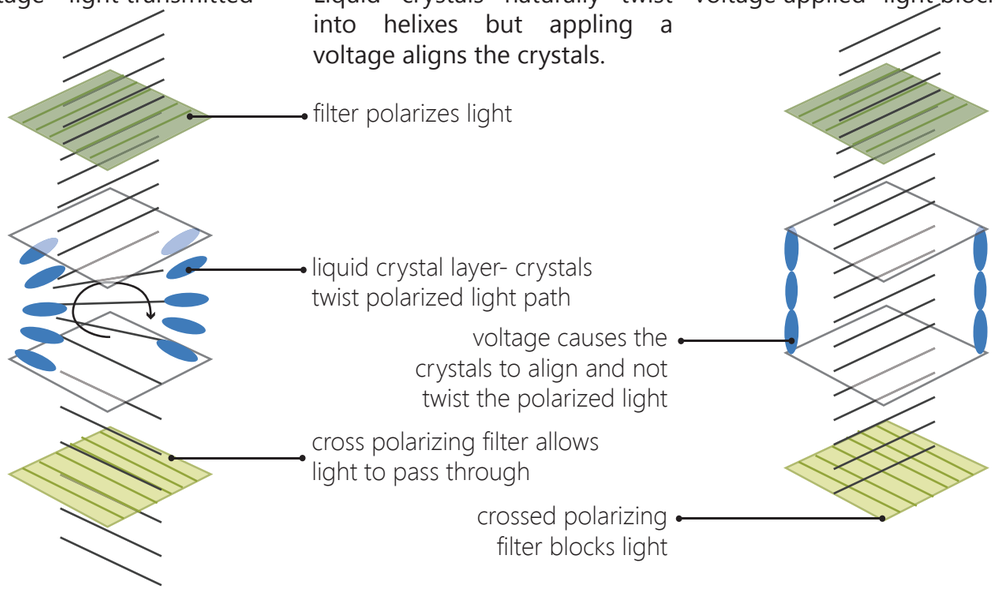


no voltage - light transmitted



Liquid crystals naturally twist into helixes but appling a voltage aligns the crystals.

voltage applied- light blocked

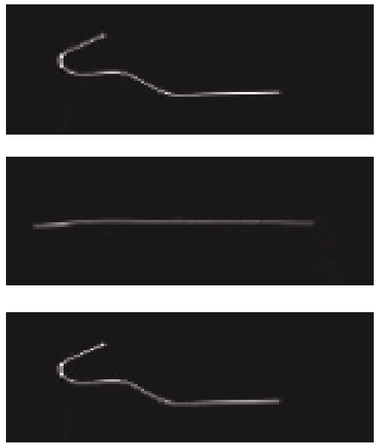


MATERIAL INDEX: SHAPE MEMORY

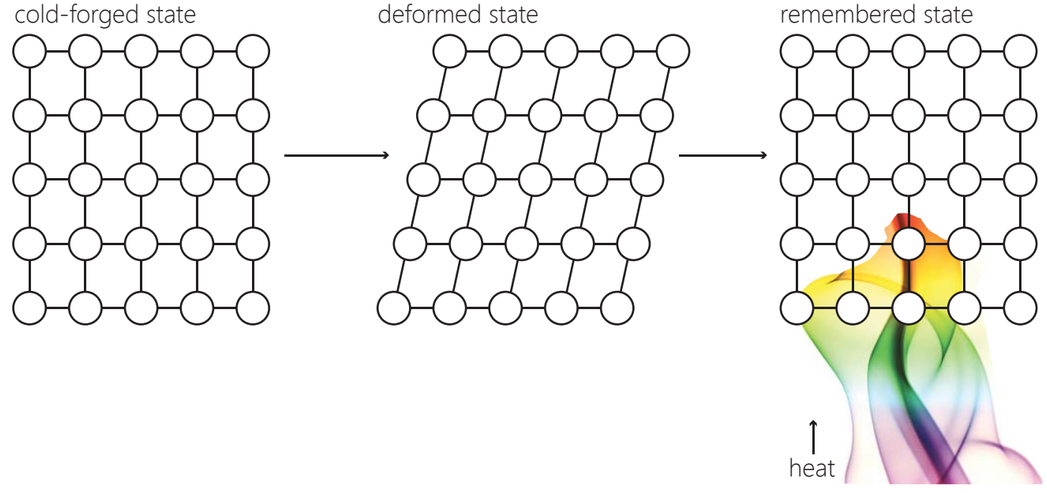
material type : **type I**
stimuli : **heat, magnetic fields**
result : **shape changing**

Shape memory materials are typically alloy materials. They are initially formed by a process called cold-forging, and they are unique in that they have the ability to return to a 'remembered form'. The material can be repeatedly deformed and returned to its initial shape by applying heat or a magnetic field to the material.

WIRE FORM : DEFORM : FORM



:SHAPE MEMORY ALLOY LIGHT:

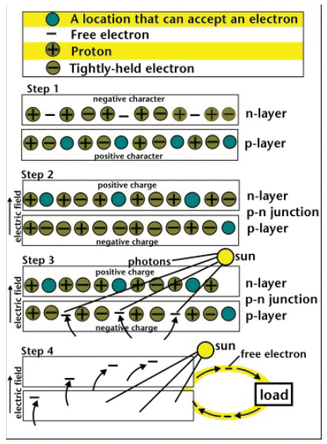


MATERIAL INDEX: PHOTOVOLTAIC

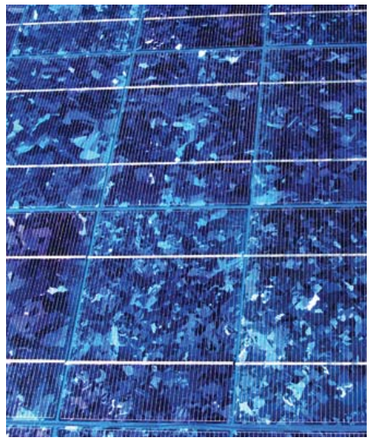
material type : **type II**
input : **light**
output : **electricity**

Photovoltaic cells harness the energy of the sun and convert it into electricity. Direct solar radiation that is incident on the photovoltaic panel charges a battery system. The energy stored in the battery can be used directly from DC outlets, or it can be converted for use in AC outlets.

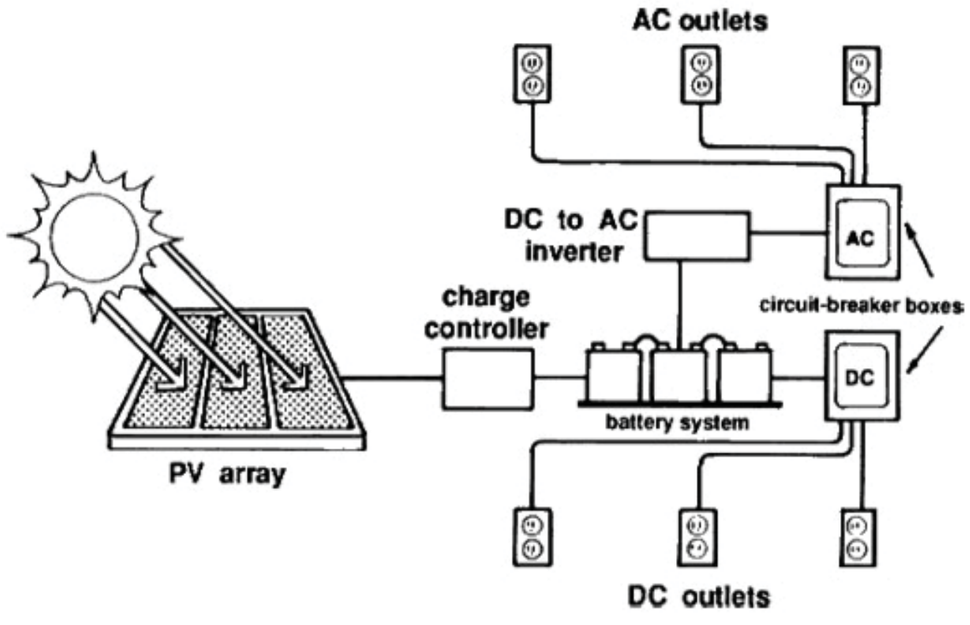
PV Cell Formation:



PV Cell Formation:



PV Field Array:

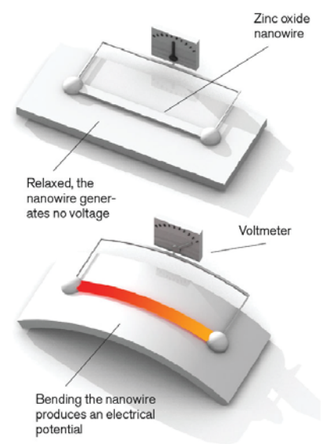


MATERIAL INDEX: PIEZOELECTRIC

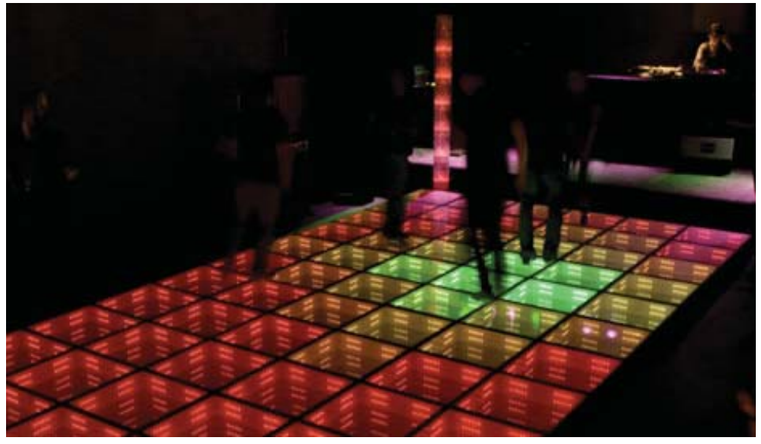
material type : **type II**
input : **pressure**
output : **electricity**

Piezo electric generate energy when pressure is applied to a material. In its resting state, a piezoelectric material's charge is balance; the positive and negative forces cancel out. When the material is deformed, the charges no longer cancel out. Opposite sides of the material become oppositely charged. The charge across opposite faces generates an electric current. Conversely, if an electric current is applied to a piezoelectric material, the material will deform.

Piezoelectric material:



Piezoelectric Dance Floor:



resting state: charges cancel out

pressure applied: voltage created

MATERIAL CASE STUDIES

classification_ **metamaterial**
subclassification_ **cladding**
material name_ **Junk Wood**
creator_ **Sheila Kennedy**
research base_ **MATx Research**

Sheila Kennedy's work has taken her into unexplored regions of synthesis between materiality and electricity. In reimagining how electricity behaves with respect to architecture, her work and her writing show a new kind of metamaterial that breaks electricity free from the cavity in the wall. 'Hidden infrastructure' is a definition of the past with regard to electricity, and it is no longer known to be a function separate but related to architecture optimized into categories of simply 'power' and 'light.'

"Neither architecture nor purely product, the synthetic union of digital technology in materials introduces applications for electrical infrastructure at the scale of architecture, the city, and the body." [91]

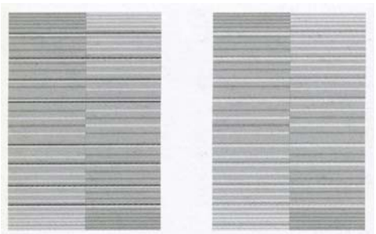
below: Junk Wood recycles wood and plastic through a process that ultimately changes the proportion of their molecular makeup in order to create channels of inner light reflection. Woven in between the second lives of the wood and plastic are LCD display texts providing mobile data, sliding through surfaces to engage the environment, material, and user.

MATERIAL CASE STUDIES

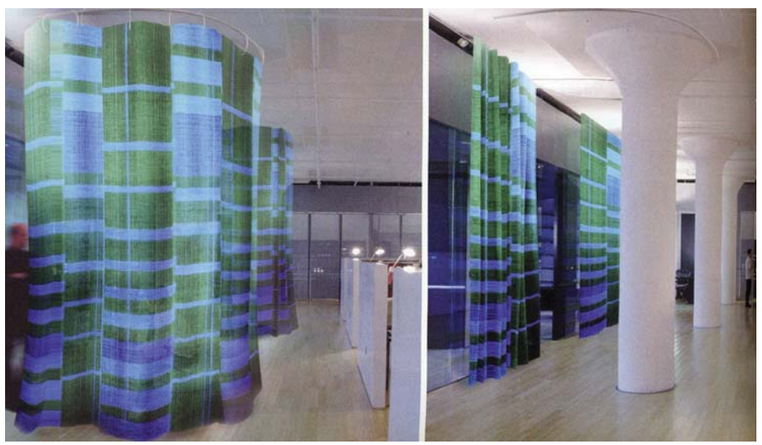
classification_ **metamaterial**
subclassification_ **cloth**
material name_ **Give Back Curtain**
creator_ **Sheila Kennedy**
research base_ **MATx Research**

The Give Back Curtain presents a metamaterial operating in a fluid manner. Light enters at one point and is emitted in dynamic patters moving in response to interaction with the technofabric. Touching the fabric, bunching it up and ruffling it concentrate the digital light.

below: Patterns produced by the light changes



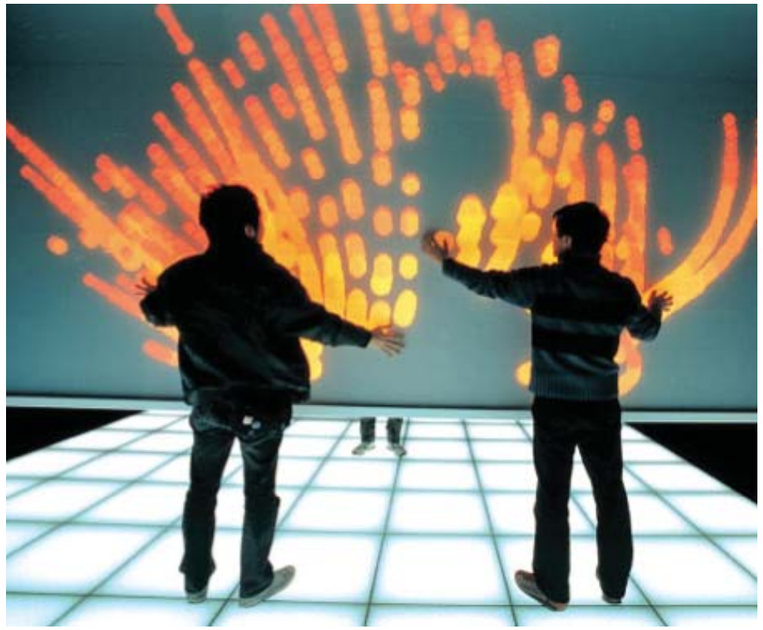
"As the infrastructure of light becomes absorbed into materials, its visibility as a distinct system diminishes, but its effects gain a greater presence as they are mediated and transformed by the host material." [89]

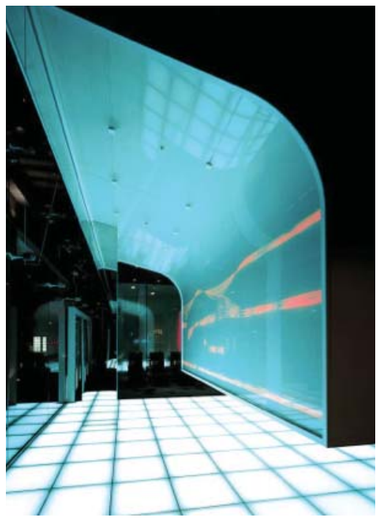


MATERIAL CASE STUDIES

classification_ **metamaterial**
subclassification_ **interactive wall**
material name_ **ICE, @ Bloomberg HQ**
creator_ **Klein Dytham + Toshio Iwai**
research base_ **DKa**

KDa has experience in electronic billboards and three-dimensional digital architecture, so this was a natural progression. The ICE installation is made of a 5 x 3.5 curved glass wall that responds to bodily movement while displaying streams of financial data (it was commissioned and funded by Bloomberg). It works by a network of infrared sensors behind the surface that detect the users presence. Initial engagement with the surface brings up a menu of four digital play options and as the user interacts with the surface. The sensors synthesize movement and touch into optical and acoustical signals, portrayed back into real-time through digital reflective patterns and electronic shadows.





"An innocent yet knowing design, ICE defies the boundaries between office interior and street, work and play, data and body." AD [13]

MATERIAL CASE STUDIES

classification_ **metamaterial**
subclassification_ **wall system**
material name_ **Aegis Hyposurface**
creator_ **Mark Goulthorpe**
research base_ **group effort**

The Hyposurface is a linkage of information and form that can be manipulated to tune into a wide array of inputs and subsequently output physical activity as well as engaging interactivity. Inputs range from sound to internet, and outputs take the shape of a moving, dynamic surface that is being called an architectural-cybernetic-prototype. It can move back and forth up to 2 feet and at speeds close to 60 mph. The undulating surface links the virtual to a realtime shifting architecture and is contextual and yet without locality. It derives it's context from the surrounding users.

"What I recognized immediately was that the HypoSurface was born not as a willful invention, but as the intersection of several lines of research exploring the potentials of digital technology in architecture." Charles Allen

MATERIAL CASE STUDIES

classification_ **nanomaterial**
subclassification_ **biomimetic**
natural inspiration_ **gecko feet**
researcher_ **Bharat Bhushan**
research base_ **Nano Magazine**

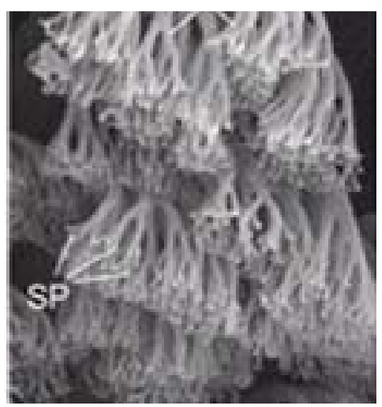
The nano structure of gecko feet allows them to selectively attach and detach their feet from vertical surfaces. Their feet are composed of tiny tube-like structures that are designed with maximum surface area in mind. This allows them to support more weight on a vertical surface and traverse a variety of surface textures. The dry adhesion enabled by the gecko foot nano structure is of interest to designers who wish to create smart and reversible adhesion between surfaces.

"By gaining an understanding of how the natural world works, we can imitate nature to produce new and better materials, devices and processes."

Below: a micro-scale image of a gecko foot

"Geckos have both the highest body mass and greatest density of terminal elements (spatula). Spiders and geckos can generate high dry adhesion, whereas beetles and flies increase adhesion by secreting liquids at the contacting interface. About three million setae on their toes can produce a clinging ability of about 20 N (vertical force required to pull a lizard down a nearly vertical (85°) surface) and allow them to climb vertical surfaces at speeds of over 1 m/s with the capability to attach or detach their toes in milliseconds."

At right is the nano structure of the gecko foot. The foot exhibits three levels of hierarchy that allows the gecko to move on a variety of surfaces.



MATERIAL CASE STUDIES

classification_ **nanomaterial**
subclassification_ **biomimetic**
natural inspiration_ **lotus leaves**
researcher_ **Bharat Bhushan**
research base_ **Nano Magazine**

Lotus leaves are an example of a self-cleaning nano structure. Their surface is composed of tubular wax cones that form a hierarchical structure. The wax cones force water droplets on the leaves to sit on the apex of the wax tubes. This allows the water droplets to absorb any contaminents that fall onto the leaves to be washed away as the water slides off the surface of the leaf. Potential design applicaitons for this nano structure are self cleaning windows and low drag surfaces.

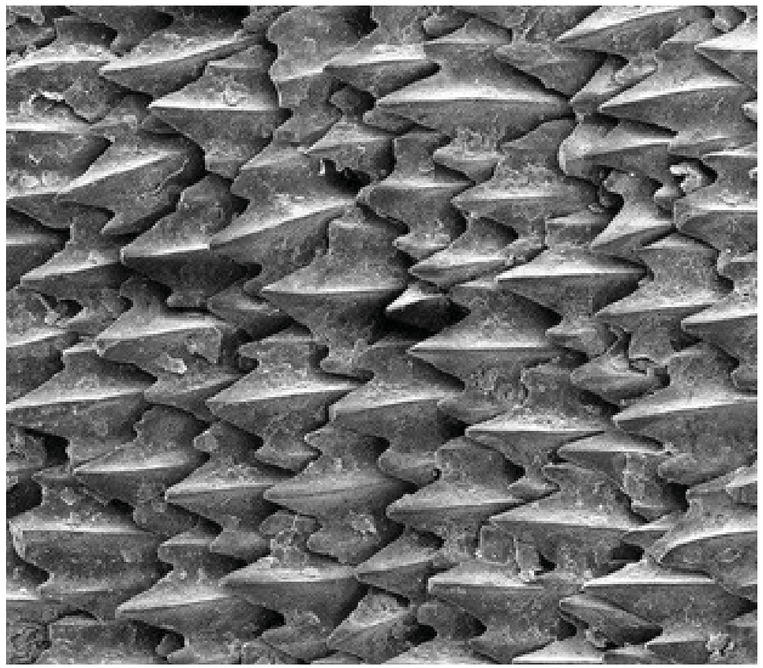
left: water droplets on a lotus leaf.
below left: the nanostucture of a lotus leaf.

MATERIAL CASE STUDIES

classification_ **nanomaterial**
subclassification_ **biomimetic**
natural inspiration_ **shark scales**
researcher_ **Bharat Bhushan**
research base_ **Nano Magazine**

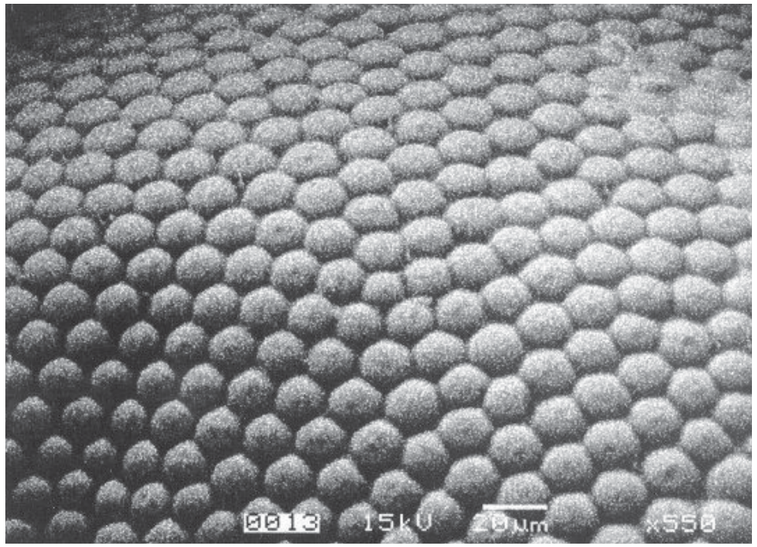
Shark skin is composed of nano structures called dermal denticles. The dermal denticles form lateral channels along the sharks body that allow the shark to move more quickly through the water with less water disturbance. The channels function primarily in three ways:
1. they increase the speed of the water over the surface of the shark by constricting the volume that the water passes through;
2. they pull faster moving water towards the shark where it mixes with slower moving water, thus decreasing the speed differential;
3. they divide up the mass of water flowing over the shark, thus reducing eddying action that follows the shark's movement.
The nano structure of shark skin is an inspiration for materials that seek to increase speed and reduce drag.

right: shark skin dermal denticles.



MATERIAL CASE STUDIES

classification_ **nanomaterial**
subclassification_ **biomimetic**
natural inspiration_ **moth eyes**
researcher_ **Bharat Bhushan**
research base_ **Nano Magazine**

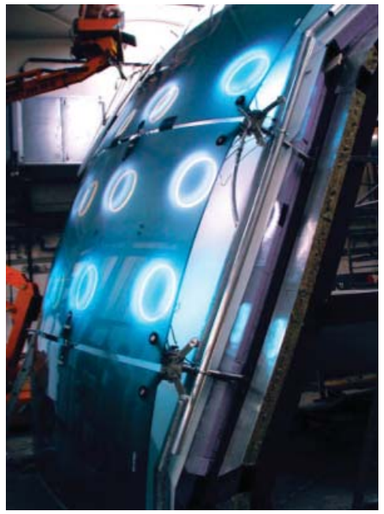


Moth eyes are designed to protect the moth from night time predators. Their hexagonal nano structure is designed to reflect little to no light, thus concealing the moth's presence. For zero reflectance to occur, the refraction index of the surface and the air must be equal. By dividing the surface into nano hexagons, the refraction index of the cornea is increased so that it is nearly equal to that of air. This structure is of interest for the design of non-reflective surfaces, like computer screen and windows.

left: hexagon nanostructure of a moth eye

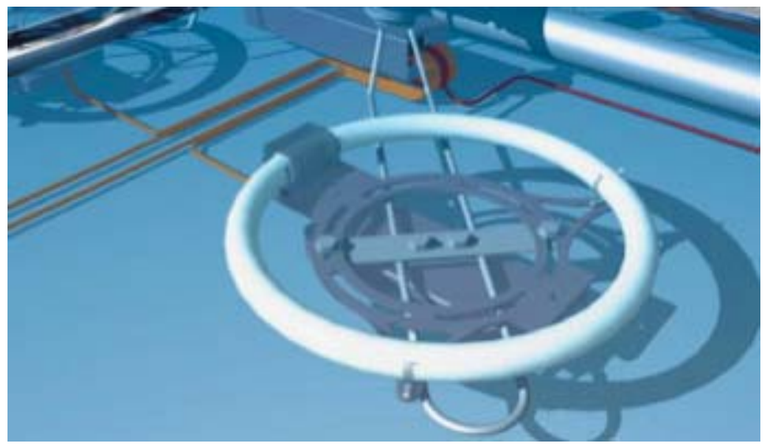
APPLICATION CASE STUDIES

example_ **Kunsthaus**
location_ **Graz, Austria**
material/system_ **BIX MATRIX**
creator_ **realities:united**
date_ **2003**



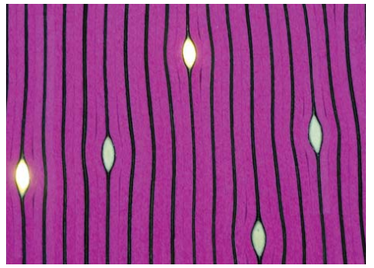
Under the building's acrylic facade on the river side is an intermediate electronic membrane on top of a mesh layer forming the internal covering. Designed by he Berlin-based architects realities:united ... it is a unique, effective and imaginative use of technology, a 900-square-metre media skin called BIX2 (big pixels) integrating architecture, technology and visual message, used as an instrument and platform for artistic production in a new level of mediation. [AD 83]

"In our designs we synchronise architecture, information technology and communication content to develop design concepts, technologies and action strategies that unite the material 'old' reality with the immaterial 'new' realities, which increasingly overlay and augment the present." realities:united

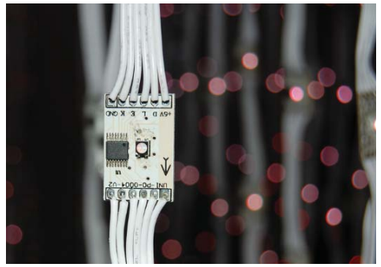


MATERIAL PROGRESSION

CELL, LAMA CONCEPT

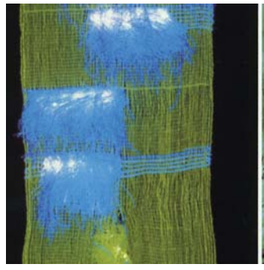


OCEAN OF LIGHT



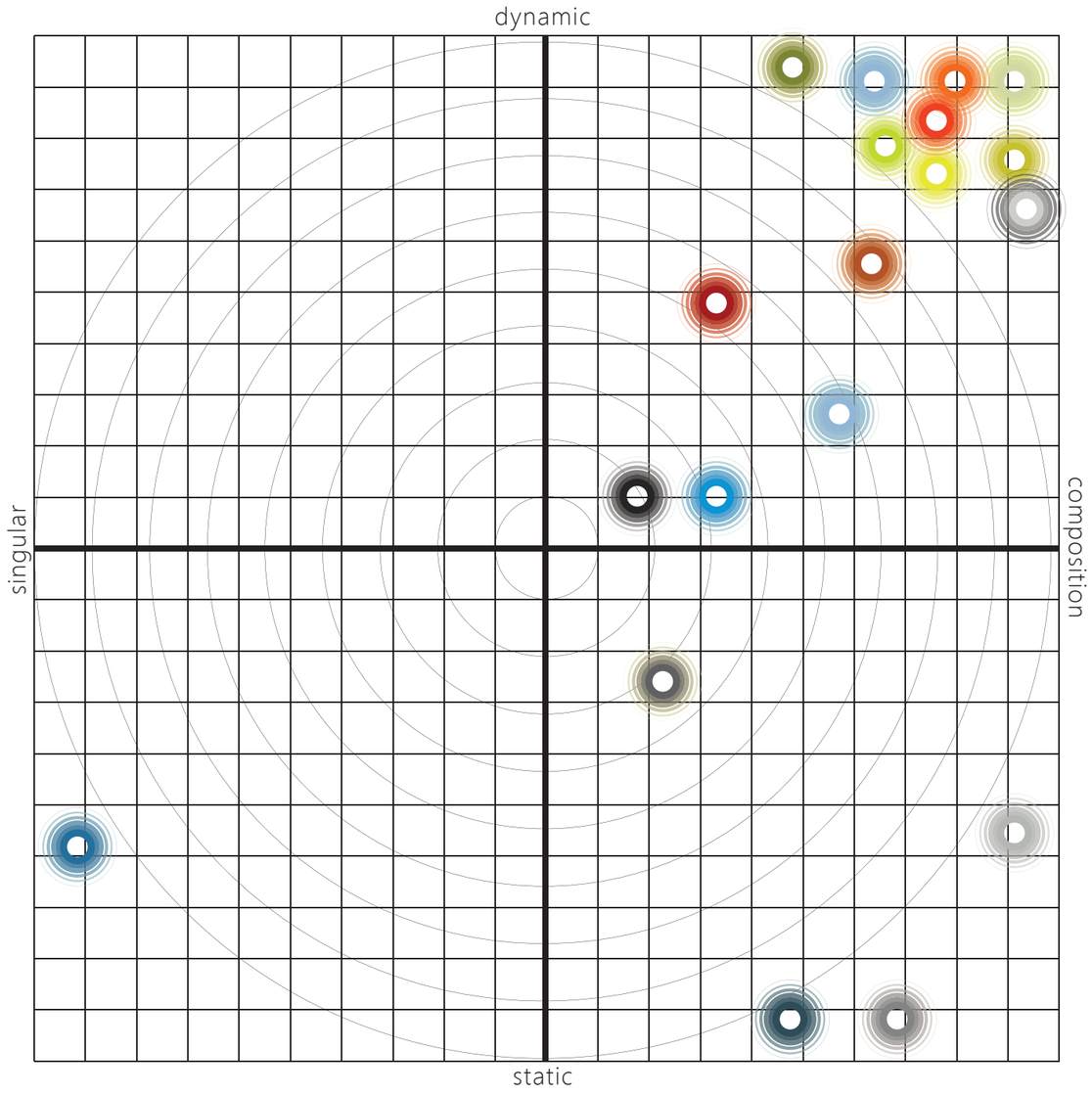
F A B R I L E D

GIVE BACK CURTAIN



UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

PERFORMANCE_ singular>composition VS. static>dynamic



CONVENTIONAL

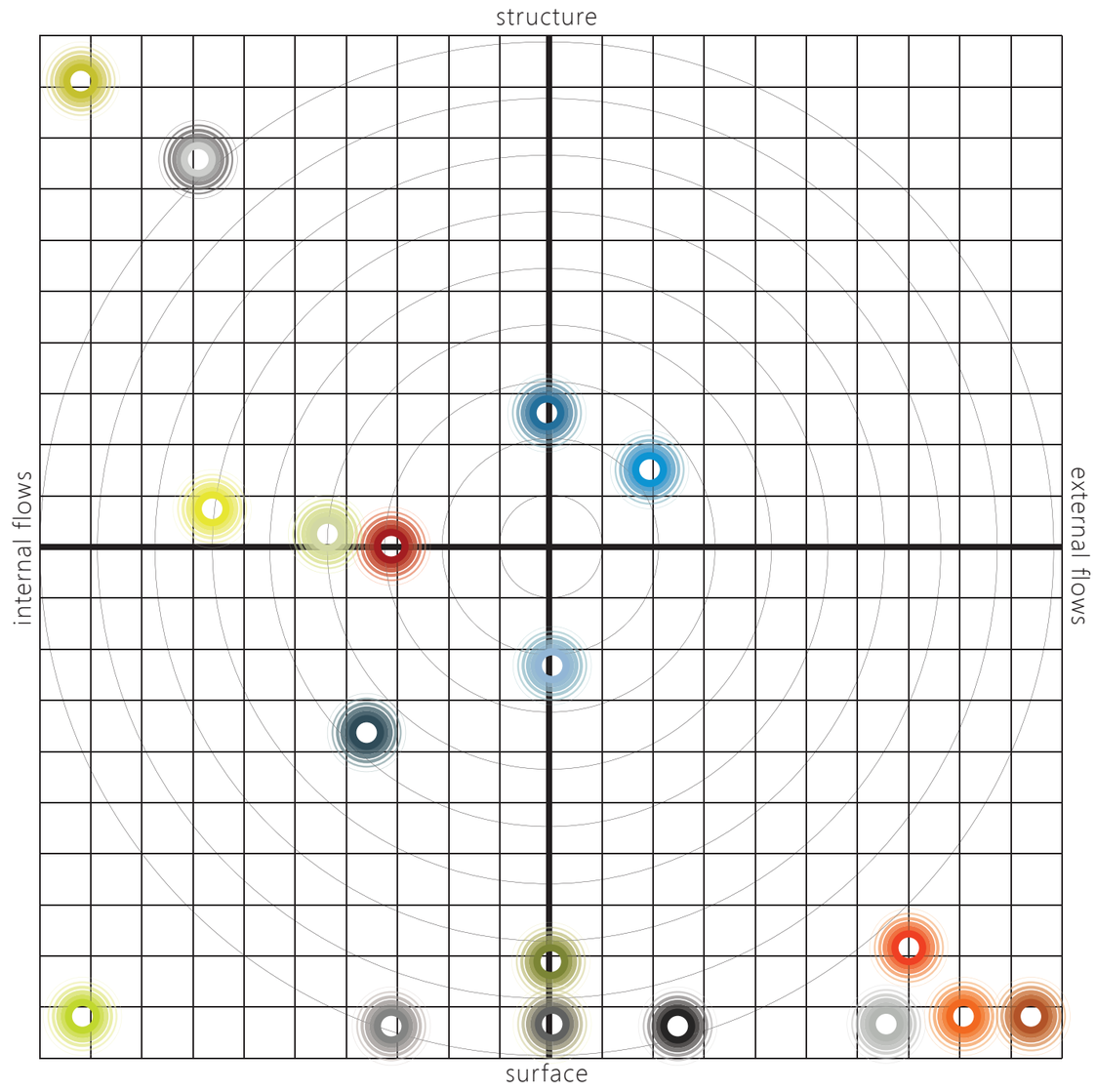
wood
glass curtainwall
brick
etfe

METAMATERIALS

junk wood
give back curtain
ice
hyposurface
electro-magnetic metamaterials

UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

PERFORMANCE X100_ internal flows>external forces VS. surface>structure



TRANSMATERIALS

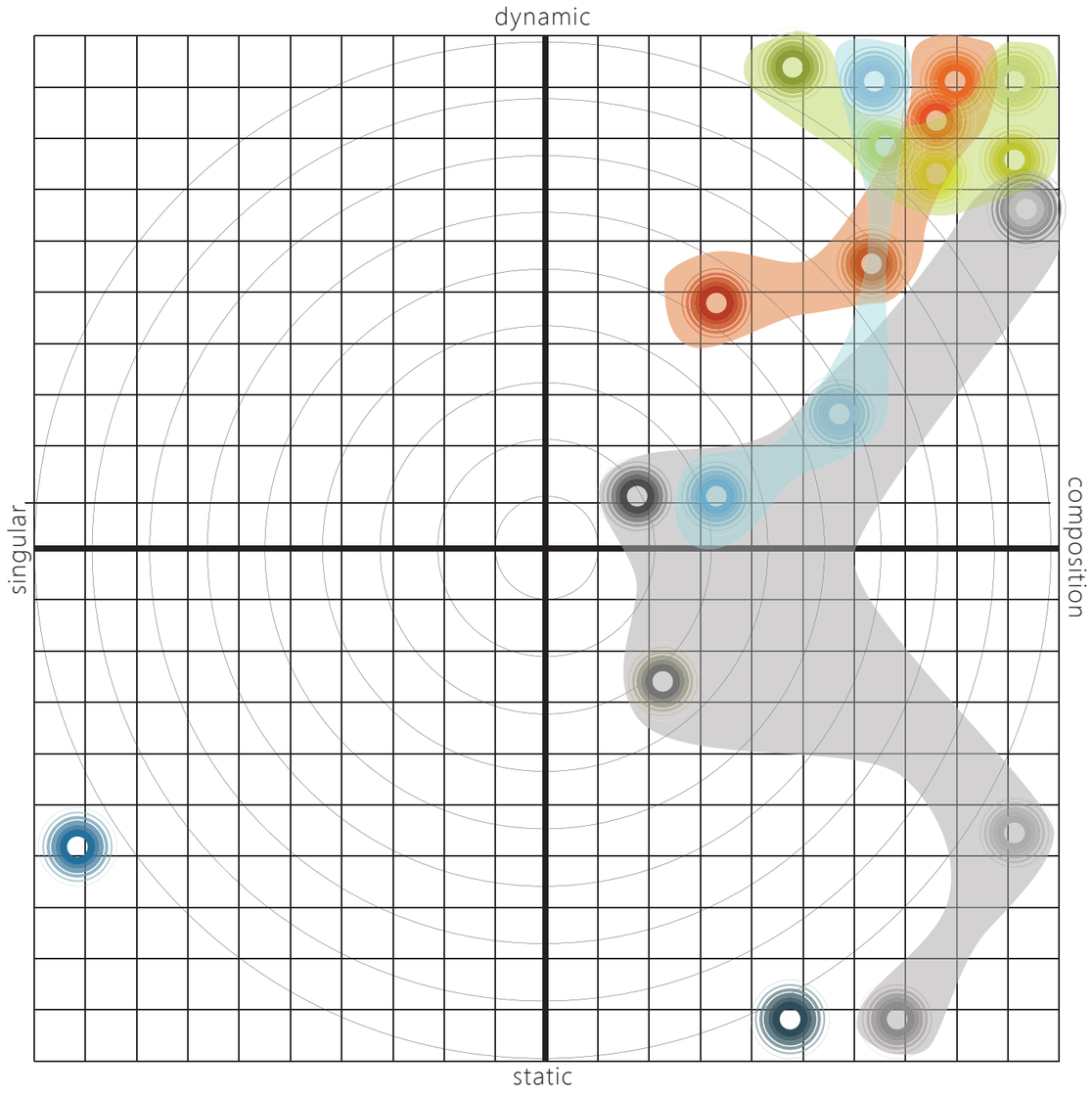
northern lights
sensa cell
piezoelectric dancefloor
koch center smartglass

BIOMIMETIC NANOMATERIAL

gecko feet
lotus leaves
shark scales
moth eyes
nano-technology

UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

PERFORMANCE_ singular>composition VS. static>dynamic



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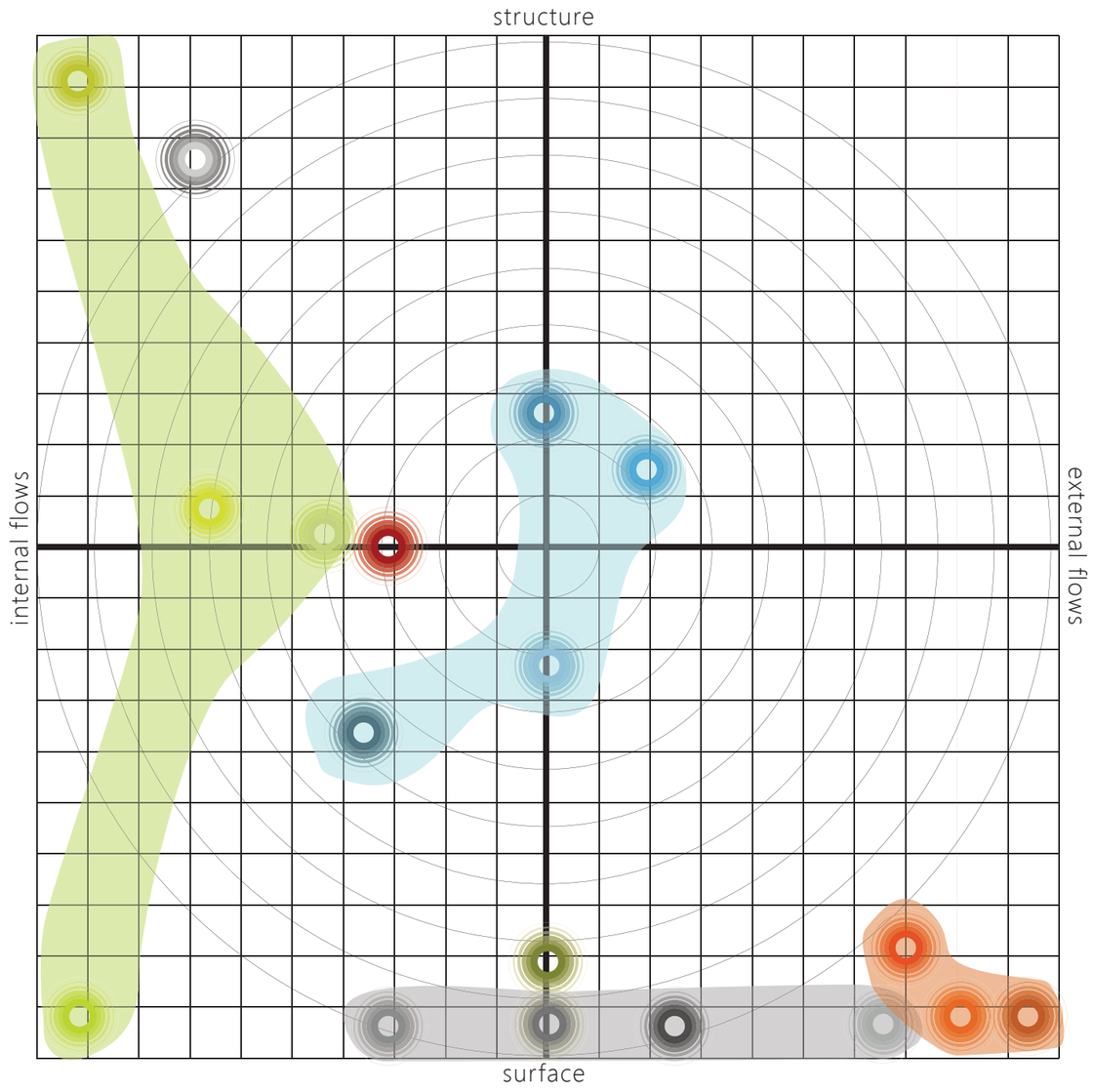

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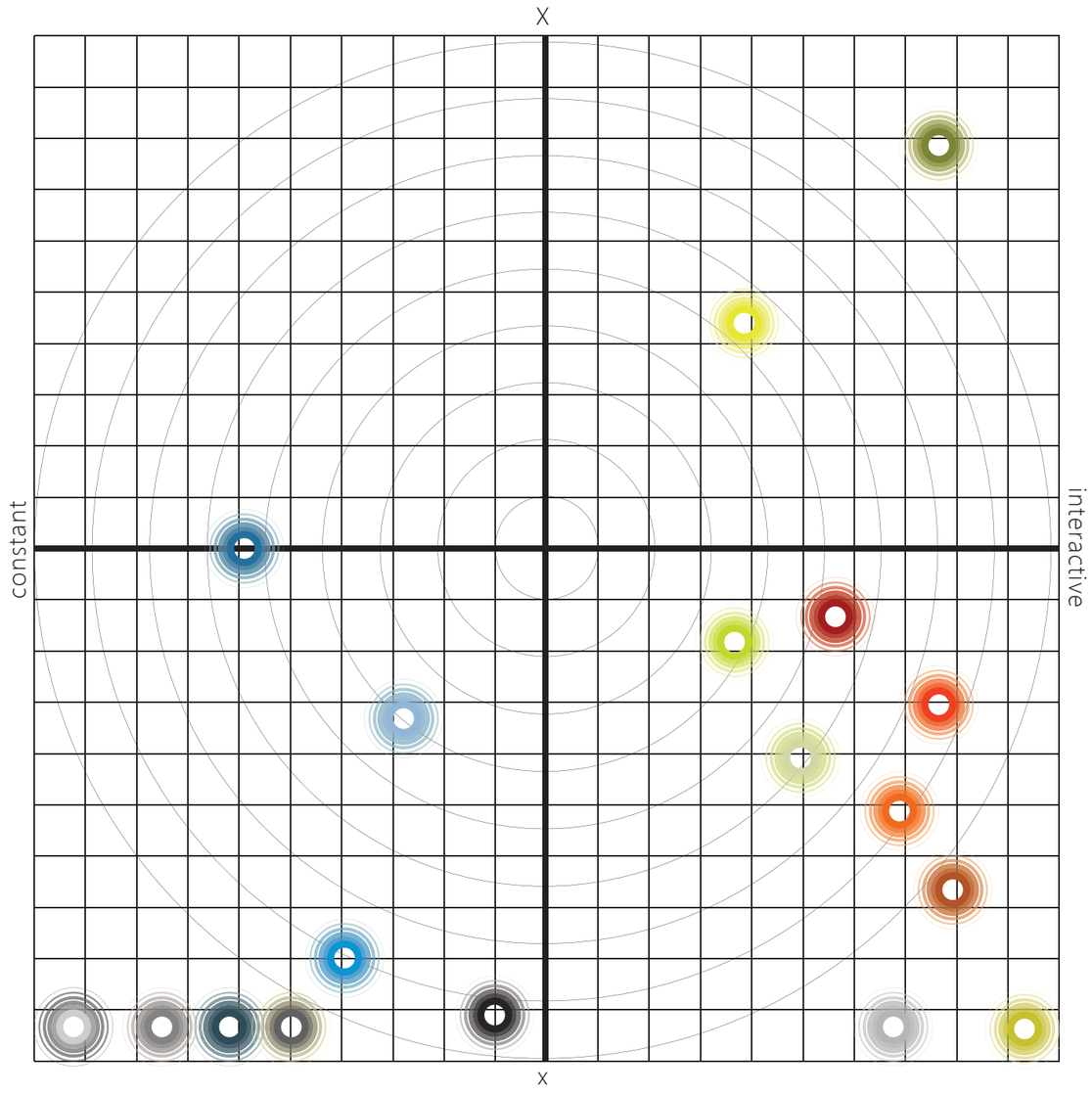
UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

SPATIAL CONSTRUCT_ constant>interactive VS x>X



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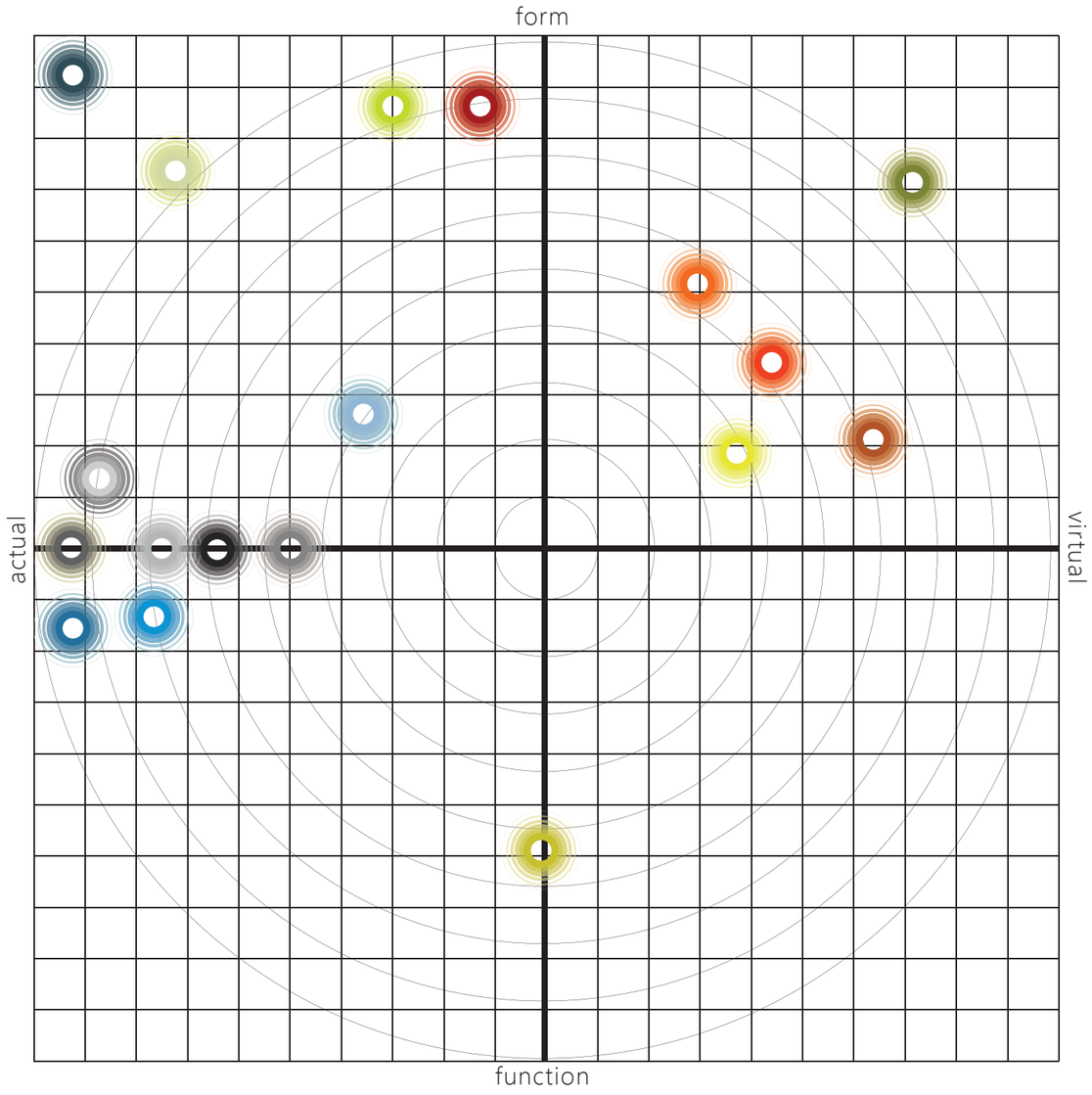
UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

OBJECT PRESENCE_ actual>virtual VS funtion>form



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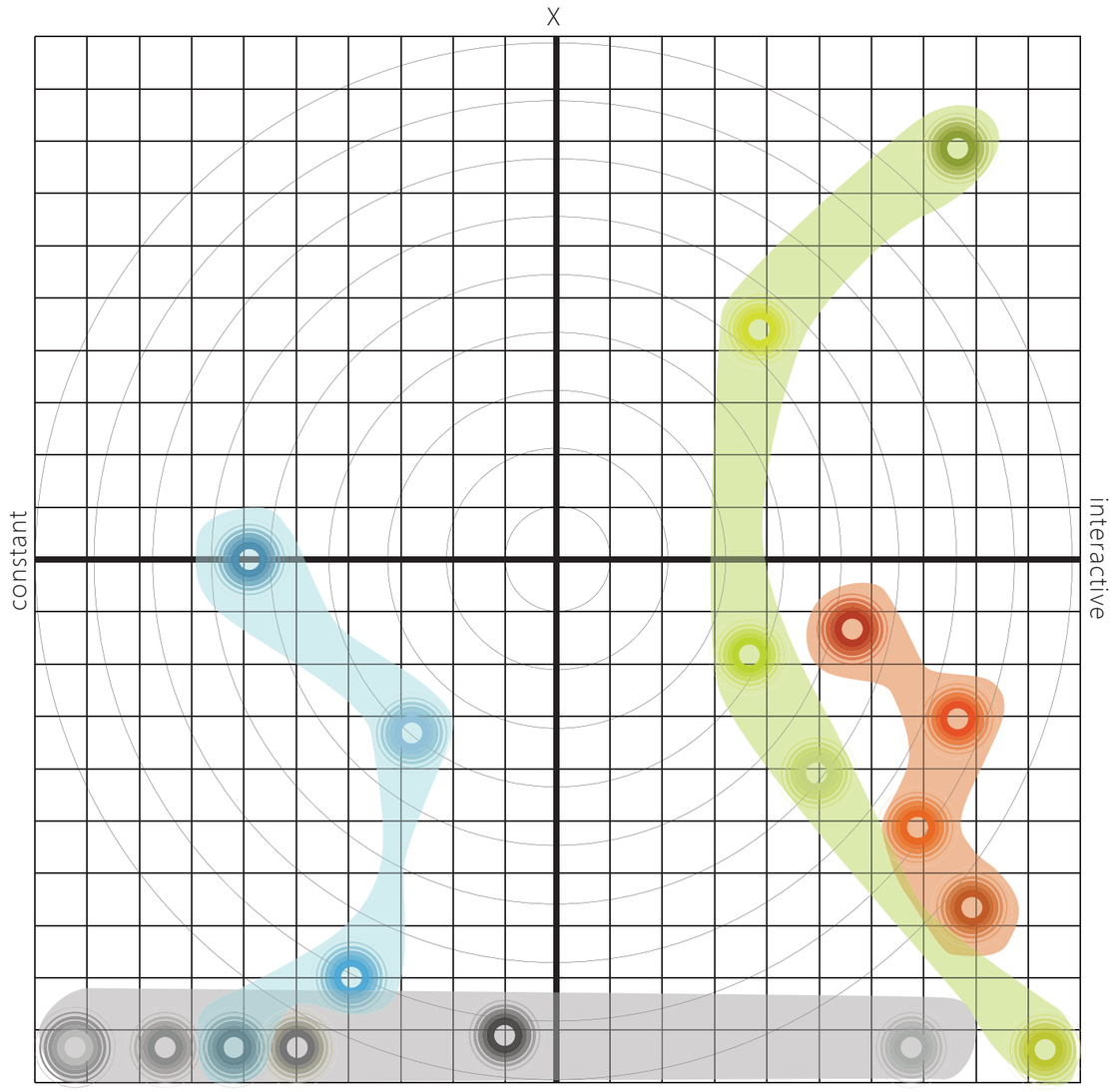
SPATIAL CONSTRUCT_ constant>interactive VS x>X



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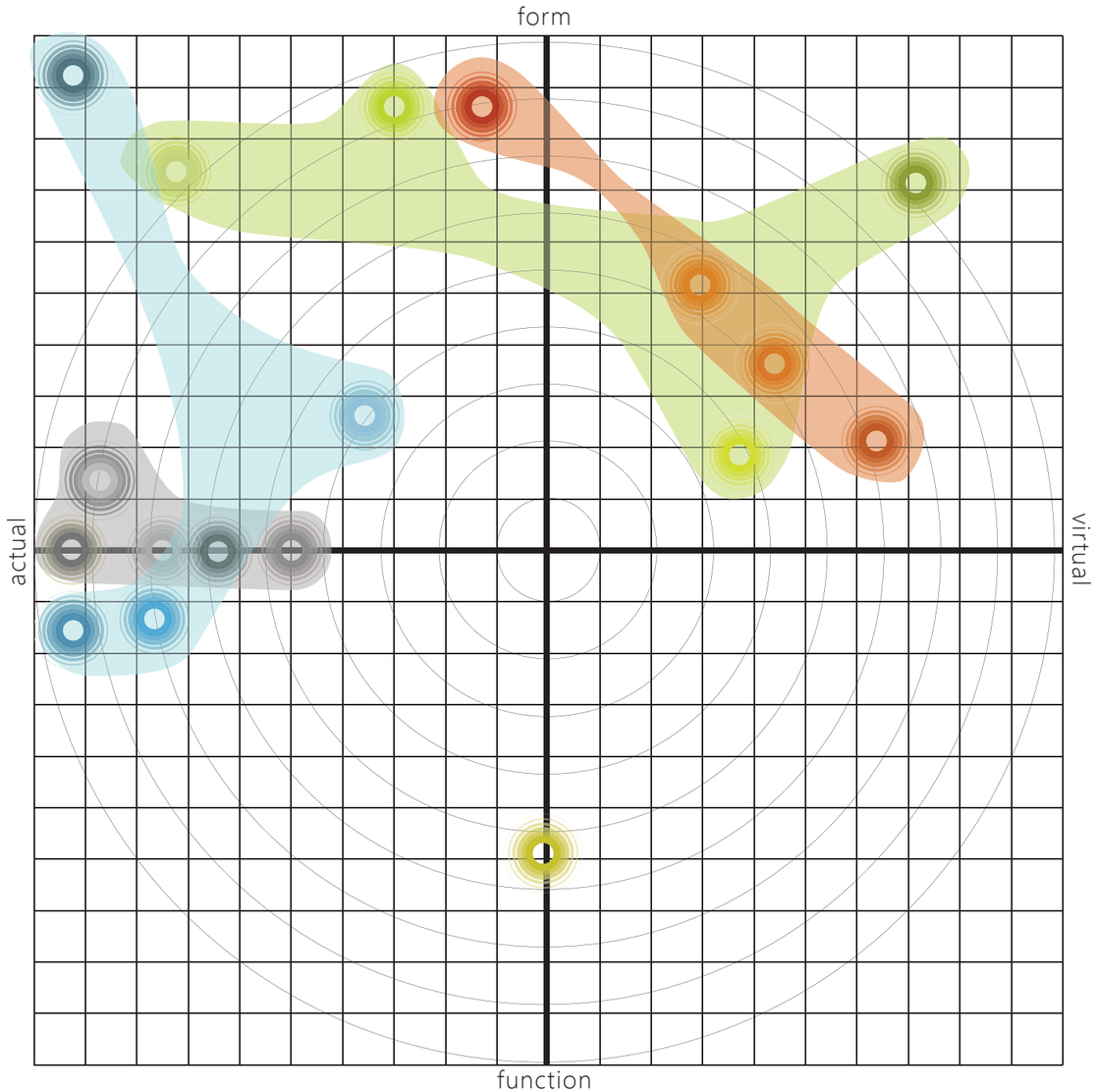

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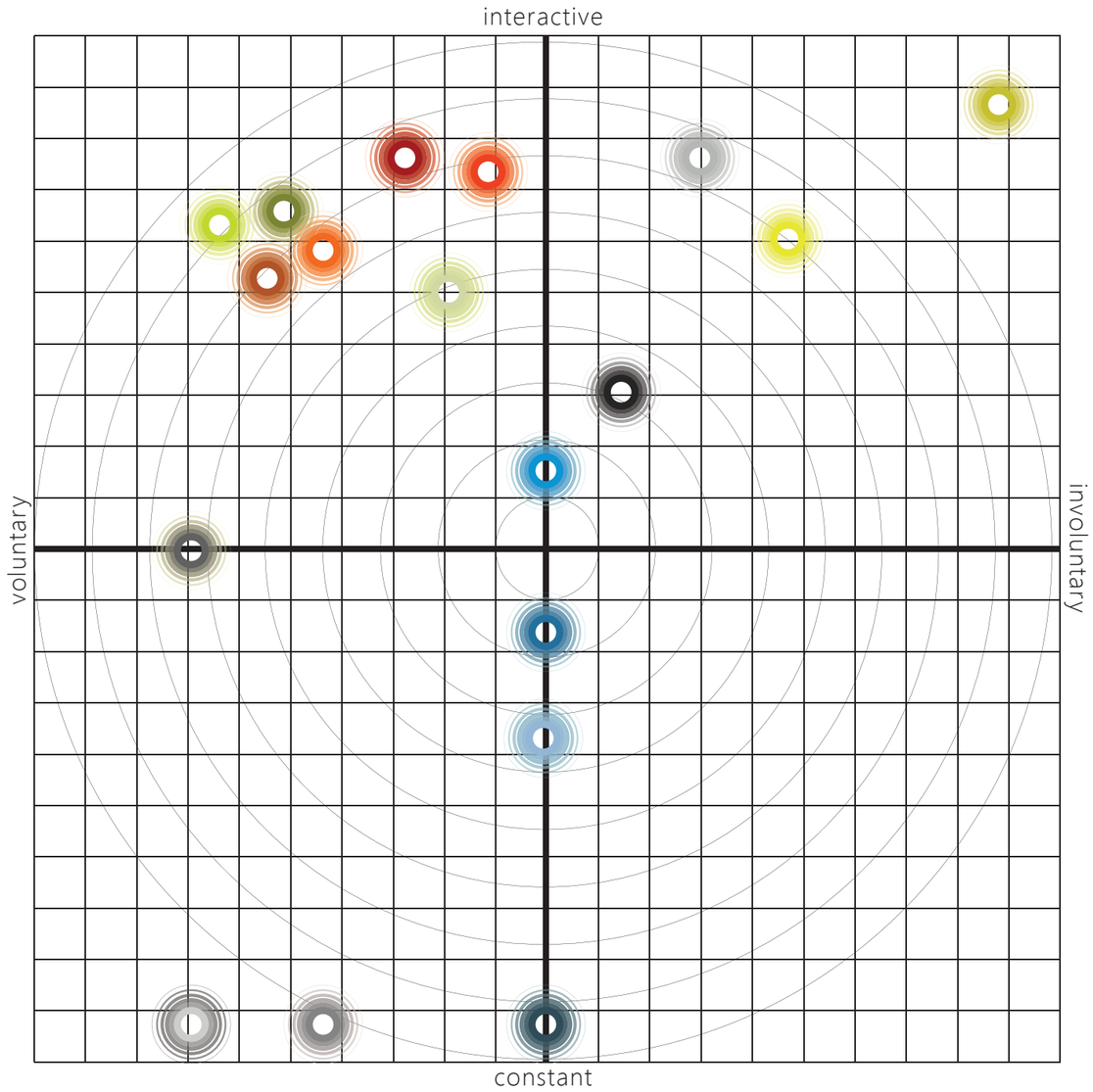
UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

INFORMATION EXCHANGE_ voluntary>involuntary VS. constant>interactive



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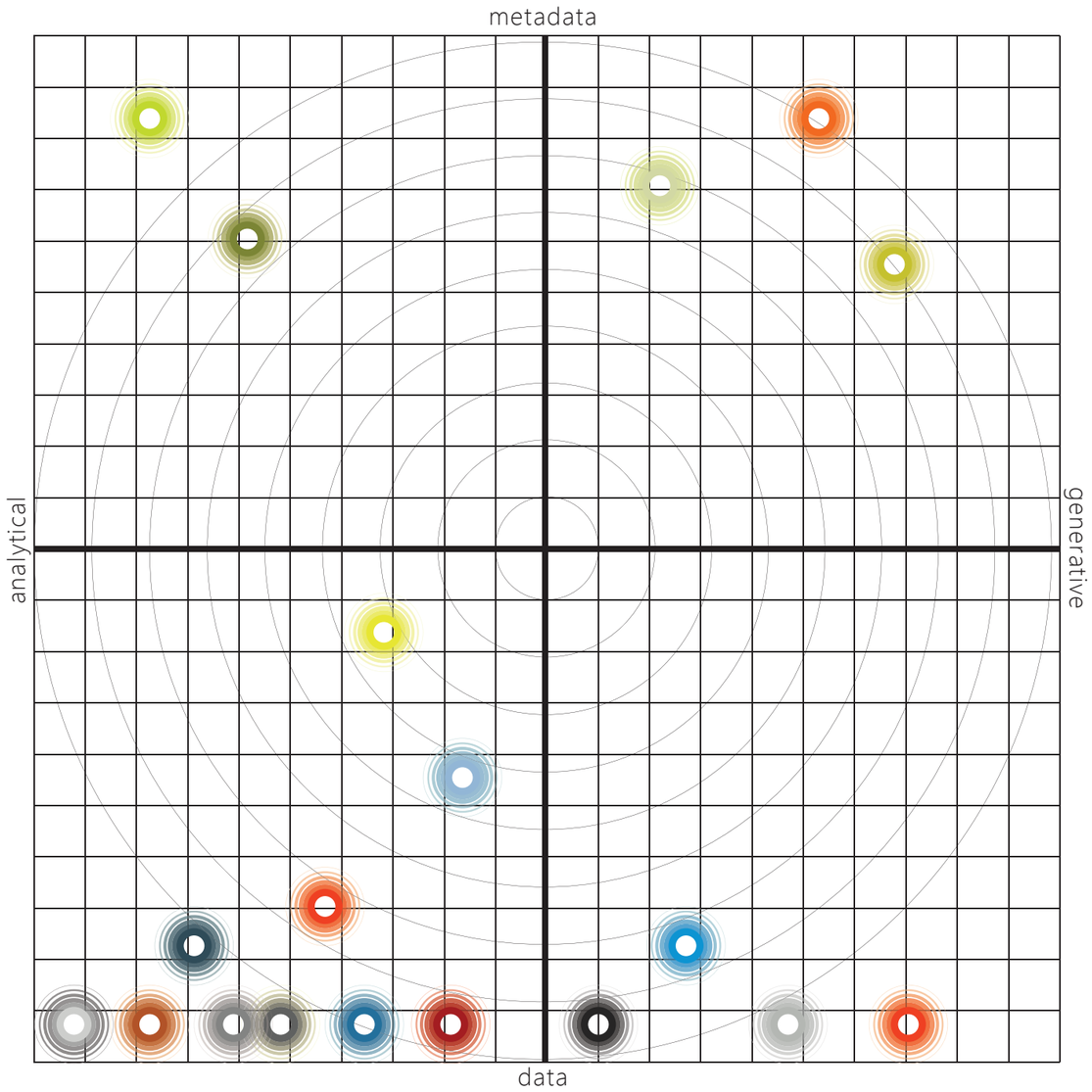
UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

METHODOLOGIES OF INFORMATION ASSEMBLY_
analysis>generative VS. data>metadata



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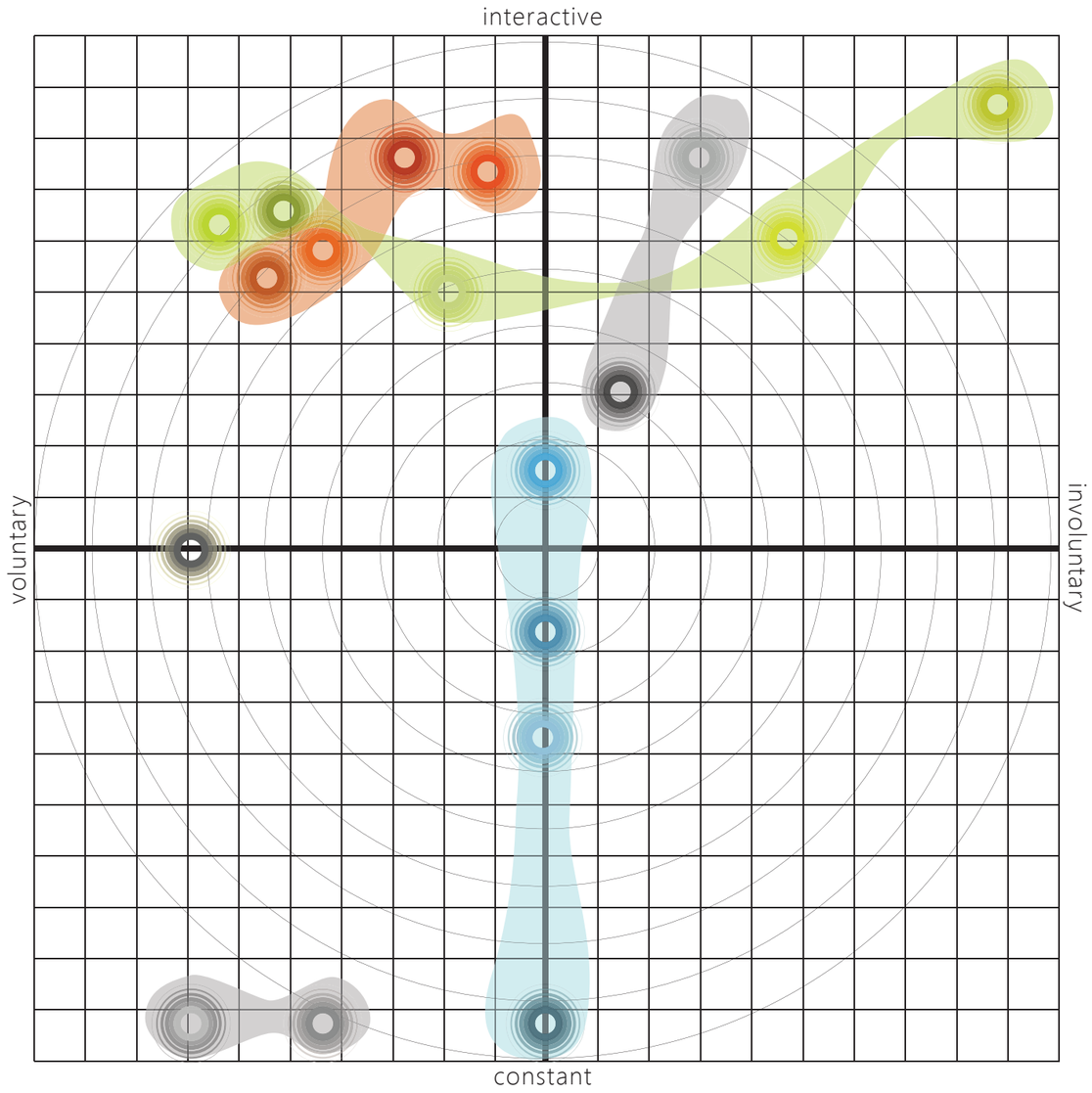

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UNDERSTANDING MATTER/SPACE OF NEW MATERIALS

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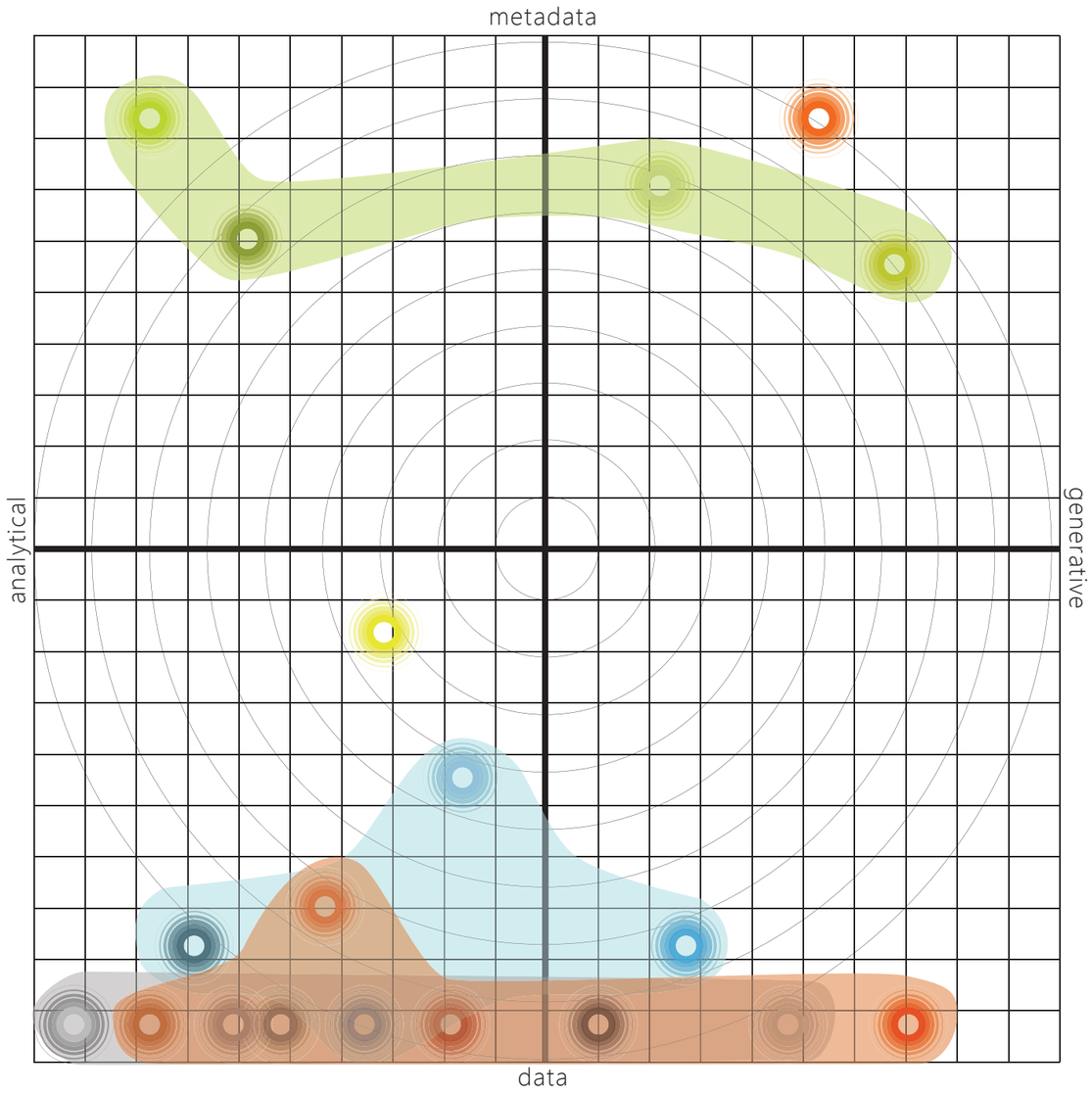
analysis>generative VS. data>metadata



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